

Arrow TSA Timber Supply Analysis

B.C. Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7

September 1994

Canadian Cataloguing in Publication Data:

Main entry under title:

Arrow TSA timber supply analysis

Timber supply review

Includes bibliographical references: p.

ISBN 0-7726-1969-7

1. Timber-British Columbia - Arrow Lakes Region-
Supply and demand. 2. Forests and forestry - British
Columbia - Arrow Lakes Region - Mensuration. 3. Forest
management - British Columbia - Arrow Lakes Region. 4.
Nelson Forest Region (B.C.) I. British Columbia.
Ministry of Forests. 11. Title: Timber supply review.

SD438.B7 1994 333.75'11'0971162 C93-092412-6

© 1994 Province of British Columbia
Ministry of Forests

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 or changes in management practices.

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

Unlike past analyses, which normally assessed the implications of several forest management scenarios, this report focuses on a single scenario — current management practices. Current management practices are defined by the specifications in management plans for the timber supply area, and include guidelines for the protection of forest

resources, and official land-use decisions made by Cabinet. The current nature and capabilities of the local forest industry are also considered.

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis process, allowing analysis of all TSAs in the province to be completed by the end of 1994. An important part of these analyses, however, is an assessment of how results might be affected by uncertainties — a process called *sensitivity analysis*. Together, the sensitivity analyses and the assessment of the effects of current forest management on timber supply will form a solid basis for discussions among stakeholders about alternative timber harvesting levels.

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

Executive Summary

As part of the provincial Timber Supply Review, the British Columbia Forest Service has examined the availability of timber in the Arrow Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the next 200 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 the report indicate only the timber supply implications of current practices and uncertainty. **As such, the forecasts should be used for discussion purposes only; they are not allowable annual cut (AAC) recommendations.**

The Arrow TSA covers a total area of 754 000 hectares, of which approximately 217 000 hectares are considered available for timber harvesting under current management practices. The area is dominated by stands of Douglas-fir, lodgepole pine, larch, balsam, spruce, hemlock and cedar. About two-thirds of the available stands are currently classified as immature.

The Arrow TSA is managed on an integrated resource basis with about 42% of the land base assigned to special management zones to account for wildlife habitat, water quality and quantity, and landscape aesthetics. Non-timber resources, notably water quality and landscape aesthetics, are particularly important to residents in the Arrow TSA. As a result, harvesting has been avoided in parts of the TSA that are otherwise eligible for harvest when current management guidelines are considered.

The analysis results indicate the current AAC of 619 000 cubic metres per year can be maintained for 7 decades without causing future shortages in timber supply. After 7 decades, the harvest level declines 10% per decade to the long-term harvest level in decade 11. The long-term level is 422 000 cubic metres per year, approximately 32% below the current AAC.

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

Short-term timber supply is moderately sensitive to changes in volume estimates for existing stands. If these volume estimates were actually 10% higher than indicated in the existing inventory, the initial harvest level would be 10% higher than the base case. Conversely, if volume estimates were actually 10% lower than assumed in the base case, the initial harvest level could only be maintained for 4 decades before declining to the long-term harvest level.

Forest cover requirements and green-up periods are significant sources of uncertainty, partly because it is difficult to determine the requirements needed to meet objectives such as maintenance of water quality, but also because there is uncertainty about the length of time required for stands to reach green-up requirements.

The uncertainty about forest cover requirements could have a significant effect on the harvest forecast. If objectives for forest cover were actually 10% less than assumed in the base case (more relaxed), the only effect on the harvest forecast would be that the decline to the long-term harvest level could be delayed for 2 decades. However, if forest cover objectives were increased by 10%, the harvest rate would decline 5 decades sooner to a reduced long-term harvest level.

If the green-up periods needed to meet these forest cover objectives were actually 5 years less than estimated, there would be no effect on harvest levels. However, if stands require 5 additional years to achieve green-up conditions, the initial harvest rate would drop after decade 2 rather than decade 7, and the long-term harvest level would be approximately 6% less than in the base case.

The cutblock adjacency rules applied in the base case approximate a 4-pass harvest system whereby no more than 25% of an area may be covered by forests less than the green-up height. Sensitivity analysis examines the effect if more passes (for example, 5- or 6-passes) were required to meet adjacency objectives. If a 5- or 6-pass harvesting guideline were required to meet adjacency objectives, there would be a significant effect in the short term, with the decline to the long-term harvest level occurring much sooner than in the base case. In both cases, long-term harvest levels would be reduced as well.

Executive Summary

There exists some uncertainty about the size of the timber harvesting land base. Any changes in the timber harvesting land base would likely have a significant effect on the results of this analysis. If the timber harvesting land base were 20% larger than assumed, both the initial harvest rate and the long-term harvest rate would be significantly increased. A 20% decrease would result in a 5% lower initial harvest rate, but would have an extreme effect on the timber supply from decade 2 onwards.

Management practices in the visual quality and watershed zones (zones 1 - 3) are associated with a great deal of uncertainty. Although the forest cover requirements for these zones are based on guidelines, they pertain to areas that have actually been accessed. Many of the areas in these zones have not been accessed yet due to harvesting and planning delays; therefore, experience in applying the guidelines has been limited. To examine this situation, sensitivity analyses investigate the impact on the harvest forecast if forest cover constraints were changed in these zones as well as how the harvest forecast would be affected if harvesting were deferred in these areas.

The results indicate that increasing forest cover requirements in these zones would have a significant effect on the harvest over the first 80 years. Decreasing the requirements would have only a slight effect. Long-term harvest levels would be only

moderately affected by changes in the forest cover constraints for these zones. Both a 20- and 40- year deferral would result in an immediate decline in the harvest level to 500 000 cubic metres per year that would last for the duration of the deferral. The long-term impacts of these deferrals would be slight.

Uncertainty in regenerated stand volume estimates has no impact in the short term; however, both increases and decreases in these volume estimates have a significant impact on long-term harvest levels.

Timber supply is affected only slightly by uncertainty in minimum harvestable ages and old-growth requirements

In conclusion, the analysis based on current inventory and growth and yield information indicates that timber harvests in the Arrow TSA can be maintained for several decades without causing future shortfalls. However, meeting the management guidelines in the Arrow TSA requires a high degree of flexibility in locating and scheduling harvest. Given the high sensitivity of the harvest forecast to changes in these guidelines, any attempts to keep the harvest at the present level for a significant period of time will reduce this flexibility and present a risk to the projected harvest levels. It is important to examine these management guidelines to ensure that they accurately reflect demands and meet objectives.

Table of Contents

Preface	iii
Executive Summary	iv
Introduction	1
1 Description of the Arrow Timber Supply Area	3
2 Information Preparation.....	4
2.1 Land base inventory	4
2.2 Timber growth and yield.....	10
2.3 Management practices.....	10
2.4 Management zones.....	11
3 Analysis Methods	13
4 Results.....	14
4.1 Harvest forecast.....	14
4.2 Age class distribution over time.....	16
4.3 Average harvest size, harvest age, and volume per hectare.....	18
4.4 Harvest profile in decade 1 compared to the standing inventory profile	21
5 Timber Supply Sensitivity Analyses	22
5.1 Alternative initial harvest rates and harvest flows over time.....	22
5.2 Uncertainty in minimum harvestable ages	24
5.3 Uncertainty in existing stand volume estimates.....	25
5.4 Uncertainty in regenerated stand volume estimates.....	26
5.5 Uncertainty in forest cover requirements.....	27
5.6 Uncertainty in green-up periods.....	28
5.7 Uncertainty in cutblock adjacency guidelines.....	29
5.8 Impact of an old-growth requirement.....	31
5.9 Uncertainty in the land base available for timber harvesting	32
5.10 Uncertainty in Management Practices in Zones 1 to 3	33
6 Summary and Conclusions	35
7 References	36
8 Glossary	37
APPENDIX A Description of Data Inputs and Assumptions.....	39
Introduction	40
A.1 Management Zone and Analysis Unit Definitions.....	41
A.2 Utilization Levels	45
A.3 Definition of the Timber Harvesting Land Base	46
A.4 Forest Management Assumptions.....	55
A.5 Yield Estimates for Existing and Regenerated Stands.....	64

Table of Contents

Tables

1.	Timber harvesting land base, Arrow TSA	6
A-1.	Analysis unit characteristics.....	43
A-2.	Area by management zone and analysis unit.....	44
A-3.	Strata shifted to another because of lack of representation	44
A-4.	Total area in each ownership category, Arrow TSA.....	47
A-5.	Per cent area reductions for environmentally sensitive areas	49
A-6.	Per cent area reductions for problem forest types	51
A-7.	Timber licence reversions	54
A-8.	Identification of minimum harvestable age for each analysis unit.....	55
A-9.	Harvest profile constraints	56
A-10.	Forest cover requirements	56
A-11.	Unsalvaged losses	60
A-12.	Not satisfactorily restocked (NSR) areas based on silviculture history records	62
A-13.	Not satisfactorily restocked (NSR) area based on inventory records	63
A-14.	Regeneration assumptions.....	63
A-15.	Volume estimates (cubic metres per hectare) for existing and regenerated stands.....	65

Figures

1.	Map of the Arrow TSA.	3
2.	Classification of the total and productive forest land bases, Arrow TSA	7
3.	Current age class distribution for the timber harvesting land base, Arrow TSA.....	8
4.	Area by dominant tree species for the timber harvesting land base, Arrow TSA.	9
5.	Volume by dominant forest type and site category for the timber harvesting land base, Arrow TSA.....	9
6.	Management zones defined for the timber harvesting land base, Arrow TSA.....	12
7.	Base case harvest forecast, Arrow TSA.	14
8.	Growing stock over time for the timber harvesting land base, Arrow TSA base case	15
9.	Changes in the age class distribution on the timber harvesting land base over time, Arrow TSA base case.	17

Table of Contents

10.	Area harvested over time for the timber harvesting land base, Arrow TSA base case.	18
11.	Average harvested age over time, Arrow TSA base case.	19
12.	Average harvested volume per hectare over time, Arrow TSA base case.....	20
13.	Harvest profile in decade 1 versus standing inventory profile, Arrow TSA base case.....	21
14.	Alternative harvest flow patterns using base case data, Arrow TSA.....	23
15.	Available growing stock over time under alternative harvest flows, Arrow TSA.....	23
16.	Harvest forecast with alternate minimum harvestable ages applied, Arrow TSA.....	25
17.	Harvest forecasts with existing stand timber yields changed by 10% , Arrow TSA.....	26
18.	Harvest forecasts with regenerated stand volume estimates changed by 25%, Arrow TSA.....	27
19.	Harvest forecast with forest cover requirements changed by 5% and 10%,Arrow TSA.....	28
20.	Harvest forecast with all green-up periods changed by 5 years, Arrow TSA.	29
21.	Harvest forecast with cutblock adjacency requirements changed, Arrow TSA.	30
22.	Harvest forecast if forest cover objectives for old-growth are different from the base case, Arrow TSA.	31
23.	Harvest forecast, timber harvesting land base increased and decreased by 20%, Arrow TSA.	32
24.	Uncertainty in management practices in zones 1-3 — forest cover requirements, Arrow TSA.	34
25.	Uncertainty in management practices in zones 1-3 — harvest deferrals, Arrow TSA.	34

Introduction

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

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

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

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

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

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

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

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

Timber Supply Area (TSA)

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

Allowable annual cut (AAC)

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

Introduction

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

The following sections outline the timber supply analysis for the Arrow TSA. Following a brief

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

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

Forest inventory

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

1 Description of the Arrow Timber Supply Area

The Arrow TSA is located in the south-east corner of British Columbia, within the Nelson Forest Region (Figure 1). The TSA consists of approximately 754 000 hectares and is administered from the Arrow Forest District office in Castlegar and the Nakusp Field Office.

The main population centres within Arrow TSA are Castlegar, Trail, Rossland, Fruitvale, Salmo, New Denver, Nakusp, and Slocan. The economy of these communities is largely dependent on the forest and mining industries. In addition, there is a rapidly growing tourism and recreation industry that is supported by the presence of Arrow and Slocan Lakes and provincial and national parks.

The Arrow TSA is an important source of timber for the wood processing plants located in the Arrow Forest District. It supplies 30% of the approximately 2 million cubic metres per year currently processed by these plants. Tree farm licences 23 and 3, which

cover 552 745 hectares within the Arrow Forest District, private lands, and lands from other districts, also contribute significantly to the overall district timber supply. The two TFLs are part of the Arrow Forest District but are not included in the Arrow TSA.

Forests of the Arrow TSA are composed of stands varying in tree species and age. Of the total forested area, Douglas-fir stands cover 26%, balsam 24%, pine 18% and larch 14%. Hemlock, spruce, cedar and deciduous species are not as prevalent but contribute significantly to the diversity of species found throughout the TSA. The Arrow TSA is located in the interior wet-belt and includes the interior cedar hemlock and englemann spruce - subalpine fir biogeoclimatic zones. The Arrow TSA is characterized by steep terrain and sensitive soils that limit the availability of timber for harvest over much of the land base.

Figure 1. Map of the Arrow TSA.

2 Information Preparation

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

2.1 Land base inventory

Land base inventory information used in this analysis comes in the form of a computer file prepared by the B.C. Forest Service Inventory Branch in 1992. This file contains a considerable amount of data about the thousands of pieces of forest land that make up a TSA, including the geographic location, the area and the nature of the forest cover (such as presence or absence of trees, number of trees, species, age and timber volume).

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

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

It is important to remember that removal of data for areas not contributing to the timber supply does not imply withdrawal of these areas from the TSA. The B.C. Forest Service still manages the entire area of the TSA (except for certain designated lands) as a

forest unit that contributes a mix of timber and non-timber values. Within that integrated resource context, the timber supply is managed. The timber supply analysis in this report is consistent with this philosophy.

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

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

- areas not managed directly by the B.C. Forest Service — these include non-Crown land, areas managed by other agencies (for example, parks, recreation areas) and forest land not administered as part of the TSA (for example, woodlot licences or TFLs);
- non-forest areas — areas not capable of growing productive forest cover (for example, rock, swamp and alpine areas);
- non-commercial cover areas — areas occupied by non-commercial tree or brush species;
- inoperable areas — areas classified as unavailable for harvest for terrain-related or economic reasons. Characteristics used to define operability* include slope, topography (for example, presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality;

Timber harvesting land base

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

Operability

A classification of the availability of an area for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.

2 Information Preparation

- soil instability areas and steep slope areas;
- environmentally sensitive areas* — portions of the areas classified as sensitive are considered unavailable for timber harvesting;
- non-merchantable forest types* — areas occupied by timber stands of low volume or value (deciduous and problem forest types) and areas with low timber-growing potential (low site index*). A portion of the total area in each category was removed;
- road, trail and landing areas — to account for the loss of productive forest land that has occurred during past timber harvesting and development, a deduction of 10.1% was applied to all area classified as young forest stands (i.e. less than 40 years old). Future losses of productive forest land due to roads, trails and landings are projected and modelled as deductions over time as future harvesting occurs.

Table 1 summarizes the areas represented by these categories. A more detailed description of these categories and the rationale for their removal is provided in Appendix A, "Description of Data Inputs and Assumptions."

Table 1 shows that not satisfactorily restocked* (NSR) areas are also initially deducted from the timber harvesting land base but later added as indicated in Table A-13. found in Appendix A, "Description of Data Inputs and Assumptions."

Areas within timber licences that have reverted to the Crown are also added to the timber harvesting land base. Harvested volumes from these old tenure arrangements do not contribute to the AAC for the TSA. However, once harvested, these areas revert to the Crown and all future harvests are included in the AAC. In the Arrow TSA, these reversions occur in decades 1 through 4. The area in these timber licences that is not expected to be available for timber harvesting is determined using the management criteria listed above.

Environmentally sensitive areas

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

Non-merchantable forest types

Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.

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.

Not satisfactorily restocked (NSR)

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

2 Information Preparation

Table 1. Timber harvesting land base, Arrow TSA.

Classification	Area (hectares)	Per cent of TSA area	Per cent of productive forest area
Total land base	754 079	100.0	
Not managed by B.C. Forest Service	127 637	16.9	
Non-productive/non-forest land	222 178	29.5	
Total productive forest managed by Forest Service (Crown forest)	404 264	53.6	100.0
Reductions to Crown forest:			
Non-commercial cover	6 521	0.9	1.6
Inoperable	123 262	16.3	30.5
Unstable soils/steep slopes	7 476	1.0	1.8
Environmentally sensitive	31 395	4.2	7.8
Non-merchantable			
Low site	2 430	0.3	0.6
Deciduous types	7 442	1.0	1.8
Problem forest types	7 560	1.0	1.9
Existing roads, trails, and landings	3 253	0.4	0.8
Not satisfactorily restocked	13 862	1.8	3.4
Total current reductions	-203 201	26.9	50.3
Current timber harvesting land base (less additions)	201 063	26.7	49.7
Additions:			
Operable NSR ^a	7 481		
Operable NSR stocked ^b	6 381		
Timber licence reversions	1 835		
Total additions	+15 697	2.1	3.9
Total current timber harvesting land base	216 760	28.7	53.6
Future reductions:			
Future roads	-15 891	2.1	3.9
Long-term timber harvesting land base	200 869	26.6	49.6

^a The NSR figure is based on the inventory file as of December 31st, 1991. However, both backlog and current NSR are updated to 1989 only.

^b The inventory file indicates that these areas have an unknown stocking status. However, District staff have determined that this area is stocked.

2 Information Preparation

Figure 2 represents both the total area of the Arrow TSA and the total productive forest managed by the B.C. Forest Service. The total area chart shows that over 80% of the total area of the Arrow TSA falls within B.C. Forest Service jurisdiction, and of that area, over half is classified as either non-forest or non-productive forest. The productive forest area

shows the categories of productive forest land not within the timber harvesting land base, and shows that almost half (49.7%) of the productive forest is considered available for timber harvesting. Overall, the current timber harvesting land base comprises 26.7% of the total land base (see Table 1).

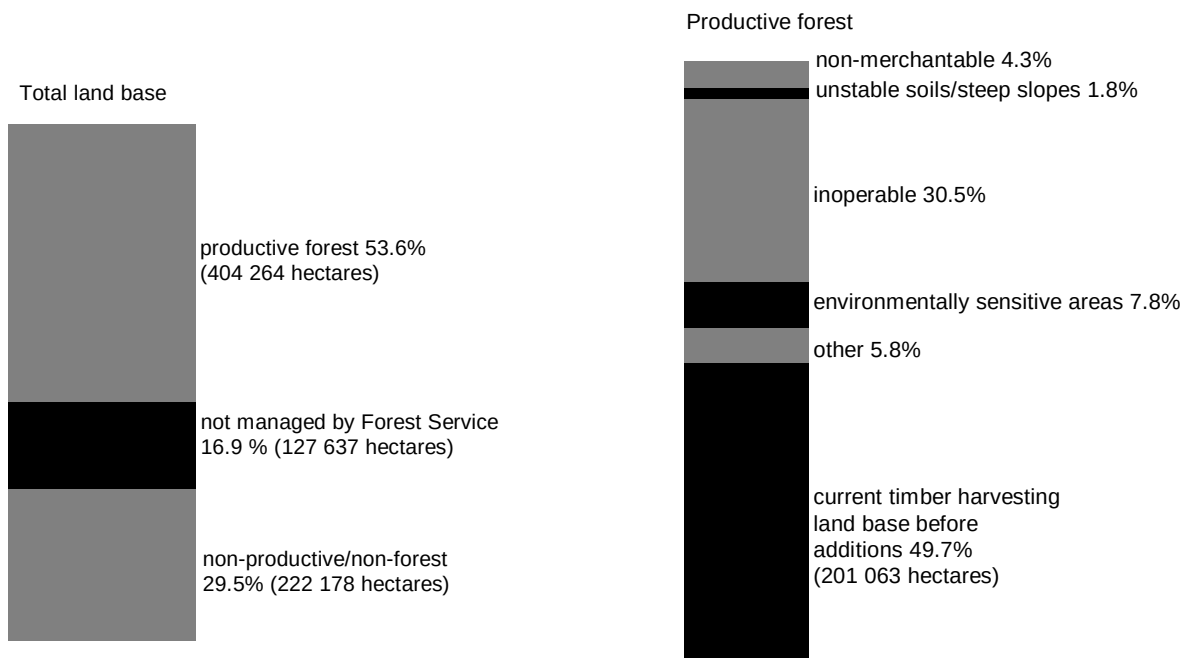


Figure 2. Classification of the total and productive forest land bases, Arrow TSA.

2 Information Preparation

Figure 3 shows the current age class distribution of stands by species for the current timber harvesting land base. The stand ages are grouped into 20-year age classes, with the exception of very old stands. This figure shows a fairly even age class distribution with no significant gaps. Fires occurring at the turn of the century account for more area being in age classes 61 - 80 and 81 - 100. These stands consist

primarily of pine, larch and Douglas-fir. Relatively little area of the timber harvesting land base (16.2%) is occupied by old-growth stands (older than 140 years) and only 3.3% is occupied by stands of timber older than 250 years.

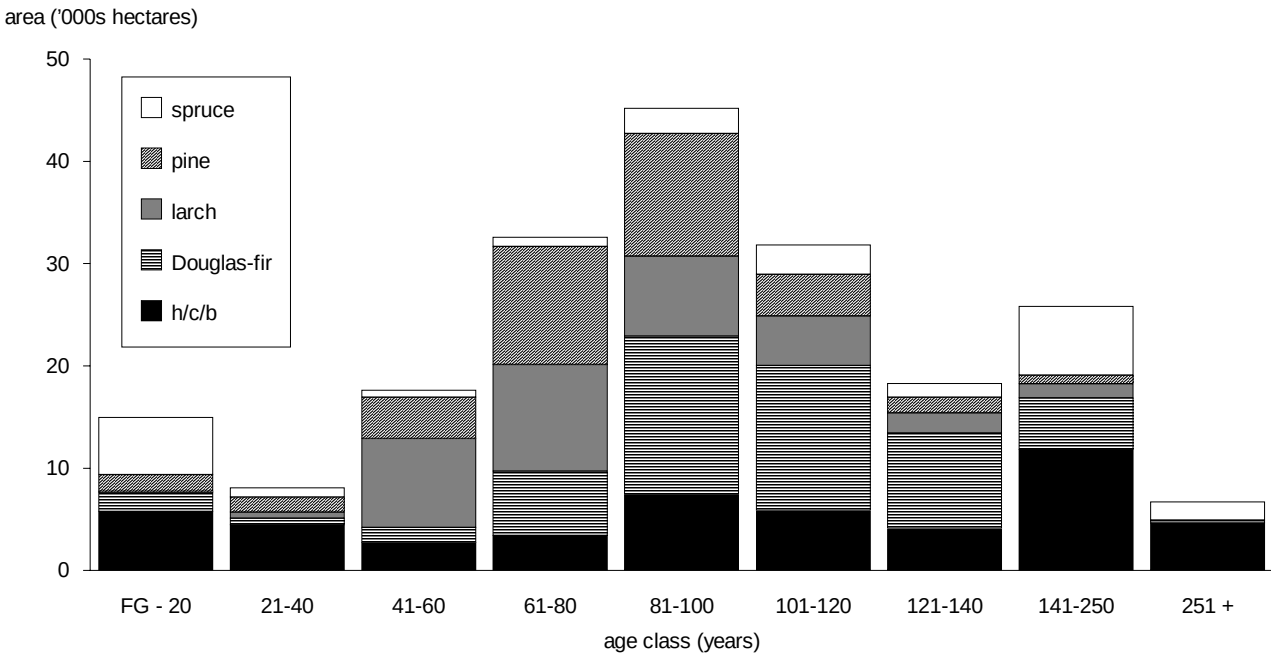


Figure 3. Current age class distribution for the timber harvesting land base, Arrow TSA.

2 Information Preparation

Figure 4 illustrates timber harvesting land base tree species composition by area and maturity. Douglas-fir, lodgepole pine, larch, and balsam stands are most prevalent, but spruce, hemlock and cedar

stands are also common. Note that a large portion (approximately 67%) of the forest is immature.

Figure 5 provides a breakdown of the timber volume by species and site class for the Arrow TSA timber harvesting land base.

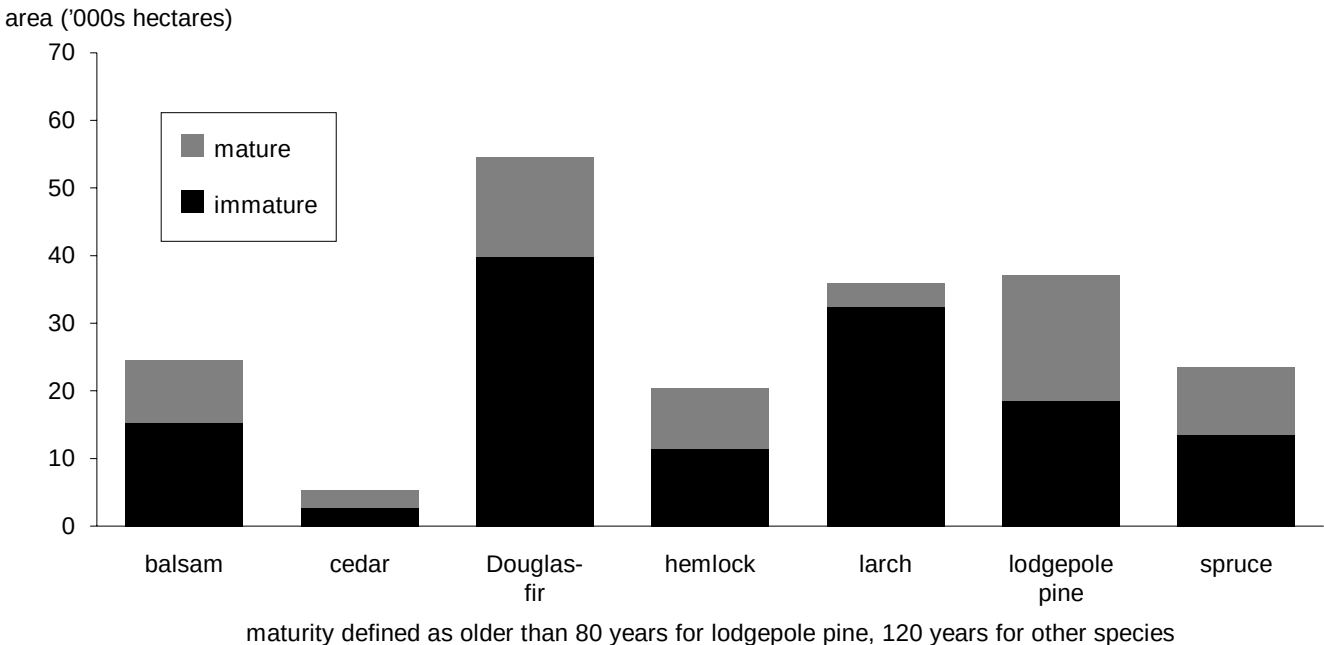


Figure 4. Area by dominant tree species for the timber harvesting land base, Arrow TSA.

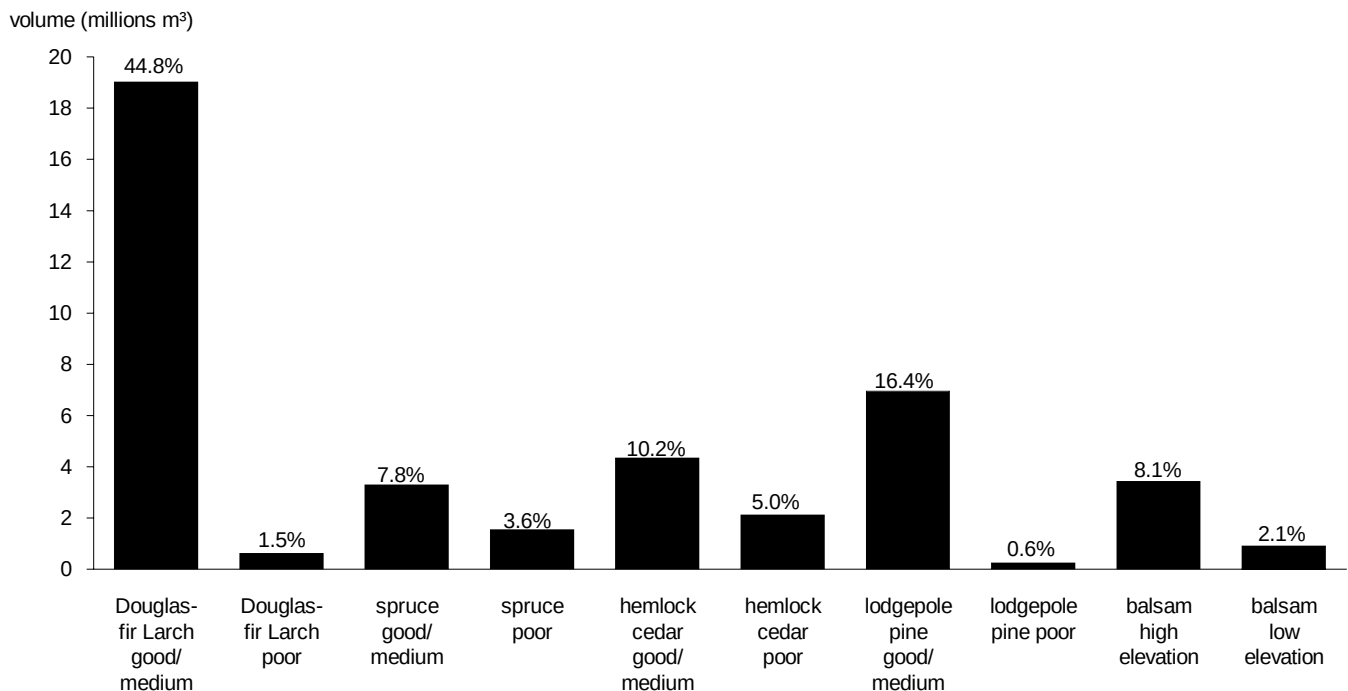


Figure 5. Volume by dominant forest type and site category for the timber harvesting land base, Arrow TSA.

2 Information Preparation

2.2 Timber growth and yield

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

Timber volumes applied to existing stands and future regenerated stands in this analysis are based on the Variable Density Yield Prediction model developed by the B.C. Forest Service, Inventory Branch. This model provides estimates of stand volume according to age. Sensitivity analysis addresses the possibility that stand volumes may be different from those predicted.

2.3 Management practices

Timber supply is directly connected to forest management activity. The focus of the Timber Supply Review is to describe the timber supply based on current management practices, as implemented in plans for the area. Staff in the Arrow Forest District and in the Nelson Forest Region defined these

practices as described in the following management assumptions*:

- basic silviculture levels — reforestation activities required to establish free growing stands of acceptable species;
- forest health and unsalvaged losses — losses of merchantable timber to fire, pest (insect, disease, animal) and wind damage;
- stream and non-timber resource protection — measures taken to protect streamside areas and non-timber values throughout the Arrow TSA;
- utilization levels — minimum size limits for trees and logs that must be harvested and removed from a site;
- minimum harvestable ages — the time it takes for stands to grow to harvestable size. The minimum harvestable age defines the youngest age at which a specific type of stand is expected to be available for harvest. The actual harvest age may be greater, but not less than the minimum, and will depend on ages of other stands, overall harvest level targets, and harvesting guidelines;
- rate of restocking current and backlog NSR — the schedule of restocking by species and area;
- cutblock adjacency* and green-up* — guidelines that specify that harvested stands must reach a desired condition, or green-up, before adjacent mature timber may be harvested;

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 harvest ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.

Cutblock adjacency

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

2 Information Preparation

- forest cover objectives — specify the desired distribution of areas by age (for example, at least 70% of the forest area should be over 40 years old). These objectives are used to specify general adjacency and green-up guidelines as well as desired conditions for wildlife, watershed protection and visual quality objectives* (VQOs).

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

2.4 Management zones

In the Arrow TSA, all areas important for visual quality, watershed protection and wildlife habitat were identified. Areas sharing a similar management emphasis, such as those areas with similar water quality emphases, were assigned to a management zone having specific forest cover requirements. The forest cover requirements for a zone were determined using management guidelines for the resources being managed or protected. When several resource management concerns overlapped in an area — for example, water quality and wildlife habitat — the most restrictive forest cover requirements were used.

The management objectives for the Arrow TSA timber harvesting land base are provided for in 5 management zones as follows:

- retention VQO* — this zone covers all areas classified as Retention VQO in the landscape inventory. This classification indicates that maintaining visual aesthetics is very important. For a given landscape, visible evidence of timber

harvesting must be minimal. Very restrictive logging guidelines apply here;

- partial retention VQO* — this zone covers areas classified as Partial Retention VQO in the landscape inventory. Maintaining the visual integrity of designated landscapes is important in this zone. More harvesting in partial retention VQOs is possible than in retention VQOs but applicable logging guidelines are also quite restrictive;
- class 1 and 2 watersheds — this zone includes small areas which produce water for consumptive use. The intent is to limit harvesting so that it does not detract from water quality and quantity;
- timber — this zone covers all areas within the timber harvesting land base not specifically assigned to another zone. It is important to note that the *Timber* label applied to this zone does not imply that non-timber resource values are ignored. For example, wildlife summer range and general water quality requirements are considered in this zone. The use of the *Timber* designation means that harvesting is the emphasis, subject to integrated resource management guidelines for the TSA;
- wildlife winter range — this zone identifies areas which are important white tail deer and caribou winter range.

A detailed discussion of the management assumptions applied to each zone can be found in Appendix A, "Description of Data Inputs and Assumptions."

Visual Quality Objective (VQO)

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

Retention VQO

Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity.

Partial retention VQO

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

2 Information Preparation

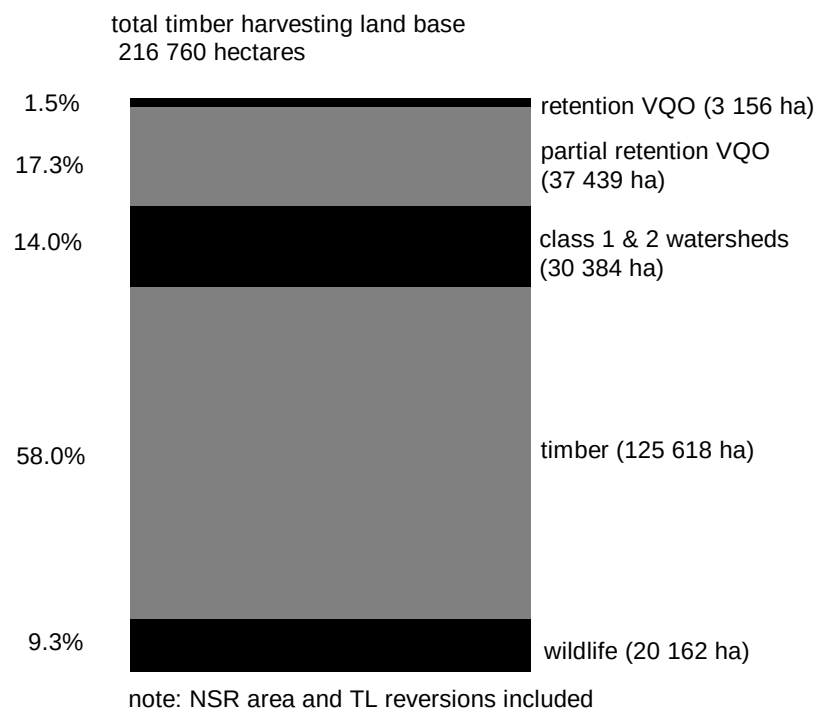


Figure 6. Management zones defined for the timber harvesting land base, Arrow TSA.

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in the Arrow TSA, in light of current forest management practices. A timber supply computer simulation model developed by the B.C. Forest Service was used to aid in the assessment. A timber supply model, as distinct from a growth and yield model, assists the timber supply analyst in determining how a whole forest (collection of stands) could be managed to obtain a harvest forecast (supply of timber over time). The simulation model uses information about the timber harvesting land base, timber volumes, and the management regime to represent how trees grow and are harvested over a period of up to 400 years. Only the results for the first 200 years are shown graphically in this report, because the harvest flow remains constant after that time.

Similar to other models, the B.C. Forest Service model assumes that trees grow according to provided yield projections and are harvested according to either a volume target or a specified objective set by the analyst, such as harvest volume maximization. However, the Forest Service model differs from most other models in that it allows the use of forest cover guidelines that specify the desired age composition of the forest. These guidelines can be used to examine the effects of cutblock adjacency and green-up

prescriptions. For example, guidelines might specify that no more than some maximum percentage of the forest can be younger than a specified green-up age, or that some minimum percentage of the forest must be in older age classes to provide wildlife habitat. The B.C. Forest Service simulation model examines the effects of such guidelines on timber supply.

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

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

4 Results

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

4.1 Harvest forecast

Figure 7 shows the base case harvest forecast* based on current management assumptions for the Arrow TSA. The initial harvest level is the current AAC of 619 000 cubic metres per year. This level is maintained for 7 decades, after which it declines 10% per decade until the long-term level of 422 000 cubic metres per year is reached in decade 11. Overall, there is a 32% decline between the initial and long-term harvest level.

The base case was chosen according to several criteria: maintaining current harvest levels as long as possible, maintaining a reasonable and gradual rate of decline to the long-term harvest level*, and avoiding drops below the long-term level for any significant period of time.

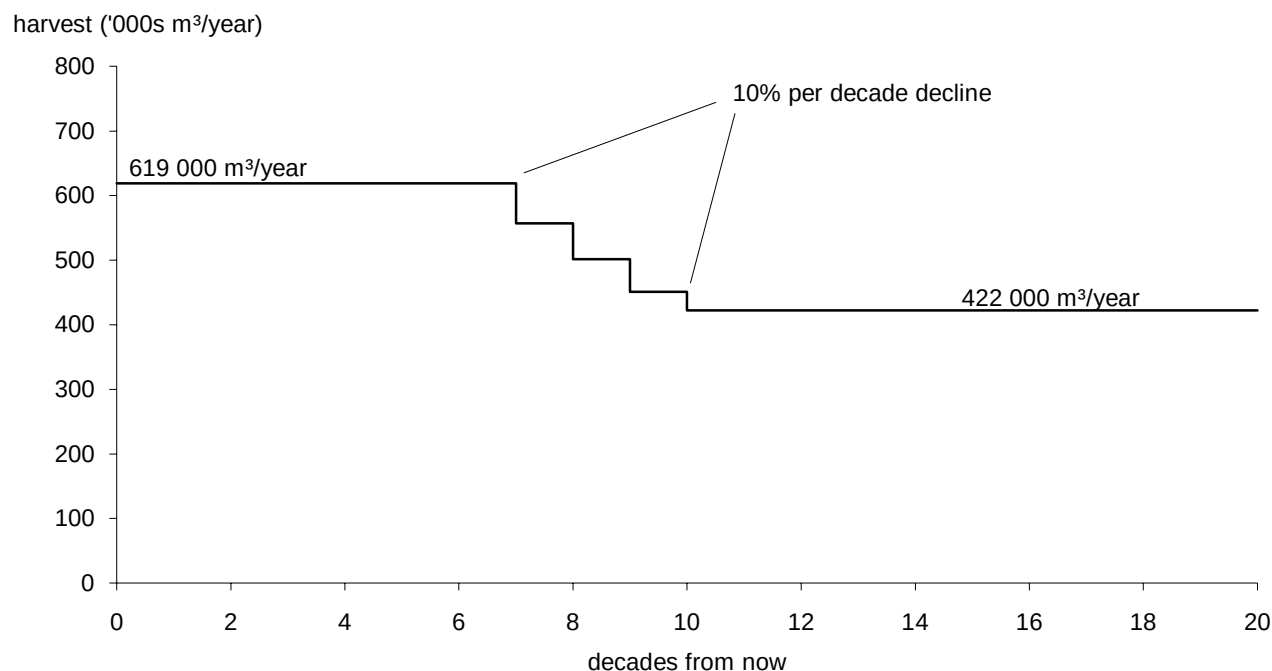


Figure 7. Base case harvest forecast, Arrow TSA.

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.

Long-term harvest level

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

4 Results

The long-term harvest rate was defined as the harvest level that will maintain timber growing stock* at a near constant level once the existing older timber has been harvested. The growing stock for the Arrow TSA base case harvest forecast is shown in Figure 8. A constant volume of growing stock indicates that a particular harvest level can be sustained indefinitely. Conversely, a declining volume of growing stock indicates that the long-term harvest level exceeds the productive capability of the land, and that growing stock levels would eventually fall below the level needed for the harvest. Figure 8 also shows the available growing stock, which includes only stands above the minimum harvest age. Similar to overall growing stock levels, an increase in available growing stock would indicate that harvest levels could likely

be increased without exceeding the timber growing capacity of the land base. A decrease in the growing stock volume would eventually limit the amount of timber available for harvest.

Both the total and available growing stock are projected to decline over the next 10 decades as the harvest shifts from the remaining older stands to second-growth stands which are harvested at a younger age. At decade 10, the inventory of available growing stock is approximately one-third of what exists now. This low level occurs because much of the initial inventory has been harvested and there is limited regenerated timber old enough to harvest. The inventory increases slightly between decades 11 and 16, and afterwards remains stable through to the end of the forecast period.

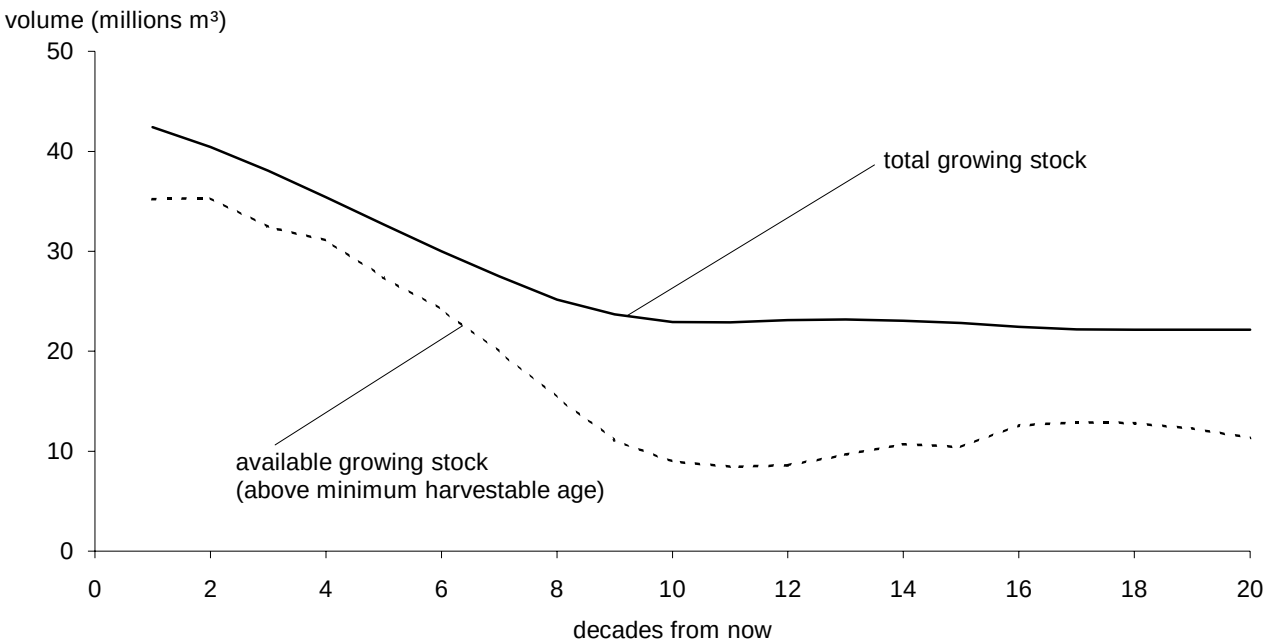


Figure 8. Growing stock over time for the timber harvesting land base, Arrow TSA base case.

Growing stock

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

4 Results

It is important that the long-term harvest levels not be interpreted as being the same as a theoretical maximum sustainable harvest level based on the maximum mean annual increment (MAI)*. The theoretical level, about 473 000 cubic metres per year, is not achievable for several reasons. First, stands are not necessarily harvested at ages that would maximize volume over the long term because of the applied minimum harvestable ages and forest cover objectives, or because of practical limitations on scheduling harvests. Also, harvest forecasts are reduced by the estimated volume losses to fire and other destructive agents.

The base case harvest forecast shown here is only one of many possible harvest flows given current forest management assumptions. Some of these alternative harvest flows are examined in Section 5, "Timber Supply Sensitivity Analyses." Note that the harvest forecast shown here, as well as those shown in Section 5, provide an upper limit on timber supply, given the land base and management practices discussed earlier. **This forecast is for discussion purposes only and is not intended to suggest a particular AAC.**

4.2 Age class distribution over time

Figure 9 shows the changes that occur in the forest age class distribution over the 200 year planning horizon. Initially a wide range of age classes exist, but over the planning horizon the oldest classes are harvested. A balanced age class distribution is arrived at after 100 years, and it continues to the end of the planning horizon. At year 200, stands between the ages of 140 and 200 still exist, but by then about 90% of the forest is less than 120 years old. A regular timber flow is easier to achieve with an even age class distribution because a constant percentage of the forest remains at or near the age of maturity and suitable for harvest. An even age class distribution, combined with a constant total growing stock, indicates a stable forest that can maintain the long-term harvest level indefinitely. An unbalanced age class structure, conversely, would indicate that the percentage of the forest at or near the age of maturity would fluctuate significantly throughout time, possibly leading to periodic shortages of suitable timber.

Mean annual increment (MAI)

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

4 Results

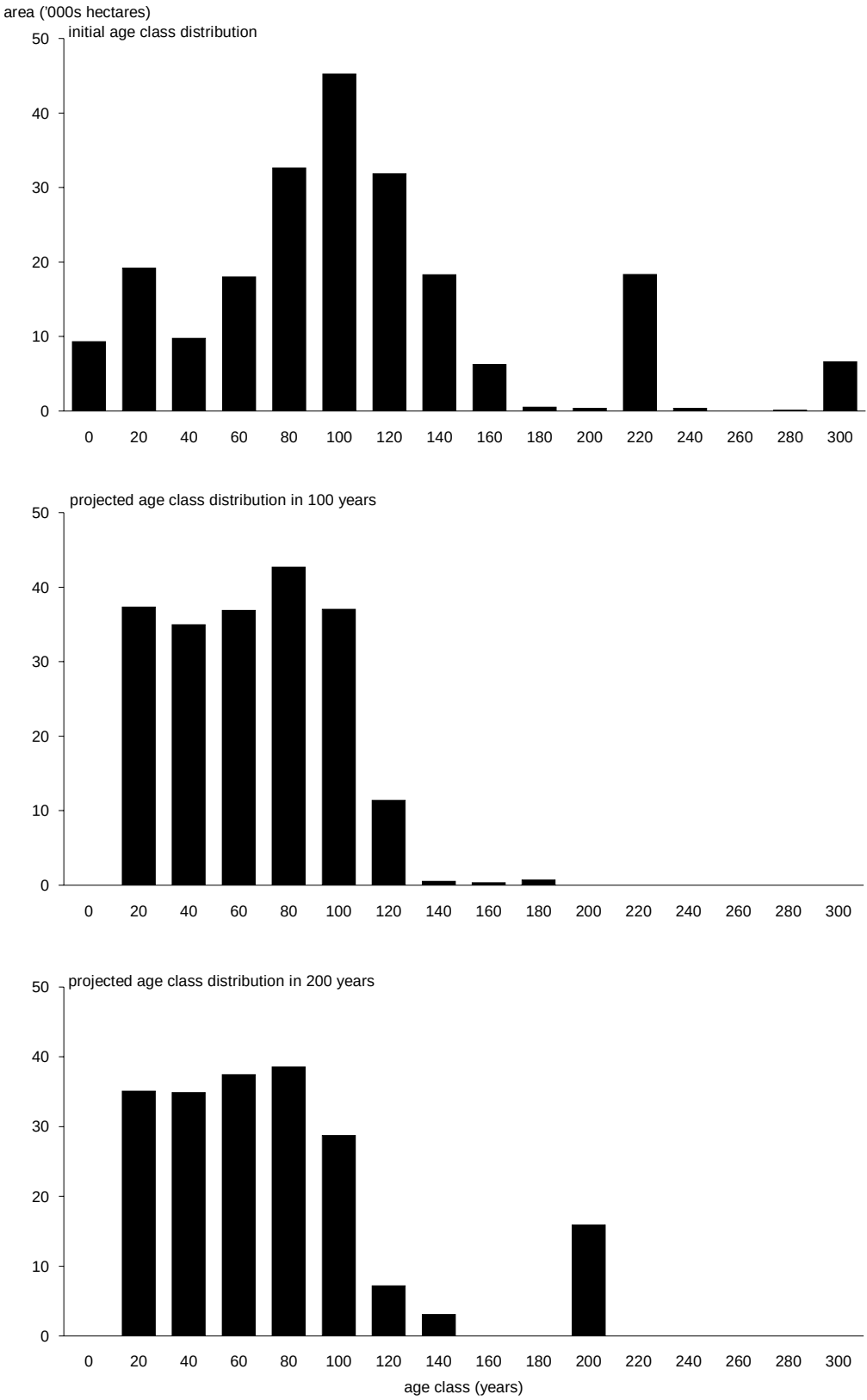


Figure 9. Changes in the age class distribution on the timber harvesting land base over time, Arrow TSA base case.

4 Results

4.3 Average harvest size, harvest age, and volume per hectare

Figure 10 shows how the average area harvested would change over the next 200 years if the base case harvest forecast were followed. An estimation of the areas depleted by fire, insects, disease, and wind throw is included in the average, so the actual harvested area is likely to be approximately 5% less than indicated here.

Initially, close to 1850 hectares is harvested or depleted each year to achieve a harvest target of 619 000 cubic metres. The amount of area harvested to achieve the target harvest volume increases during

the first 2 decades because harvesting is restricted in hemlock, cedar and balsam forest types. During this time, the percentage of the harvest taken from hemlock, cedar and balsam forest types is limited to the percentage of these forest types in the standing inventory profile. Between decades 7 and 10, the area harvested annually declines, reflecting the declining harvest rate. After decade 10, when harvesting occurs at the long-term harvest rate of 422 000 cubic metres per year, the amount of area harvested remains relatively stable. Overall, the amount of area harvested annually changes relatively little throughout the 20 decade period.

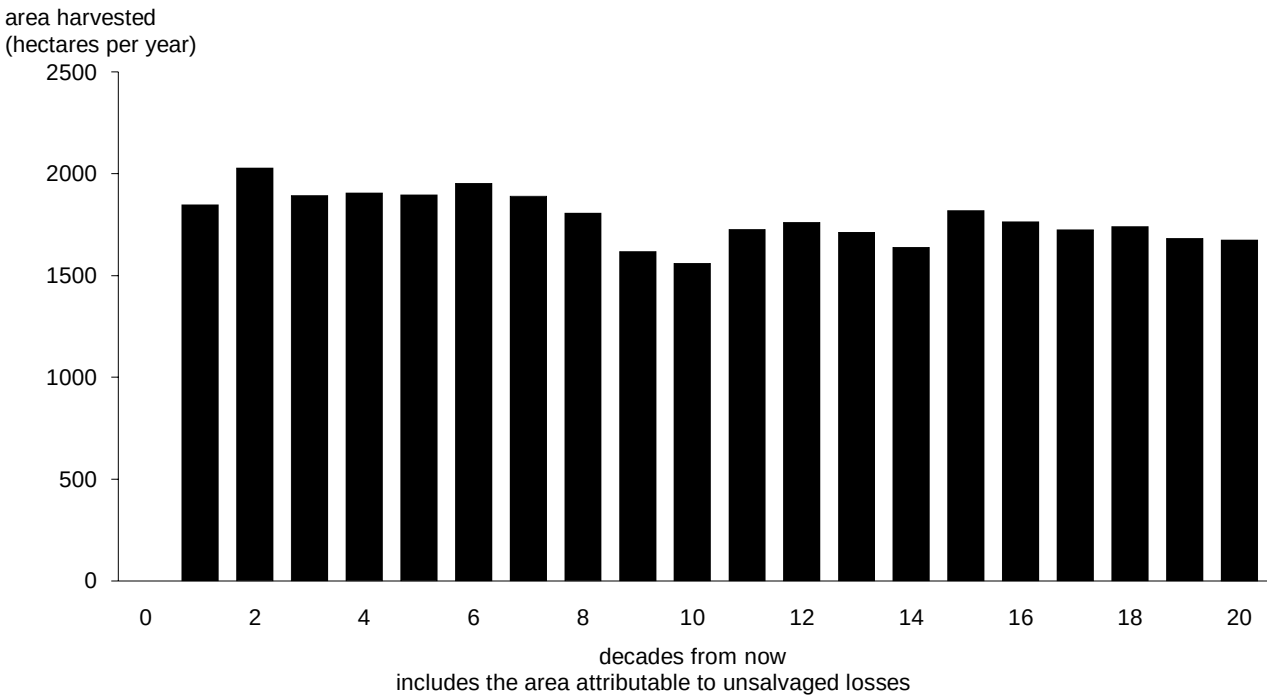


Figure 10. Area harvested over time for the timber harvesting land base, Arrow TSA base case.

4 Results

The average harvest age (Figure 11) initially declines rapidly from an average of 234 years in decade 1 to about 140 years in decade 4 and continues to trend downwards to 110 years by decade 11. There is a lower harvest age on average in decade 11 because a very large percentage of the available

timber is found in second-growth stands at or just above their age of maturity. In later decades, when a wider selection of older stands are available, the average harvest age increases to around 120 years, where it remains relatively stable.

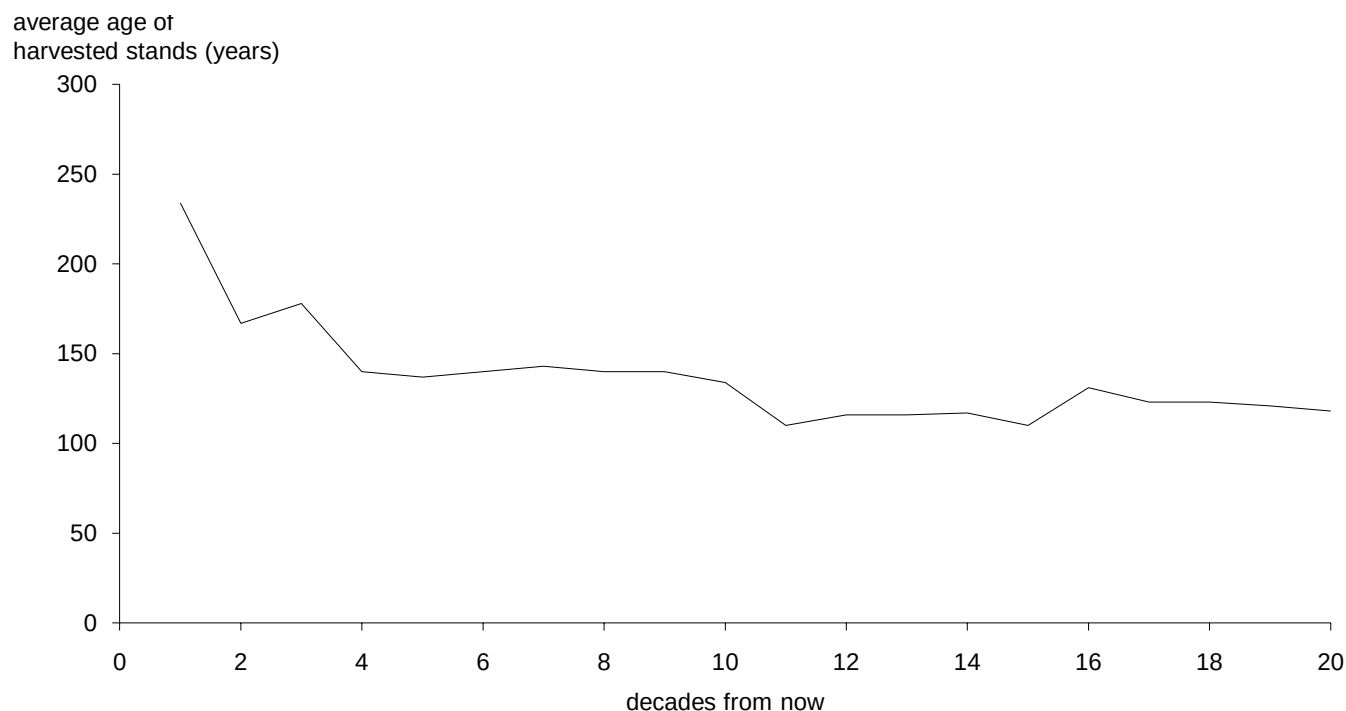


Figure 11. Average harvested age over time, Arrow TSA base case.

4 Results

Figure 12 shows annual harvest yields of around 340 cubic metres per hectare between decades 1 and 8. Afterwards, the average yield drops to approximately 260 cubic metres per hectare by

decade 11 as the transition from existing to second-growth forest occurs. After decade 11, annual harvest yields remain relatively stable.

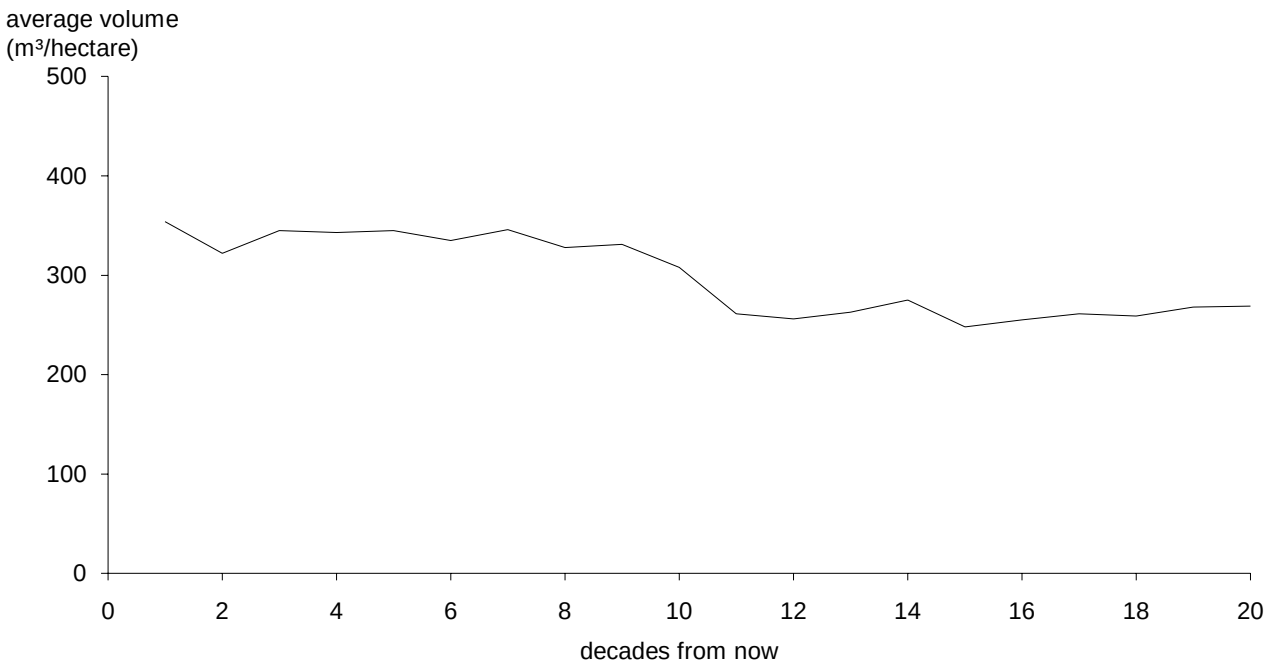


Figure 12. Average harvested volume per hectare over time, Arrow TSA base case.

4 Results

4.4 Harvest profile in decade 1 compared to the standing inventory profile

Figure 13 provides a comparison between the harvest profile in decade 1 and the standing inventory profile. The bar on the right shows the harvest profile for decade 1 when the maximum proportion of the harvest in hemlock, cedar, and balsam forest types is limited to the percentage of the standing inventory found in hemlock, cedar, and balsam forest types. The harvest profile limits, which were applied for the

first 20 years to control the amount of harvesting in older hemlock, cedar, and balsam stands, resulted in 24% of the harvest in decade 1 coming from these forest types. In comparison, these forest types represent 27% of the standing inventory profile, as shown by the bar on the right. Lodgepole pine forest types contribute significantly less to the decade 1 harvest profile, as compared to their representation in the standing inventory profile, because the other forest type stands are older than the lodgepole pine stands and are therefore scheduled for harvest first.

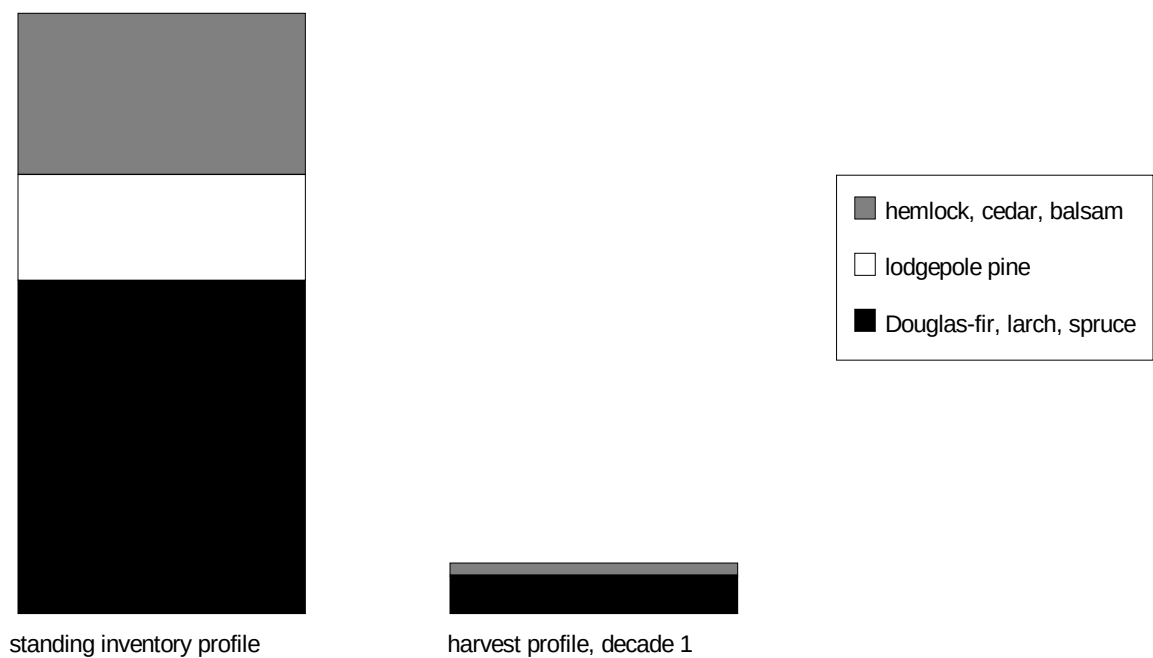


Figure 13. Harvest profile in decade 1 versus standing inventory profile, Arrow TSA base case.

5 Timber Supply Sensitivity Analyses

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

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

Another important way of dealing with uncertainty is to assess its potential effects on values of interest, for example, timber supply. Every decision either implicitly or explicitly incorporates an attitude towards uncertainty. If we believe that existing information accurately reflects reality, we are being neutral to uncertainty, believing essentially that any inaccuracies probably balance out. Ignoring uncertainty is implicitly neutral. If maximizing timber supply were the goal, someone with an optimistic position towards uncertainty would believe that current information probably underestimates timber supply, and that problems can be resolved through human ingenuity and changes to practices. A conservative position would be that current information probably overestimates timber supply, and that decisions should minimize the potential for future timber supply shortages, or negative effects on other values.

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

Sensitivity analysis is one way of evaluating how uncertainty could affect analysis results, and ultimately, decision-making. One purpose of

sensitivity analysis is to highlight which variables most affect results. For example, it is possible that small inaccuracies in estimating some variables could have negligible effects. Sensitivity analysis can therefore highlight priorities for collecting information for future analysis. It can also clarify whether current best estimates provide safe bases for decisions, or whether high uncertainty about important variables means more conservative decisions may be wiser.

In this section results of several sensitivity analyses are outlined. The results that are based on current forest management assumptions (shown in Figures 7 to 13) are referred to as the base case.

5.1 Alternative initial harvest rates and harvest flows over time

The base case harvest forecast for the Arrow TSA (Figure 7) shows an initial harvest level of 619 000 cubic metres per year, which is maintained for 7 decades before declining by 10% per decade to a steady long-term level. Many other harvest patterns are possible. For example, feasible alternatives include higher or lower initial harvest rates and higher or lower rates of decline.

Like most forecasts, the base case relies on current assumptions remaining constant for the entire forecast period. If current management assumptions change, shortages in growing stock may become a serious issue. Some of this risk could be offset by lowering the initial harvest rate sooner to create a higher reserve of forest inventory. On the other hand, higher initial harvest rates may create short-term economic opportunity, or be used as a measure to combat the spread of insect pests, without necessarily jeopardizing the long-term timber supply outlook. This section examines the impact of higher and lower initial harvest rates on the available growing stock forecast.

Figure 14 illustrates the harvest flow pattern for initial harvest rates 15% higher and lower than the base case and equal to the long-term rate. An initial rate 15% higher can be maintained for 4 decades before it declines at a rate of 10% per decade toward the long-term level of 422 000 cubic metres per year in order to avoid a future shortage. A rate 15% lower can be maintained for 16 decades before it has begun declining to the long-term level.

5 Timber Supply Sensitivity Analyses

Figure 15 illustrates that when the initial harvest rate is set at 619 000 cubic metres per year or higher the inventory of available growing stock declines significantly between decades 1 and 10, then gradually increases between decades 11 and 17 to a steady level approximately one-third of the starting level. When the initial harvest rate is 15% lower than

the base case a more gradual decline in the inventory is seen and the low point between decades 10 and 11 is avoided. When the initial harvest level is set at the long-term level, the inventory level, after declining initially, stays relatively stable throughout the 200-year forecast.

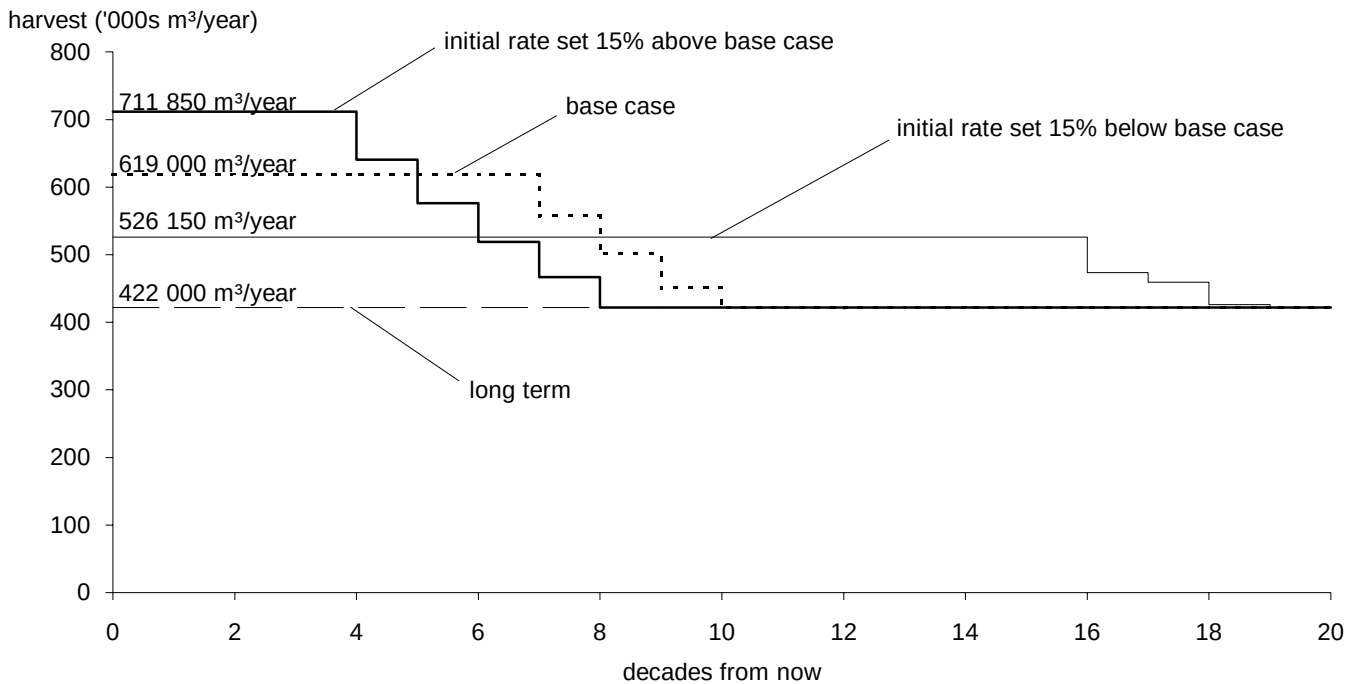


Figure 14. Alternative harvest flow patterns using base case data, Arrow TSA.

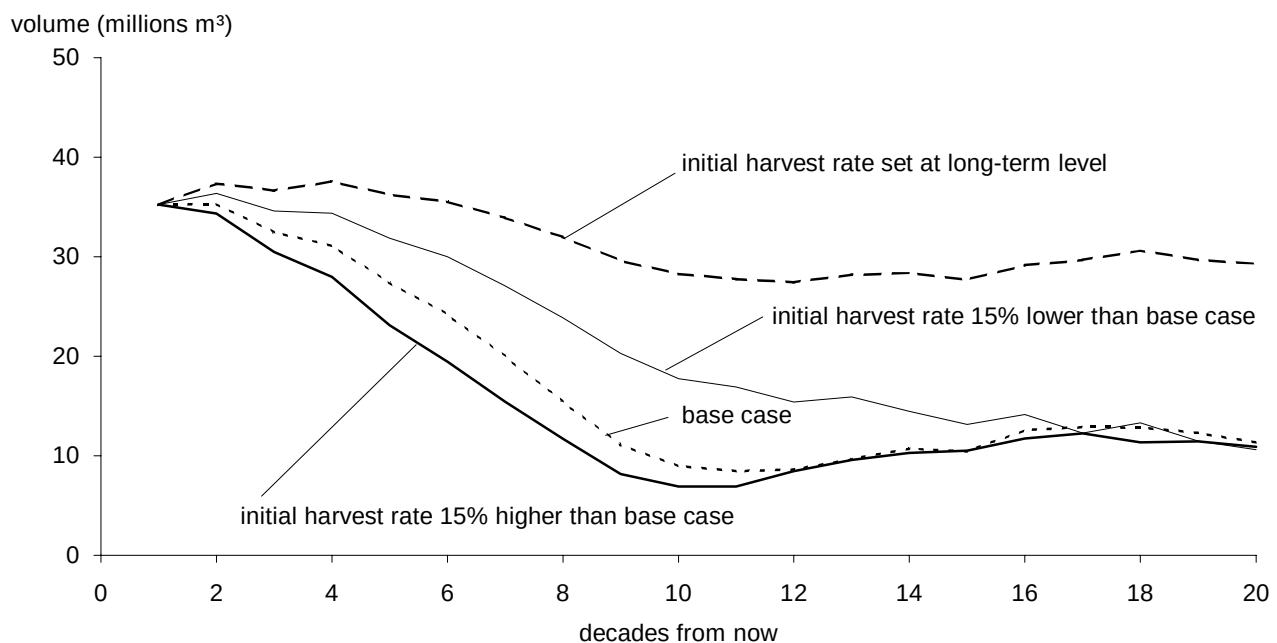


Figure 15. Available growing stock over time under alternative harvest flows, Arrow TSA.

5 Timber Supply Sensitivity Analyses

The alternative harvest flows indicate that the amount of available growing stock would change significantly if an initial harvest rate differing from the base case were chosen. In the Arrow TSA, a lower initial harvest rate might be justified if more available growing stock were needed to provide the operational flexibility required to achieve forest management objectives. In practice, harvest scheduling may need flexibility in order to address fire, insect, or disease concerns, landscape aesthetics, or land use issues in areas where timber harvesting has been avoided. On the other hand, choosing to keep forest management options open by maintaining a large reserve of available growing stock through slower harvesting rates could result in a loss of economic benefits and a forest more prone to losses from fire, insects or disease. Any advantage gained by keeping a significant reserve of available timber would be lost if the forest could not be adequately protected from these losses.

5.2 Uncertainty in minimum harvestable ages

Minimum harvestable ages estimate the amount of time that is required for a stand to reach a merchantable condition. Minimum harvestable ages can affect timber supply because they define when second growth stands will be available for harvest, and therefore determine how quickly existing stands may be harvested. The time at which stands will become merchantable is highly uncertain, partly

because of uncertainty about the growth of regenerated stands, but more importantly because we cannot foresee future conditions that will determine merchantability. Typically, stands have been harvested at older ages and higher volumes than the minimum ages and volumes assumed in the base case. In the future, however, minimum harvestable ages may be older or younger than those estimated by the Arrow Forest District staff due to changes in technology, silvicultural practices and wood products markets.

The purpose of this sensitivity analysis is to estimate the effects on timber supply of minimum harvestable ages that are 20 years older or younger than assumed for the base case. In addition, this analysis examines the impact on the timber supply of setting minimum harvestable ages at culmination ages, which would result in a maximum average harvest over the long term.

Figure 16 shows the effect on the harvest forecast of changing all minimum harvestable ages by 20 years. If minimum harvestable ages are 20 years less than assumed for the base case, then the current harvest rate of 619 000 cubic metres per year can be maintained for 8 decades, as compared to 7 decades for the base case. If minimum harvestable ages are 20 years greater than assumed for the base case, or are equal to the culmination ages, the current harvest rate drops to the long-term rate a decade or two sooner.

5 Timber Supply Sensitivity Analyses

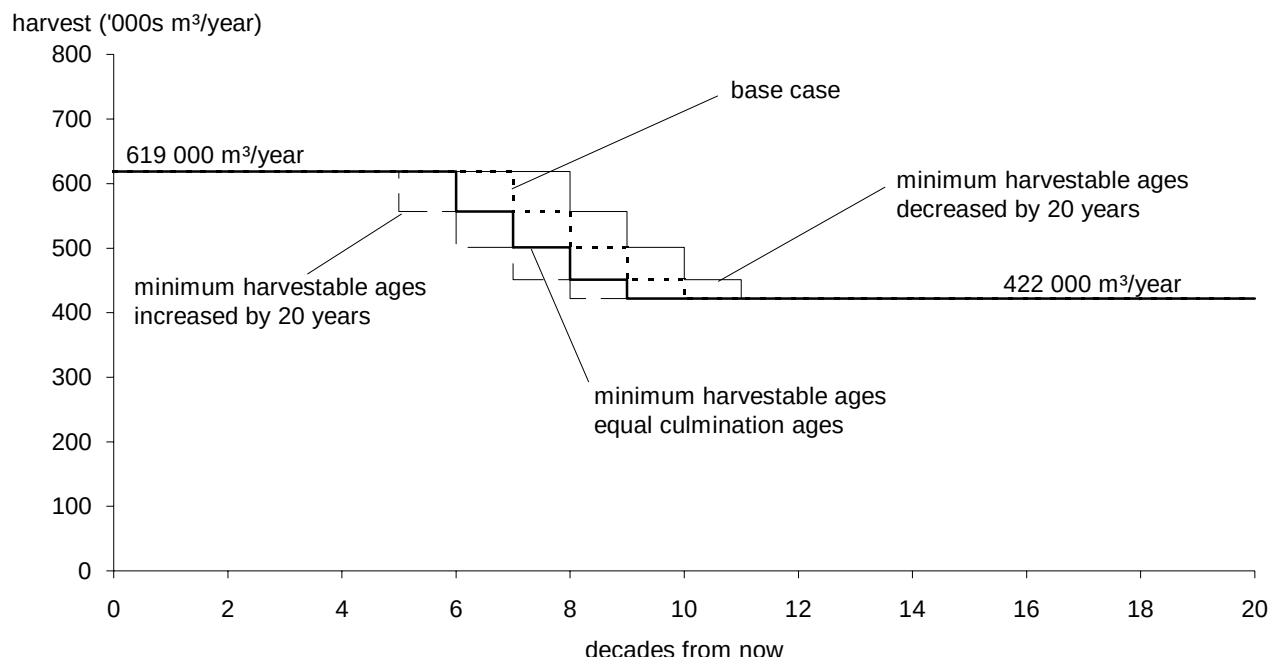


Figure 16. Harvest forecast with alternate minimum harvestable ages applied, Arrow TSA.

Increasing the minimum harvestable ages by 20 years reduces the initial available growing stock by 25%. To compensate for less available growing stock, the initial harvest level has to be reduced sooner. However, due to various other factors that affect harvest scheduling, the minimum harvestable ages are not limiting to timber supply. The actual harvest ages are the same in the long term as the harvest ages in the base case, so there is no long-term effect on the harvest level.

Decreasing the minimum harvestable ages increases the amount of growing stock available for harvest; however, only a minor change is seen in the harvest forecast because factors such as forest cover requirements keep actual harvest ages well above the minimum harvestable ages.

These results show that the harvest forecast has low to moderate sensitivity to increases or decreases in minimum harvestable age. Changes in the minimum harvestable ages have no impact on the long-term harvest level.

5.3 Uncertainty in existing stand volume estimates

Volume estimates from the Variable Density Yield Prediction (VDYP) system were used in the base case for existing stands. The purpose of this sensitivity analysis is to estimate the effects on timber supply of existing stands yields that are greater or less than those assumed for the base case. The impacts of uncertainty in regenerated yields are examined in Section 5.4, "Sensitivity to uncertainty in regenerated stand volume estimates".

Figure 17 shows that if current yields are 10% higher than was assumed for the base case, the initial harvest can be raised by 10% to 680 900 cubic metres per year. Alternatively, the current harvest level of 619 000 cubic metres per year can be extended for more decades before declining to the long-term harvest level (not shown). If, however, current yields are 10% lower than was assumed for the base case, the initial harvest level of 619 000 cubic metres per year must be reduced 3 decades earlier than in the base case.

The results indicate that initial harvest levels are moderately sensitive to increases in existing volumes. Decreases in existing volumes do not affect harvest levels initially, but do have a moderate effect between decades 4 and 11. Long-term harvest levels are unaffected by changes in existing stand yields.

5 Timber Supply Sensitivity Analyses

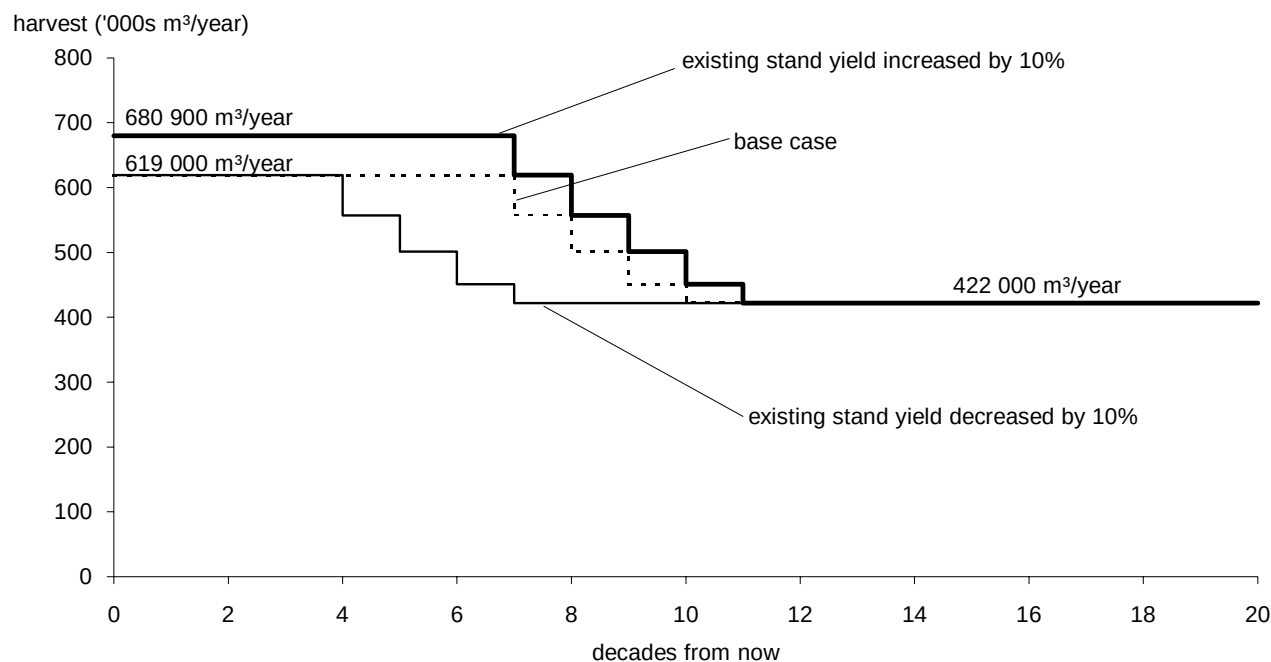


Figure 17. Harvest forecasts with existing stand timber yields changed by 10% , Arrow TSA.

5.4 Uncertainty in regenerated stand volume estimates

The VDYP system was also used to estimate volume yields for regenerated stands. Regenerated yields were assumed to be the same, on average, as yields for existing stands. However, yields for regenerated stands might be significantly different from the stands they replace. The purpose of this sensitivity analysis is to examine how regenerated yields different from those assumed for the base case affect the harvest forecast.

Figure 18 shows the harvest forecast if regenerated volumes are increased or decreased 25%. There is no difference in the harvest forecast from the base case for the first 7 decades. If regenerated yields are increased by 25%, the long-term harvest level is reached by decade 9 at a level 26% above the base case long-term level. If, however, regenerated yields are decreased by 25%, the long-term harvest level decreases by about 27% to 310 000 cubic metres per year.

In summary, significant changes in regenerated yields have no impact on initial harvest rates, but do have a significant impact on long-term harvest levels.

5 Timber Supply Sensitivity Analyses

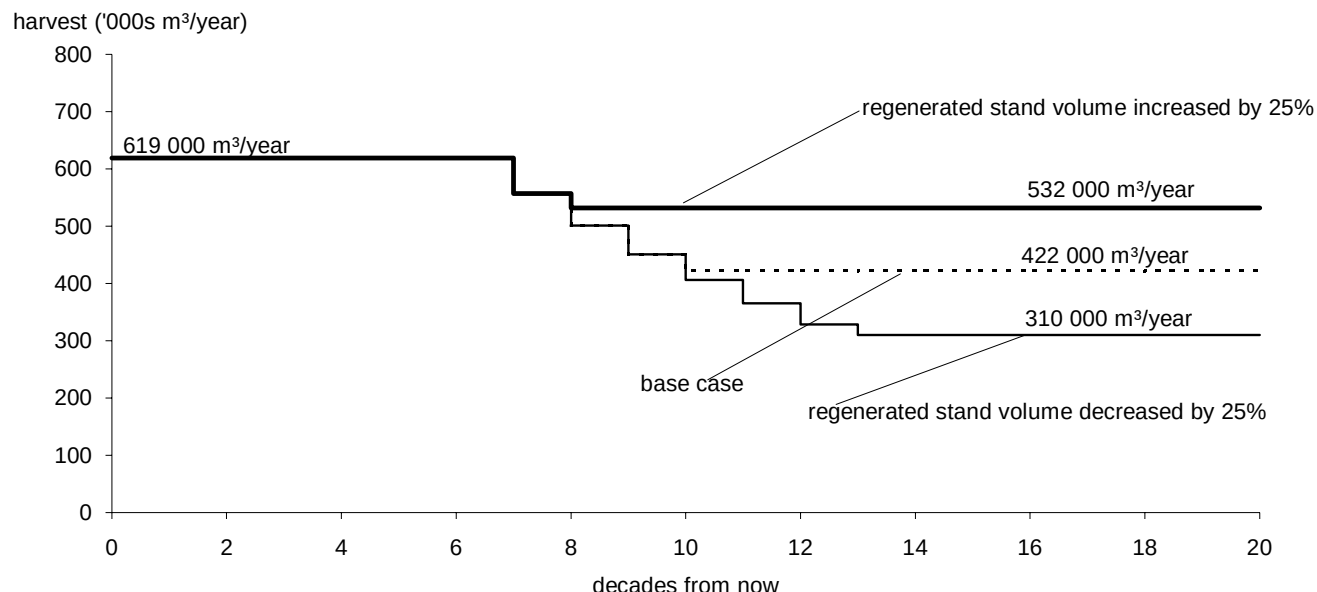


Figure 18. Harvest forecasts with regenerated stand volume estimates changed by 25%, Arrow TSA.

5.5 Uncertainty in forest cover requirements

Green-up forest cover requirements ensure that no more than a maximum percentage of the forest is in specific size classes or ages of forest cover at all times. Old-growth forest cover requirements may also be used to ensure a portion of the forest is held at ages older than some specified minimum age. They are applied by indicating, for example, that no more than 25% of an area may be in forest less than 17 years old, or that at least 5% of an area must be in forest more than 140 years old.

This sensitivity analysis examines the effects on the harvest forecast of varying the forest cover percentages determined for each management zone. The percentages represent the portion of the forest required to be beyond the green-up age: 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. (An analysis of uncertainty in green-up

periods follows in Section 5.6, "Uncertainty in green-up periods.")

From the base case, forest cover percentages were tightened and relaxed by 5 and 10 percentage points across all 5 management zones. Using the class 1 & 2 watersheds management zone as an example, in the base case, 70% of the area must be covered by forest older than 32 years old to ensure water quality and quantity are protected. For this analysis, in place of 70%, forest cover requirements of 60, 65, 75, and 80% were tried. Percentages were varied the same way for the 4 other management zones.

Figure 19 shows how the harvest forecast changes when the forest cover requirements are changed from those assumed in the base case. If the cover requirement is tightened (increased) by 10 percentage points the short-term harvest rate declines 5 decades sooner and the long-term level falls from 422 000 cubic metres per year to 402 000. If the cover requirement is tightened by 5% the initial harvest rate declines 1 decade sooner and there is a slight decrease in the long-term harvest level, which is not discernible in Figure 19.

5 Timber Supply Sensitivity Analyses

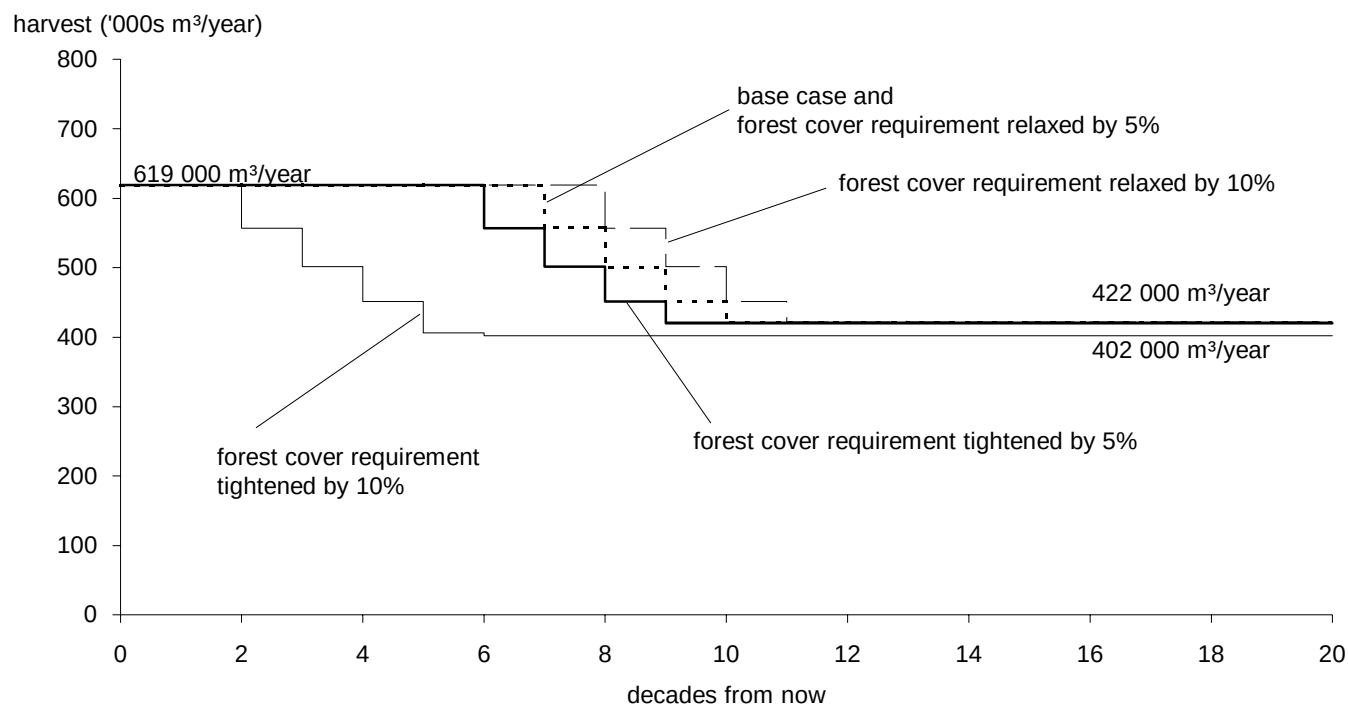


Figure 19. Harvest forecast with forest cover requirements changed by 5% and 10%, Arrow TSA.

If the forest cover requirement is relaxed (decreased) by 10 percentage points, the initial harvest rate declines one decade later than the base case harvest forecast. Relaxing the cover requirement by 5 percentage points has no impact on the harvest forecast.

Generally, the harvest forecast has low to moderate sensitivity to the forest cover guidelines specified for the management zones but tightening forest cover requirements by 10% or more significantly affects the harvest forecast.

5.6 Uncertainty in green-up periods

Forest cover requirements for visual quality and adjacency applied in this analysis involve estimates of when regenerated stands will reach green-up conditions, normally expressed as the desired height of a stand. Determination of the appropriate height can be subjective because desired tree height may have to meet several management objectives stated for the same area. For example, forest cover may

need to meet the objectives of maintaining water quality, wildlife habitat and visual quality.

Added to the problem of deciding how tall the trees need to be is the problem of determining the exact length of time it takes a crop of trees to reach a specified height (this length of time is referred to as the green-up period). Normally some allowances need to be made to account for site and species variations. Consequently, some uncertainty about the green-up period exists.

The impact on the harvest forecast of increasing or decreasing all green-up periods by 5 years from those assumed in the base case was examined in this sensitivity analysis. As illustrated in Figure 20, if the green-up period is lengthened by 5 years, the initial harvest rate drops after the second decade rather than the seventh. The long-term level also drops from 422 000 cubic metres per year to 398 000, 5.7% lower than the base case. Shortening all green-up periods by 5 years had little impact on the harvest forecast.

In conclusion, the harvest forecast is highly sensitive to longer green-up periods, but not to shorter green-up periods.

5 Timber Supply Sensitivity Analyses

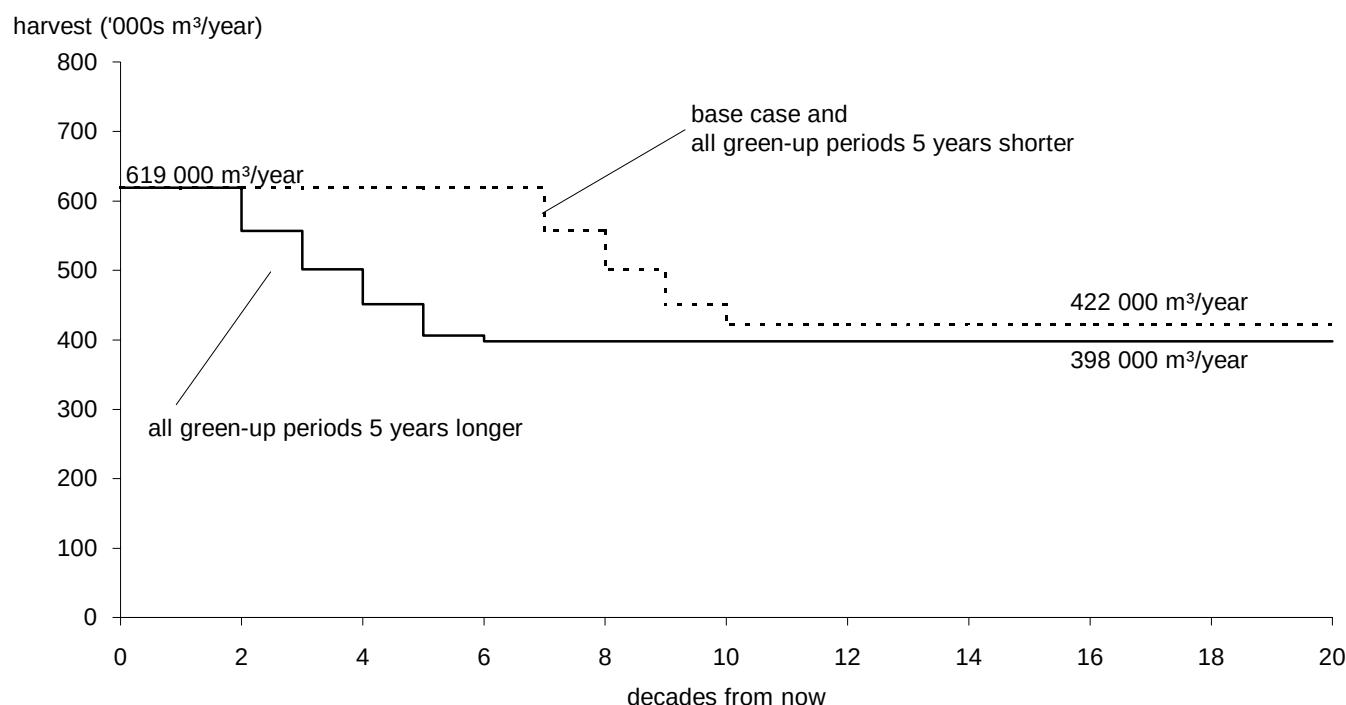


Figure 20. Harvest forecast with all green-up periods changed by 5 years, Arrow TSA.

5.7 Uncertainty in cutblock adjacency guidelines

To ensure that harvesting does not become overly concentrated in an area, guidelines establish a maximum limit on the overall area that has not reached the green-up condition. The intent of the forest cover requirements assumed in the base case is to approximate a 4-pass harvest system in all management zones. This means that no more than 25% of an area may be covered by forest less than 3 metres tall (3 metres is the green-up height used in cutblock adjacency guidelines). However, some uncertainty exists when considering the possible operational factors. Arrow Forest District staff believe that a 4-pass system may be difficult to achieve in many areas. An intended four-pass system could actually become a five- or six-pass system after

adjustments are made to address the on-ground realities.

This sensitivity analysis examines the impact of 5- and 6-pass adjacency requirements on the harvest forecast. Figure 21 illustrates that if a 5-pass harvesting system is assumed, the initial harvest rate drops after decade 1 and continues to decrease until the long-term level of 390 000 cubic metres per year (7.6% lower than the base case long-term level) is reached. If a 6-pass harvesting system is assumed, the initial harvest rate drops immediately by 19% to 501 400 cubic metres per year. After decade 2, the 6-pass harvest rate drops 10% per decade for 3 decades to a long-term level of 353 000 cubic metres per year, which is 16.4% lower than the base case long-term level.

In conclusion, the harvest forecast is affected significantly when either 5- or 6-pass cutblock adjacency requirements are assumed.

5 Timber Supply Sensitivity Analyses

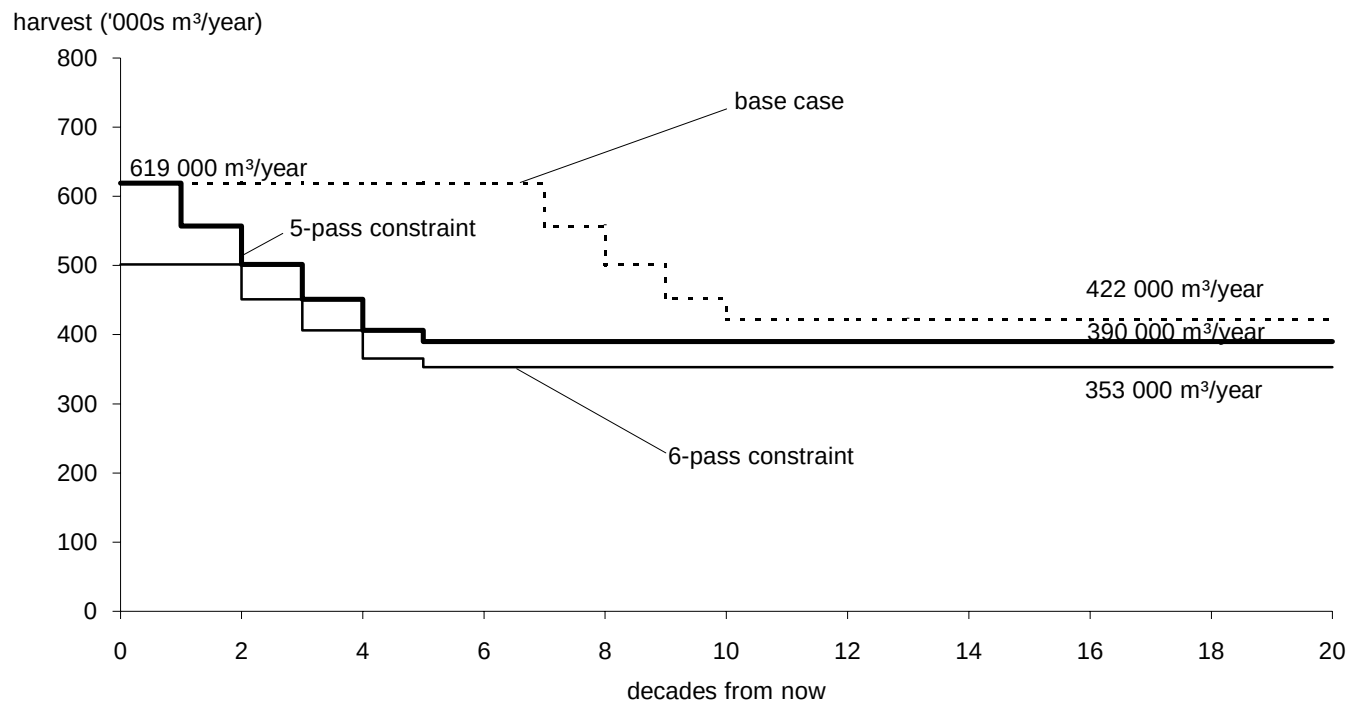


Figure 21. Harvest forecast with cutblock adjacency requirements changed, Arrow TSA.

5 Timber Supply Sensitivity Analyses

5.8 Impact of an old-growth requirement

Currently, management practices implemented to protect resources other than old-growth and biodiversity* provide protection for these values as an additional benefit. Increased concerns for biodiversity, however, frequently result in a desire to maintain a certain proportion of the land base in older age classes. For example, it may be decided that a minimum of 10-12% of all forested area should be over 140 years old. Often, forest land outside the timber harvesting land base is also considered to contribute to this total. As a result, there may only need to be 5-7% of the timber harvesting land base held in older stands. Arrow Forest District staff do

not presently require old growth to be directly considered as part of development plans for the Arrow TSA.

In recent months the Arrow Forest District staff have started considering riparian* corridors and forest ecosystem networks in development planning. Neither of these are modelled directly in this analysis but their impact is likely to be similar to the old-growth requirement. The purpose of this section is to investigate the uncertainty surrounding this issue by examining the impact of incorporating an old-growth objective into the analysis.

Figure 22 shows the impact of 5 and 10% old-growth requirements. In this analysis, forest over 140 years is considered to be old-growth.

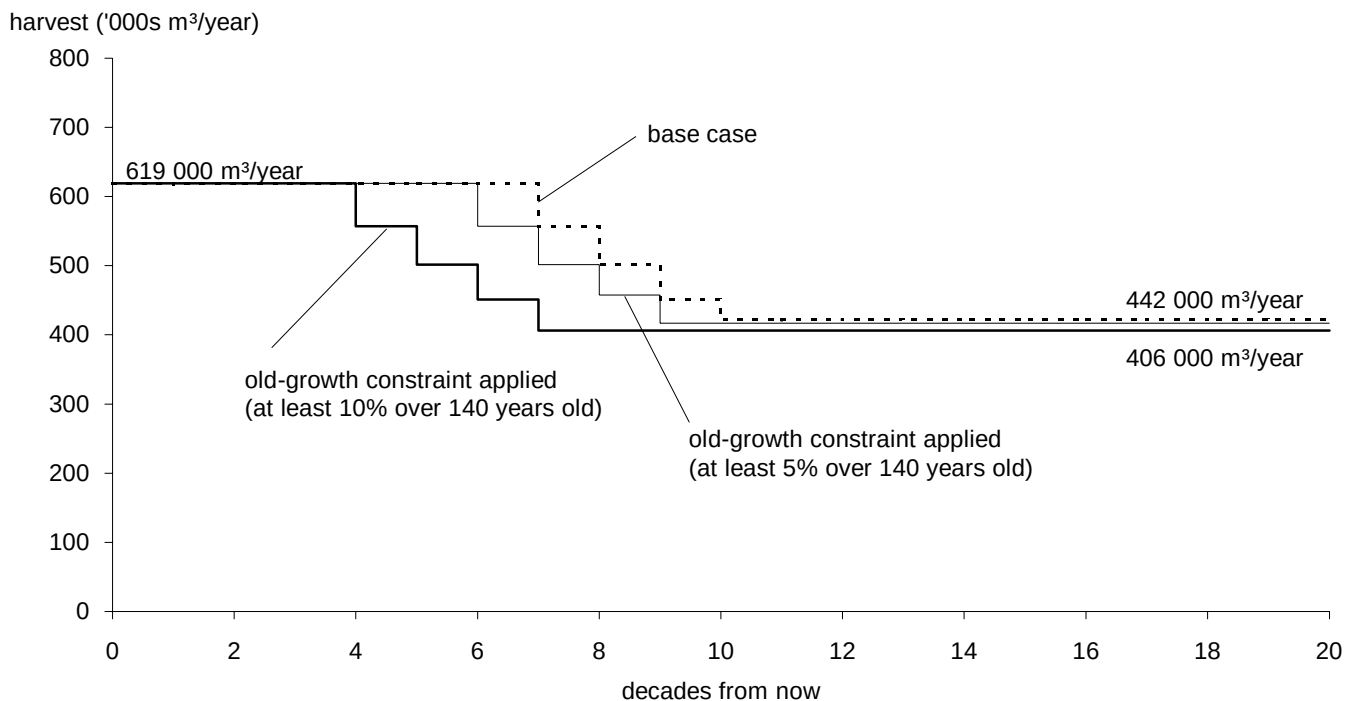


Figure 22. Harvest forecast if forest cover objectives for old-growth are different from the base case, Arrow TSA.

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.

Riparian area

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

5 Timber Supply Sensitivity Analyses

Maintaining at least 5% of the forest in each management zone in old growth results in the harvest rate dropping 1 decade sooner, as compared to the base case forecast. A 10% old-growth requirement results in the harvest rate dropping 3 decades sooner and a lower long-term harvest level. The long-term harvest level of the 10% old-growth harvest forecast is 4% lower than the base case level.

The addition of an old-growth objective has little impact on short-term timber supply and only a moderate impact on the long-term level.

5.9 Uncertainty in the land base available for timber harvesting

The timber harvesting land base is subject to significant uncertainty because of changes in operability, changes in areas classified as problem forest types and environmentally sensitive areas (ESAs), and the amount of reductions for roads, landings and skid trails. In addition, the size of the timber harvesting land base can change because of shifts in public values and attitudes about resource use.

This sensitivity analysis examines the impact on the harvest forecast of significant increases and decreases in the size of the timber harvesting land base. Figure 23 shows the impact on the base case harvest forecast when the timber harvesting land base is increased and decreased by 20% across all forest types.

Increasing the land base permits a higher initial harvest rate while still allowing a gradual decline to the long-term harvest level and avoiding significant drops below the long-term level. Long-term harvest levels increase as expected but not to the point where they meet the current harvest requirement of 619 000 cubic metres per year. This level is not achieved even when assuming a 30% increase in the land base (not shown in Figure 23). If a smaller land base is assumed, the initial harvest rate must be lowered slightly. A 20% decrease in the land base results in only a 5% decrease in the initial harvest rate; however, the long-term harvest level is significantly impacted by a reduced land base. A 20% decrease in the timber harvesting land base would result in a long-term harvest level of 326 000 cubic metres per year, a level 47% lower than the current harvest level of 619 000.

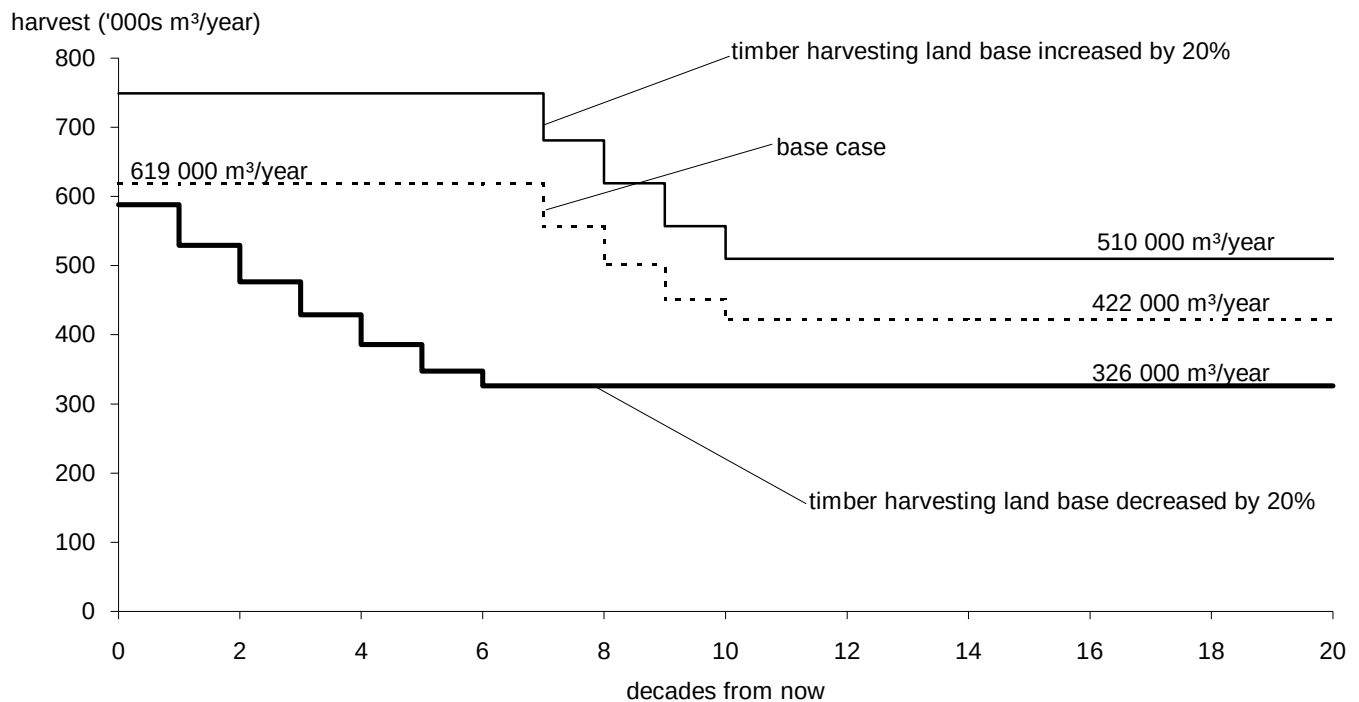


Figure 23. Harvest forecast, timber harvesting land base increased and decreased by 20%, Arrow TSA.

5 Timber Supply Sensitivity Analyses

5.10 Uncertainty in Management Practices in Zones 1 to 3

Management zones 1 - 3 (Retention VQO, Partial Retention VQO, Class 1 & 2 watersheds) make up about 33% of the timber harvesting land base. While some harvesting has occurred in these areas they have not been harvested in proportion to their representation in the mature operable land base. This is apparent throughout these zones but is most noticeable in the places where retention and partial retention VQOs overlap with class 1 and 2 watersheds. The forest cover requirements that are used for these zones are primarily based on guidelines (and some experience) but they pertain to individual watersheds or landscape units that have actually been accessed. These forest cover constraints do not account for the fact that many of these units are simply avoided due to local resistance to harvesting. For example, local public resistance to harvesting in these areas has resulted in well known harvest moratoriums like Hasty Creek and numerous other instances of extended planning periods with no harvesting. In some areas where timber harvesting is now occurring, significant planning delays were experienced prior to gaining access to timber, and district staff have no reason to believe that these areas will be more accessible in the future. The present trend appears to be toward increasing opposition to harvesting, and opposition to harvesting proposals in watersheds is found throughout the Arrow TSA.

This analysis attempts to model this situation and is divided into two parts. Part 1 examines, by increasing the forest cover constraints, the effect of continuing the existing harvest pattern of concentrating the harvest in the timber emphasis zone and minimizing the amount of harvest in zones 1-3. To provide balance, part one also looks at decreasing the forest cover constraints in zones 1-3 to allow more harvesting in these areas. Part 2 examines the impact of avoiding particular watersheds or landscape units for an extended period of time. This is modelled by introducing harvest deferrals in management zones 1-3.

For the first part of the analysis, increases and decreases of 5%, 10%, and 15% were made to the forest cover constraints applied to zones 1-3. The result of these changes on the base case harvest forecast is shown in Figure 24. Increasing or

decreasing forest cover requirements by 5% has a negligible effect on the harvest forecast and is therefore not shown in Figure 24. Changing forest cover by 10% and 15% is shown to have a significant effect on the forecast. Increasing forest cover requirements by 15%, for example, result in a 5% lower initial harvest rate (588 000 cubic metres per year) and a new long-term level of 366 000 cubic metres per year. It also results in a much earlier decline to the long-term level; the decline starts after decade 1 rather than decade 7. Decreasing forest cover requirements by 10 - 15% allows the initial harvest level to be maintained for eight decades instead of seven before the decline to the long-term level is required. Decreasing the requirements has much less of an impact on the harvest forecast than increasing the requirements because around decade 9 the transition to the second-growth forest is being made. Not enough older stock exists to continue to support harvesting 32% above the long-term rate. As a result, even though forest cover requirements are more relaxed, the harvest rate must decline to the long-term harvest level at this time.

The second part of the analysis examines the impact on the harvest forecast if the trend of avoiding harvests in zones 1-3 persists. Harvest deferrals of 10, 20 and 40 years are introduced in management zones 1-3. The impact of these deferrals on the base case harvest forecast is shown in Figure 25.

The 10-year deferral has no impact on the base case harvest forecast. However, in order to maintain harvest levels, zones 1 - 3 must be harvested heavily in the second decade. Arrow Forest District staff believe that this would be extremely difficult to achieve on the ground. When 20- and 40-year deferrals are assumed the initial harvest level must drop immediately to 500 000 cubic metres per year. This level must be maintained for the length of the deferral. Harvesting can be increased to 619 000 cubic metres per year once the deferral has ended and maintained at this level until decade 9. After decade 9, a decline to a new long-term harvest level is required. In both cases, the initial drop to 500 000 cubic metres is necessary because of a shortage of available timber in decade 2. The forest cover requirements are particularly limiting at that time because of the amount of not satisfactorily restocked area below the age of green-up.

5 Timber Supply Sensitivity Analyses

The decline that occurs between decades 9 and 12 in both the 20- and 40-year deferral most likely occurs because of the transition to harvesting second-growth stands, rather than the length of the deferral in zones 1-3. The change in the harvest flow pattern can

account for the small difference between the base case long-term harvest level and the new long-term level. In conclusion, uncertainty in management practices in zones 1-3 related to cover requirements or the timing of access can have a significant impact on the harvest forecast in the short-term.

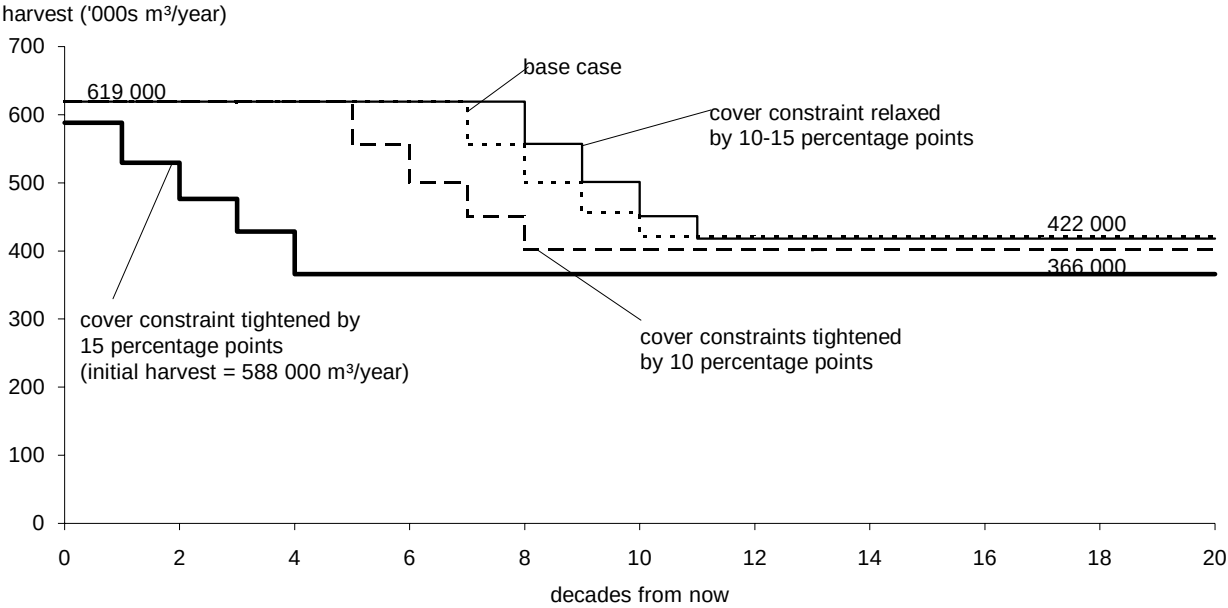


Figure 24. Uncertainty in management practices in zones 1-3 — forest cover requirements, Arrow TSA.

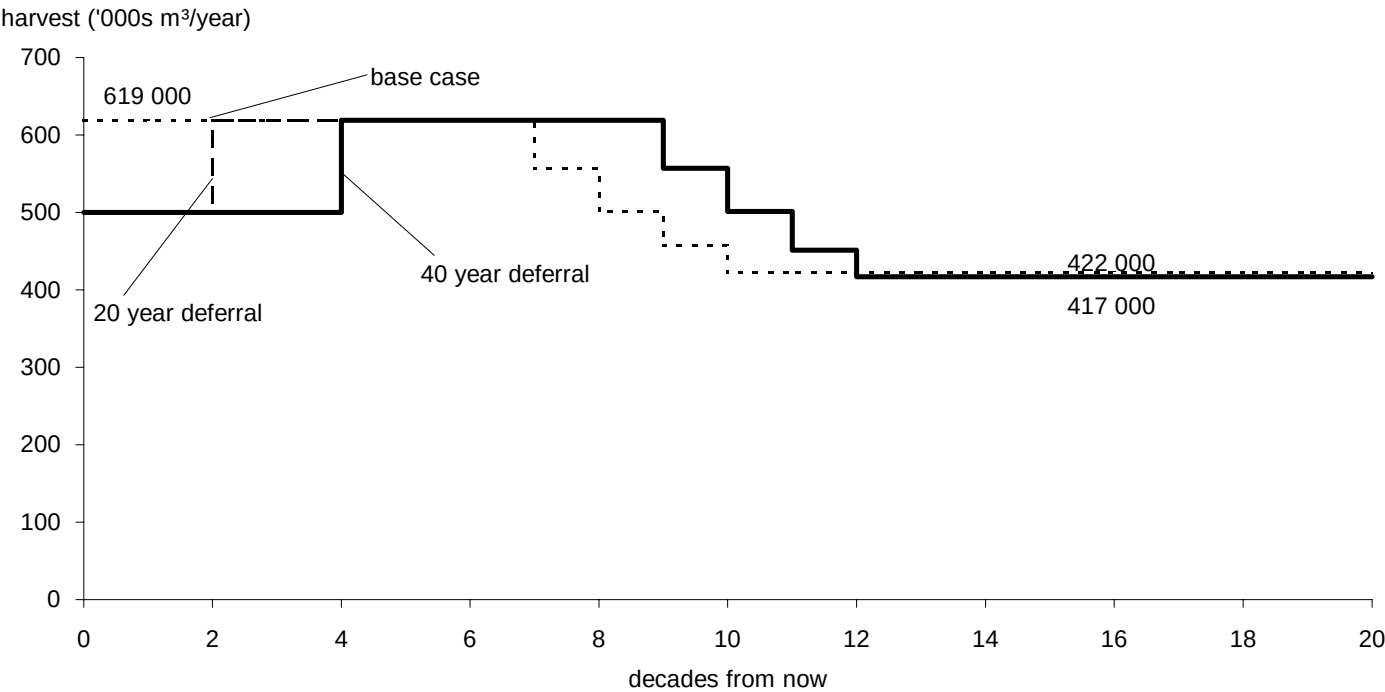


Figure 25. Uncertainty in management practices in zones 1-3 — harvest deferrals, Arrow TSA.

6 Summary and Conclusions

The analysis for the Arrow TSA indicates that given current management assumptions, the current harvest level of 619 000 cubic metres per year can be maintained for 7 decades without causing future shortages in timber supply. Harvests then begin to decline by 10% per decade until the long-term harvest level of 422 000 cubic metres per year is reached 10 decades from now. The long-term level is 32% below the current AAC.

This analysis employs the best current estimates for all variables used to describe forest management in the Arrow TSA. However, varying degrees of uncertainty surround most of the estimates. A series of sensitivity analyses show that these uncertainties can affect timber supply to varying degrees.

Timber supply in the Arrow TSA is highly sensitive to changes forest cover requirements and green-up periods. In both cases, more relaxed guidelines would have little effect on the harvest forecast. However, increased forest cover requirement or green-up periods would cause harvest levels to decline to the long-term harvest level much earlier than in the base case, and the long-term harvest level would be decreased.

Similarly, the timber supply is highly sensitive to changes in cutblock adjacency rules. If either a 5- or 6- pass harvesting system were required to meet adjacency objectives, the decline to the long-term harvest level would have to occur much sooner (after decade 2) and the long-term harvest level would also be reduced somewhat.

If the size of the timber harvesting land base were larger or smaller than assumed in the base case, the

effect on the harvest forecast would be significant. In both cases, there would be a large effect on the short- and long-term harvest levels.

Management practices in zones 1 - 3 are associated with a great deal of uncertainty because the forest cover requirements for these zones may not reflect how these zones are actually being managed. Sensitivity analyses indicate that the harvest forecast is very sensitive to increased forest cover requirements in these zones in both the long and the short term. Harvest deferrals would result in a large decrease in timber supply for the length of the deferral; however, long-term harvest levels would be only slightly affected.

Timber supply in the intermediate term is moderately sensitive to changes in minimum harvestable ages, existing stand volume estimates, and old-growth requirements. Long-term effects on the harvest forecast are slight to negligible.

Uncertainty about regenerated stand volume estimates has no impact in the short term; however, both increases and decreases in these volume estimates have a significant impact on long-term harvest levels.

Meeting the management guidelines and constraints used in the Arrow TSA requires a high degree of flexibility in locating and scheduling harvests. Given the high sensitivity of the harvest forecast to the immediate availability of the entire timber harvesting land base, attempts to maintain the harvest level at the base case starting level may reduce this flexibility and present a risk to the projected harvest levels.

7 References

- B.C. Ministry of Environment, Fish and Wildlife Branch, Kootenay Region. 1989. Logging guidelines for wildlife habitat classes. Nelson, B.C.
- B.C. Ministry of Forests, Inventory Branch. 1981. Arrow Timber Supply Area Yield Analysis Report. Victoria, B.C.
- B.C. Ministry of Forests, Inventory Branch. 1992. Variable Density Yield Prediction User Guide. Victoria, B.C.
- B.C. Ministry of Forests, Nelson Forest Region. 1989. Forest development guidelines to meet Visual Quality Objectives for the Nelson Forest Region. Nelson, B.C.
- B.C. Ministry of Forests, Nelson Forest Region and Ministry of Environment, Water Management Branch, Kootenay Region. 1991. Proposed watershed harvesting guidelines. Nelson, B.C.
- B.C. Ministry of Forests, Timber Harvesting Branch. 1989. Interim harvesting guidelines for the Interior of B.C. Victoria, B.C.

8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for timber supply areas (TSAs) and tree farm licences (TFLs) in accordance with <i>Section 7</i> of the <i>Forest Act</i> .
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.
Cutblock adjacency	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 areas	Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to 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, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of additional forest values such as recreation and visual quality.
Growing stock	The volume estimate for all standing timber, of all ages, at a particular time.
Green-up period	The time needed after harvesting for a stand of trees to reach a desired condition (e.g., height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.
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.
Long-term harvest level	A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base and includes objectives and guidelines for non-timber values) and estimates of timber growth and yield.
Management assumptions	Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvest ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.
Mean annual increment (MAI)	Stand volume divided by stand age. The age at which average stand growth, or MAI, assumes its maximum is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.

8 Glossary

Non-merchantable forest types	Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.
Not satisfactorily restocked (NSR)	An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay (the period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees) has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.
Operability	A classification of the availability of an area for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Partial retention VQO	Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see Visual quality objective)
Retention VQO	Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity.
Riparian area	Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Site index	A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.
Timber harvesting land base	The portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The harvesting land base is defined by deducting non-contributing areas from the total land base according to specified management assumptions.
Timber Supply Area (TSA)	An integrated resource management unit established in accordance with <i>Section 6</i> of the <i>Forest Act</i> .
Visual Quality Objective (VQO)	Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.

APPENDIX A

Description of Data Inputs and Assumptions

Introduction

The following tables and commentary outline the methods and inputs used to derive the timber harvesting land base, and other inputs for the timber supply model used in the timber supply review of the Arrow 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 short- and long-term timber supply picture in each TSA in the province. 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 Management Zone and Analysis Unit Definitions

A.1.1 Definition of management zones

The timber harvesting land base is divided into management zones on the basis of differences in forest cover requirements. These cover requirements simply reflect different forest management emphases within the TSA. The following 5 management zones are defined for this analysis:

- retention VQO;
- partial retention VQO;
- class 1 and 2 watersheds (small, sensitive domestic use watersheds);
- timber emphasis composed of class 3 to 6 watersheds and summer wildlife range;
- wildlife winter range.

In the case of overlaps, which are considerable between wildlife, class 1 and 2 watersheds, and the VQOs, the priority for assigning the zones is as follows: wildlife winter range, retention VQO, class 1 and 2 watersheds, and timber emphasis.

The priorities are assigned according to how the constraints for the various zones interact with each other and how they can be specified in Table A-10. In most cases, this results in the most restrictive resource being used as the basis for the zone.

Constraints are "overlapped" where wildlife winter range coincides with partial retention and a class 1 and 2 watershed. The winter range is used to define a limit on the minimum amount of area in height class 3 or more, and the more restrictive of the VQO and the watershed guidelines are used to specify a maximum amount of area in non-greened-up clearcut. Thus all values should be recognized without being more restrictive than necessary.

A.1 Management Zone and Analysis Unit Definitions

A.1.2 Procedure to define the management zones

1. Use the "Watershed Class-Planning Cell List" to assign all class 1 and 2 watersheds to zone 3.
2. Assign areas with VQOs of "Retention" and "Partial Retention" respectively to zones 1 and 2. This will "override" some of class 1 and 2 watersheds.
3. Assign the wildlife winter range areas to zone 5 as follows:

(a) White tail deer winter range.

ICH-a-1 component of planning cells I030, I040, I050, I061, I071, I080, I090, I100, I106, I110, I124, I130, G040, G060, G070, and G170. These cells are in the Slocan Valley or immediately adjacent to the valley along major tributaries such as Winlaw and Lemon Creeks. They consist primarily of southwest-southeast aspects and the ICH-a-1 criteria is used to select for the lower elevation areas.

ICH-a-1 component of planning cells E010, E020, E030, F060. These cells are along the Arrow Lake in the Inonoaklin Creek and Burton areas.

ICH-a-1 and ICH-d component of planning cells K010, K020. These are mostly south slopes in the Deer Park-Syringa area.

ICH-a-1 component of planning cell M141. This cell is mostly south aspect along the Kootenay River between Castlegar and South Slocan. It is mostly private land and has little operable area.

ICH-a-1 and ICH-d component of planning cells M280, M290, M310; ICH-a-1 and ICH-a-1 and ICH-d and ICH-a-2 component of planning cell M300. These are mostly south slopes in the Pend D'oreille area. The ICH-a-2 was included in cell M300 only since in that cell there was a considerable amount of it below 1 372 metres (4 500 feet) whereas in the other ones it was mostly above that elevation. The Ministry of Environment, Lands and Parks' Kootenay Region wildlife guidelines use this elevation as the upper limit for deer winter range in the Interior Western Hemlock Douglas-fir habitat type.

(b) Caribou winter range.

Southern Columbia Mountains (Stagleap). ESSF component of planning cells M010, M020, M040, M060, M070, M080, M090, M091, M200 and M220. The Ministry of Environment, Lands and Parks' wildlife guidelines state that caribou habitat is confined to the ESSF in the southern Columbia Mountains.

Central Columbia Mountains. These cells are in the Kuskanax, Wilson, and Bremner Creek drainages: ICH-a-2 component of planning cells D010, D020, D030, D060, D080, G080, G091, G100, G110, G120, G130 and G140.

4. Assign everything else to zone 4.

A.1 Management Zone and Analysis Unit Definitions

A.1.3 Analysis unit definition

Information on the forests in the Arrow TSA comes in a computer file provided by the B.C. Forest Service Inventory Branch. This file contains a list of land and forest cover attributes — such as tree species present, stand age, tree height, stocking (a measure of number of trees per hectare), environmental sensitivity, and timber growing quality — for a large number of distinct land units referred to as forest cover polygons. Many of these units are not considered available for timber harvesting for several reasons as discussed in Section 2, "Information Preparation" of the report, and further described later in this appendix. If information were analyzed separately for each of these forest cover polygons over the 200-year period used for timber supply analysis, not only would the computer model be extremely complex, but also the results would be difficult to check for errors, and to interpret. The main purpose of using computer models (i.e., simplified representations of the real world) is to increase our understanding of complex processes. There is always a trade-off between retaining information on a specific area, and simplifying the information base to allow better understanding. For each analysis, the decision on how to model forest management should be based on the characteristics of the area and the planned management regime. The way information is handled should correspond to the format and precision of the available information, and the type of decision to be made using analysis results. In the case of timber supply analyses, the information applies to a fairly large area, and the decision on overall allowable harvest level provides general, strategic guidance, not operational prescriptions. Therefore, information supplied in the forest inventory file is simplified considerably.

Forest inventory information could be simplified in any of several ways; for example, by combining information for land in a certain geographic area, for land having a particular resource emphasis, or for land with similar forest cover (i.e., tree species and site productivity). For this analysis, the information was simplified based on resource management emphasis and forest cover.

A.1.4 Analysis unit characteristics

An analysis unit, as defined for this analysis, represents a combination of stands dominated by specified tree species with a specified timber growing capability. For example, hemlock- and balsam-dominated stands with good timber productivity comprise an analysis unit. Each analysis unit is assigned its own timber volume projection (yield table). Site groups were assigned using new site class (NSITE) or where assigned, special site class (SSITE). Special site is a field corrected site class that can be assigned when the normal site class does not correctly reflect site quality.

The analysis units used for the Arrow TSA timber supply analysis, and the inventory file variables used to define them, are shown in Table A-1.

Table A-1. Analysis unit characteristics

Analysis unit	Species groups	Inventory type groups	Site index classes	Biogeoclimatic zone
01	Douglas-fir, larch, ponderosa pine	1-8, 32-34	good & medium	N/A
02	Douglas-fir, larch, ponderosa pine	1-8, 32-34	poor	N/A
03	spruce	21-26	good & medium	N/A
04	spruce	21-26	poor	N/A
05	hemlock, cedar	9-17	good & medium	N/A
06	hemlock, cedar	9-17	poor	N/A
07	lodgepole pine, whitebark & white pine	27-31	good & medium	N/A
08	lodgepole pine, whitebark & white pine	27-31	poor	N/A
09	balsam (high elevation)	18-20	N/A	ESSF
10	balsam	18-20	N/A	ICH

A.1 Management Zone and Analysis Unit Definitions

The combination of stands going into each analysis unit is further summarized based on zone (see Table A-2.). The different zone by analysis unit combinations, or strata, represent the possible types of management that may occur on the timber harvesting land base. Not all possible strata are found in Table A-2. because the ones poorly represented throughout the land base (i.e., less than 1000 hectares present) were amalgamated with ones adequately represented (see Table A-3.). An exception to the less-than-1000-hectare guideline was made for hemlock-cedar analysis units. These strata were left in place for zones 1 and 2 to ensure forest cover requirements were not compromised. Note that strata numbers shown in Table A-3. are just the zone and analysis unit numbers joined together (e.g., zone 1, analysis unit 02 is strata 102).

Table A-2. Area by management zone and analysis unit

Analysis unit	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total	Per cent of total
01 F,L,Py - g,m	2 401	21 586	10 253	37 022	13 346	84 608	39.03
02 F,L,Py - p	-	1 128	1 329	4 140	1 938	8 535	3.94
03 S - g,m	-	-	2 115	14 753	-	16 868	7.78
04 S - p	-	-	1 800	8 411	-	10 211	4.71
05 C,H - g,m	560	2 415	2 227	10 649	-	15 851	7.31
06 C,H - p	195	1 330	1 905	9 440	-	12 870	5.94
07 Pl,PaPw - g,m	-	8 342	3 975	19 529	3 816	35 662	16.45
08 Pl,PaPw - p	-	-	1 529	1 410	-	2 939	1.36
09 B - g,m	-	2 638	3 836	14 540	1 062	22 076	10.19
10 B - p	-	-	1 415	5 725	-	7 140	3.29
	3 156	37 439	30 384	125 619	20 162	216 760	100.00

Table A-3. Strata shifted to another because of lack of representation

Analysis unit	Zone				
	1 VQO=retention	2 VQO=partial retention	3 watershed=1 and 2	4 watershed=3-6, timber emphasis	5 winter range
01 F,L,Py - g,m					
02 F,LPy.- p,l	102 - > 202				
03 S - g,m	103 - > 303	203 - > 303			503 - > 403
04 S - p,l	104 - > 304	204 - > 304			504 - > 404
05 C,H - g,m					505 - > 405
06 C,H -p,l					506 - > 406
07 Pl - g,m	107 - > 207				
08 Pl - p,l	108 - > 308	208 - > 308			508 - > 408
09 B - ESSF	109 - > 209				
10 B - other	110 - > 209				510 - > 410

The utilization level defines the maximum allowable stump height and minimum merchantable diameter by species and is used to calculate merchantable volume. A 10-cm diameter top and a 30-cm stump height is assumed for all species.

The utilization level currently practiced in the Arrow TSA is 12.5 cm minimum diameter at breast height (dbh) for lodgepole pine and 17.5 cm minimum dbh for all other species.

A.2 Utilization Levels

The utilization level defines the maximum allowable stump height and minimum merchantable diameter by species and is used to calculate merchantable volume. A 10-cm diameter top and a 30-cm stump height is assumed for all species.

The utilization level currently practiced in the Arrow TSA is 12.5 cm minimum diameter at breast height for lodgepole pine and 17.5 cm minimum diameter at breast height for all other species.

A.3 Definition of the Timber Harvesting Land Base

This section provides the information used to define the land base considered available for timber harvesting for this analysis. The timber harvesting land base is derived by deducting several types of land and forest from the total area.

Areas were sequentially deducted from the total Arrow TSA area in the following order:

- (1) land not managed by the B.C. Forest Service (non-Crown);
- (2) non-forest area;
- (3) non-commercial cover (NCC, i.e., brush species);
- (4) inoperable areas;
- (5) high soil mass wasting hazard and steep slope areas;
- (6) other environmentally sensitive areas;
- (7) non-merchantable forest types;
- (8) road, trail and landing areas; and,
- (9) not satisfactorily restocked (NSR).

Operable future roads, trails and landings were removed from further timber production in the timber supply model after being logged for the first time.

A.3.1 Land not managed by the B.C. Forest Service

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

A.3 Definition of the Timber Harvesting Land Base

Tree farm licence (TFL) areas are managed — and have their AAC determined — separately for TSAs. Their area is not normally included in the TSA inventory. However, sometimes when the ownership of land is unreported, it is included in the TSA inventory. This land is managed as part of the TFL, and does not form part of the TSA harvesting land base.

All areas with ownership codes (OWNER,OWNRCHAR) other than 62C or 69C are excluded from the timber harvesting land base for this analysis. Table A-4. outlines the total area in each ownership category for the Arrow TSA.

Table A-4. Total area in each ownership category, Arrow TSA

Description	Ownership code	Area	
		Hectares	Per cent of Total
Private Crown grant	40-N ¹	116 577.9	15.5
Federal, federal reserve	50-N	35.7	0.0
Provincial, UREP ³	61-C ²	886.3	0.1
Provincial, UREP	61-N	1 352.5	0.2
Provincial, forest management unit (Crown)	62-C	528 322.2	70.0
Provincial, timber agreement land (C -rights)	62-N	63.9	0.0
Provincial, provincial park - class A	63-N	1 187.1	0.2
Provincial, provincial park - class C	65-N	10.7	0.0
Provincial, provincial park - special or reserve	67-N	34.8	0.0
Provincial, Crown or government reserve	69-C	102 244.9	13.5
Provincial, Crown or government reserve	69-N	1 925.2	0.2
Provincial, timber licence in a TFL	70-N	1 125.8	0.1
Provincial, TFL unreported ownership	76-C	143.2	0.0
Provincial, TFL unreported ownership	76-N	20.4	0.0
Provincial, woodlot licence, Crown land portion	77-N	2 148.0	0.3
Total		754 078.6	100.0

¹N= Land not available for long-term integrated resource management.

²C = Land available for long-term integrated resource management.

³UREP = Use for recreation and enjoyment of the public.

A.3.2 Inoperable Areas

Areas defined as economically inoperable were not considered part of the harvesting land base. Characteristics used in defining operability include slope, topography (e.g., the presence of gullies and exposed rock), difficulty of road access, soil stability, elevation and timber characteristics.

A.3 Definition of the Timber Harvesting Land Base

The operability classification on the inventory file (OPERABLE variable) was used to exclude areas from the timber harvesting land base. As well, supplementary information analyzed at the local level was used as a basis to further exclude areas considered inoperable because of steep slopes or a high mass wasting hazard. A summary of the reductions is as follows:

- (a) Inoperable areas defined by the operability line are 100% excluded;
- (b) For areas not included in class 1 and 2 watersheds, a 75% area reduction is applied to slopes of 71% or greater;
- (c) For all class 1 and 2 watersheds except planning cells B010, E020, F080, G030, K060, K070 the operable area is reduced by a further 6% to account for areas of high and extreme mass wasting hazard.

TRIM data (contour information) was obtained and processed for about 75% of the TSA (the northern parts) and it was found that there were about 9300 hectares of 71% or greater slopes in areas that were otherwise identified as operable. This amounts to 5.7% of the timber harvesting land base for the area covered. The rest (southern area) was slope classed manually but the amount of 71% or greater found was smaller. No 71%+ area is removed for the areas without TRIM data. The 75% area deduction reduces the net land base by about 4.3% ($5.7\% \times 0.75$) for the area involved (or about 3.2% for the whole TSA). The TRIM generated slope classes were plotted at a scale of 1:20 000 and several maps with large areas of 71%+ below the operability line were compared to licensee development plans to determine the degree to which this terrain is being operated on. This was a manual exercise done on a light table. It indicated that these areas were generally being avoided but some limited harvesting was occurring in them. The 75% area reduction came from this exercise.

Mass wasting hazard data (from SIL3 surveys) was overlaid (using GIS) with Forest Service Inventory data for Perry Ridge, Dayton Slope, Ringrose Slope, Elliot Creek, Christian Creek, and Trozo Creek (all in the Slocan Valley). Much of the high and extreme mass wasting hazard area was already identified as inoperable or ESA1 = 'S'. However, significant amounts (of the high and extreme) were not identified by the ESAs or the operability and are part of the operable land base. The reverse situation (ESA = 'S' and mass wasting hazard = low or moderate) also occurred but only about 50% as often. It was found that using criteria of removing all the extreme hazard and 50% of the high hazard would result in a further netdown of 6% of the operable area. The 50% criteria for the high mass wasting hazard was used for the following reasons:

- (a) past District experience indicated that this was reasonable;
- (b) the pedologist's report suggests that some of this area is operable using cable systems;
- (c) removing all of the high hazard may be overly conservative considering that some of the ESA = 'S' occurs in areas of low or moderate mass wasting hazard.

A review of terrain and soils indicated that the extrapolation of the Slocan Valley data to other areas appears to be reasonable except for planning cells B010, E020, F080, G030, K060 and K070.

The TRIM data is on a separate database but will be merged with the analysis database on a planning cell and analysis unit basis.

This approach (removal of either 71%+ slopes or high and extreme mass wasting hazard) ensures that no "double" deductions will be made. In the class 1 and 2 watersheds all of the 71% + slopes are classified as high or extreme mass wasting hazard (by definition) along with some lesser slopes depending on other soil factors.

The rationale for both the steep slope and the mass wasting hazard area deductions is that these areas have for the most part not been harvested in the past for environmental reasons which are still valid. In the future the operability line will be adjusted to identify as many of these areas as possible.

A.3 Definition of the Timber Harvesting Land Base

A.3.3 Environmentally sensitive areas (ESAs)

The forest inventory file includes a rating of the environmentally sensitive forest areas (ESAs). Areas rated as highly sensitive (1) ESAs are considered only partly available for timber harvesting. Table A-5 indicates the per cent area reduction made for each of the highly sensitive ESA categories.

Table A-5. Per cent area reductions for environmentally sensitive areas

ESA code	ESA description	Per cent area reduction
Ea 1	Avalanche concerns	90
Eh1	Water supply concerns	0
Ep 1	Regeneration problems	90
Er 1	Recreation	50
Es 1	Soil and steepness problems	90

The standard deduction (which was used in the 1981 analysis) is 90% for all of the above categories. The standard deductions have been either confirmed or modified according to the following rationale.

1. Avalanche concerns (Ea1). This was left at 90% since it was thought to be reasonable and there is so little of it (the deduction amounts to about 50 hectares for the entire TSA) that more detailed investigation is not justified.
2. Water supply concerns (Eh1). This deduction was eliminated since watershed concerns are dealt with more effectively through the mass wasting hazard deductions and the zone forest cover constraints. It involved very little area (about 50 hectares).
3. Regeneration problems (Ep1). This deduction was left at the standard 90%. A review of past performance indicated that most of the Ep areas had been logged. In most cases, however, the Ep label was attached to the polygon after harvesting had occurred and regeneration problems were encountered. The 90% reduction is considered to be appropriate since the Ep labels are mostly based on actual regeneration problems that have already occurred.
4. Recreation (Er1). This deduction was reduced from 90% to 50%. These areas were denoted prior to the existing recreation and landscape inventory. They were intended to identify areas with high recreational values and are often adjacent to lakes. The Er1s are distinct from the recreation reserves (UREP) which are removed from the net land base under the "ownership" deduction and the visual quality objectives (VQOs) which are dealt with through the forest cover constraints.

Most of the larger Er1s were located on the forest cover maps and checked for recreational values. It was found that some of them were covering areas which would probably not be harvested due to the high recreational values, some were applied incorrectly (to areas with no particular recreational values), and some were in areas with recreational values but timber harvesting either could or already had occurred with relatively little impact on either the recreational values or the volume of timber removed. On the basis of this review a deduction of 50% is considered more representative of current practices than the standard 90%. This change will result in between 700 and 800 hectares of additional area in the timber harvesting land base. Some of the Er1s should be removed at the next inventory update.

A.3 Definition of the Timber Harvesting Land Base

5. Soil and steepness problems (Es1). This deduction is confirmed at 90%. A review of past performance indicated that the rate of harvesting on these areas was greater than the 10% presently included in the timber harvesting land base (if the deduction was based purely on these figures a deduction of about 60% would be indicated). However the review also indicated that significant problems were associated with some of this harvesting (on Es1 areas). Furthermore, some of the harvesting on these Es1 areas occurred in the 1960s and early 1970s (i.e. before they were designated), considerable amounts occurred in the late 1970s (immediately after the ESAs were completed but possibly before they were on all the maps in general use), with lesser amounts in the last decade. The harvested Es1 polygons which were checked included some which were not particularly steep or sensitive (misabeled) and had no obvious problems, some in which significant post harvesting landslides originated, some with smaller slope failures, and some without mass wasting problems but with levels of detrimental soil disturbance which appeared to be in excess of current guidelines. Some of the Es1 polygons which were indicated as having a logging history had been partially cut (particularly in the Pend D'Oreille area), which in many cases meant selecting small flatter areas within the polygon. In summary our review indicates that the 10% inclusion (90% area reduction) includes enough of the Es1 areas in the timber harvesting land base to account for those that can be (and have been) harvested without problems.

A.3.4 Problem forest types

Some stands are not currently used because they either cannot be harvested economically or they contain mostly non-commercial tree species. Examples include older stands that contain low net timber volumes or poor quality trees and stands dominated by deciduous species. Areas of low site quality are also excluded because projected growth rates for second-growth forests are too low. Table A-6 lists the problem forest types for the Arrow TSA and the percentage reductions applied for each category. The low site reduction was based on new site class (NSITE) except when modified by special site (SSITE).

A.3 Definition of the Timber Harvesting Land Base

Table A-6. Per cent area reductions for problem forest types

Inventory type group	Species groups	Criteria				
		Age class	Height class	Stocking class/ (NSITE)	PSYU	Per cent area excluded
11	cedar/hemlock	8 & 9	All	All	Edgewood	50
12	pure hemlock	8 & 9	All	All	N/A	80
13-17	hemlock leading	8 & 9	All	All	N/A	30
18-19	balsam leading	8	All	All	N/A	10
18-19	balsam leading	9	All	All	N/A	100
20	balsam/spruce	8 & 9	All	All	N/A	20
28	pure lodgepole pine	≥ 5	2	≥ 2(p)	N/A	90
35-42	deciduous species	All	All	All	N/A	100

The problem forest type deductions are based on those used in the 1981 analysis. The deductions were reviewed and compared to the last 10 years harvest. A sample of the harvest was used with about 2300 hectares of harvest considered.

The rationale for confirming or changing the 1981 problem forest type deductions are as follows:

- (a) Type group 11, cedar/hemlock, age classes 8 and 9 (Edgewood PSYU). The deduction percentage should be left the same. It is apparently reasonable and there is very little of it (about 90 hectares deducted).
- (b) Type group 12, pure hemlock, age classes 8 and 9. The deduction percentage should be increased from 60% (1981) to 80%. The harvest sample showed some harvesting (mostly in Kuskanax drainage). This harvesting occurred mostly in the early 80s. It tended to focus on the better quality stands in this type group. The decision to increase the deduction from 60% to 80% is based on more recent performance (later 80s and early 90s) and the quality of the remaining stands.
- (c) Type groups 13 to 17, hemlock leading, age classes 8 and 9. This deduction was left as 30%. Some harvesting (55 hectares) occurred in these types.
- (d) Type groups 18 to 19, balsam leading, age classes 8 and 9. This deduction was left as is (10% and 100% deduction respectively) since it appears reasonable and there is so little of it that performance is difficult to confirm (although 9 hectares was harvested in age class 8).
- (e) Type group 20, balsam/spruce, age classes 8 and 9. This deduction was left as is. Considerable harvesting has occurred here (313 hectares) but some of it may still be unmerchantable.
- (f) Type group 28, pure lodgepole pine, poor sites, poorly stocked, 522 hectares. This deduction was left as is. There was no harvesting of this type in the sample but the total area is fairly small (about 370 hectares deducted).

A.3 Definition of the Timber Harvesting Land Base

A.3.5 Not satisfactorily restocked areas

All areas on the inventory file assigned to a type identity of 4, 7, or 9 were initially excluded from the land base. All of this area was subsequently added back into the timber harvesting land base (the additions are described in Section A.4.5, "Not Satisfactorily Restocked (NSR) Areas."

A.3.6 Existing unclassified roads, trails, and landings

Past timber harvesting operations have resulted in a loss of productive forest land. However, many of the existing roads, trails, landings and related disturbances are not accounted for in the inventory file. To account for this loss in the area available for timber harvesting, a 10.1% reduction was applied to all forest younger than 40 years old. Forest stands younger than 40 years old are assumed to be managed stands having existing access.

The total deduction of 10.1% is made up as follows:

- (a) roads 3.0%;
- (b) landings 3.0%;
- (c) skid roads and trails 4.1%.
 - (a) Main road deductions (3.0%) — this number includes most roads since an examination of a sample of forest cover maps indicated that very few of the roads were wide enough to be assigned a separate inventory polygon. This was done for most of the main highways and a few of the forest roads.
 - (b) Landings (3.0%) — this percentage is based on soil disturbance surveys done in the Arrow Timber Supply Area.
 - (c) Skid roads and trails (4.1%) — this figure was derived from the soil disturbance surveys using the following assumptions:
 - (i) bladed skid roads were considered to have a 40% productivity loss;
 - (ii) heavily compacted skid trails (non bladed) were considered to have a productivity loss of 20%;
 - (iii) the disturbance figures were weighted by slope class to give a TSA average, and the slope class data was from a combination of TRIM data and hand slope classing done for the Arrow TSA;
 - (iv) no data was available for cable blocks, and it was assumed that all slopes 50% or greater will be cable harvested and that the "Soil Conservation Guidelines for Timber Harvesting - Interior B.C." will be met;
 - (v) the Arrow TSA surveys were supplemented with some from TFL 23 (also in the Arrow District) for the 0-30% slope class to increase the otherwise very small sample size.

A.3 Definition of the Timber Harvesting Land Base

A.3.7 Future roads, trails, and landings

There will also be losses in productive area as future harvesting occurs. All existing stands currently over 40 years old will be subject to these losses.

The total deduction of 8.9% is made up as follows:

- (a) roads 3.0%;
- (b) landings 3.0%;
- (c) skid roads and trails 2.9%.

The roads and landings are from the previous table but the areas in skid roads and trails are the maximum allowed under the "Soil Conservation Guidelines for Timber Harvesting - Interior B.C." The following assumptions were made to convert the maximum allowable levels of detrimental soil disturbance specified in the guidelines to percentage productivity reductions:

- (a) the productivity loss factors of 40% for skid roads and 20% for heavily compacted trails were used;
- (b) in the 0-30% slope class 50% of the disturbance was from skid roads and 50% from heavily compacted trails, and in the 31-50% slope class, 67% was from skid trails and 33% from heavily compacted trails. Overall, 50% of the total disturbance was attributed to skid roads;
- (c) a disturbance limit for skidding of 13% was used for the 0-30% slopes, a limit of 10% was used for the 31-50% slopes (an average of the lower two "leading soil disturbance hazard" categories from the guidelines), and 3% was used for the 51%+ slopes (an average of the upper two categories from the guidelines);
- (d) the productivity losses were area weighted by slope class.

A.3.8 Timber licence reversions

There are three active timber licenses in the Arrow TSA:

- (1) T.O. 529, Evans Forest Products Ltd., Fish River;
- (2) T.O. 467, Crown Forest Products, Vanstone Creek;
- (3) T.O. 667, Marlow-Staubert Lake.

Initially it appeared that there was a fourth one (Slocan Forest Products - Pedro Creek) but this one has been canceled and is already included as Crown forest in the database.

- (1) T.O. 529. Out of total area of 1140 hectares, 722 is operable. Of the 722 hectares, 673 have been harvested and 49 remain to be harvested in the next two to three years. All areas have been or will be planted to varying mixtures of spruce, Douglas-fir and cedar, and all are good sites. Analysis units and year of reversion were estimated from the harvest plan, PHSP's and an Arrow District Silviculture audit of the licence.

A.3 Definition of the Timber Harvesting Land Base

- (2) T.O. 467. This is a combination of several timber licenses (2132, 2133, 2134, 2135) that lie along the boundary of the Arrow and Revelstoke Forest Districts. The Arrow portion of the licence totals 958 hectares of which all but 62 hectares are operable. These licenses have been managed by the Revelstoke District and therefore the analysis units and reversion years came from documentation from Revelstoke. The licence expires in 2025.
- (3) T.O. 667. Out of a total of 251 hectares, 216 are operable, 181 of which have already been harvested. The rest will be cut by 1995 at which point the licence reverts. Regeneration is mostly to leading hemlock with fir and pine also in the stands.

Table A-7. summarizes the timber licence (TL) reversion information for the Arrow TSA.

Table A-7. Timber licence reversions

Zone	Analysis unit	Areas of TLs reverting (hectares)				Total area (hectares)
		Years until reversion				
		0 - 5	5 - 15	15 - 25	25 - 35	
4	01	150	10			160
4	03	513	369	258	60	1 200
4	05	460	15			475
Total area		1 123	394	258	60	1 835

A.4 Forest Management Assumptions

A.4.1 Minimum harvestable ages for each analysis unit

The following sources were used to arrive at the figures listed in Table A-8.:

- (a) 1981 Arrow Timber Supply Analysis;
- (b) preliminary VDYP stand volume and diameter tables;
- (c) Arrow Forest District Staff experience with present harvesting operations.

In most cases these minimum harvestable ages are close to what was used in 1981 since these seemed reasonable in light of both district experience and the new volume and diameter tables.

Table A-8. Identification of minimum harvestable age for each analysis unit

Analysis unit	Minimum harvest ages for:		
	Culmination age	Existing stands	Regenerated stands
01	110	80	80
02	140	120	120
03	110	100	100
04	150	140	140
05	90	90	90
06	140	130	130
07	90	70	70
08	130	90	90
09	140	140	140
10	110	100	100

A.4.2 Harvest profile

Harvesting in hemlock and cedar and balsam timber types for the first 2 decades is limited to the standing forest profile (Table A-2.)

A.4 Forest Management Assumptions

Table A-9. Harvest profile constraints

Analysis unit	Per cent of total harvest
05	7.31
06	5.94
09	10.19
10	3.29

A.4.3 Forest cover requirements

Table A-10. specifies the forest cover requirements needed to achieve the forest management objectives for each zone.

Table A-10. Forest cover requirements

Zone	Age 1 (years)	Height 1 (metres)	Maximum per cent area younger than age 1	Age 2 (years)	Height 2 (metres)	Minimum per cent area older than age 2
1	17	3	25	23	5	84
2	17	3	25	23	5	75
3	17	3	25	32	7	70
4	17	3	25	38	9	47
5	17	3	25	29	7	61

The figures presented in Table A-10. are based on the following rationale.

Forest cover requirements for 4-pass cutblock adjacency guidelines, based on a minimum 3 metre green-up height requirement, apply to all zones. In addition, forest cover requirements were assessed for each zone based on the resources being emphasized. When three sets of constraints were required to meet a zone's forest cover requirements, such as the wildlife zone, the two most restrictive were included. The forest cover requirements for the management zones were assessed in the following way:

A.4 Forest Management Assumptions

1. Zones 1 and 2 — VQO="retention" and "partial retention"

The new Provincial Landscape Guidelines (November 15, 1992) are the basis of the percentages used but the interpretation of them was aided by an evaluation of past performance in partial retention units in the Arrow TSA. This study was done by Larry Price (Nelson Region Landscape Forester) and included units in the Lower Wilson Creek area.

The assumptions used to derive the forest cover requirements are as follows:

- Visual Effective Greenup (VEG) will be considered to be 5 metres regardless of slope class (Assessment of Visually Effective Greenup Using Mean Greenup Value Scores-Silvatec-October, 1992);
- Partial cutting will only occur in leading Douglas-fir, larch, ponderosa pine, lodgepole pine/fir, lodgepole pine/larch on slopes of less than 50%. The total per cent removal for clearcuts and partial cuts is limited to the maximum Equivalent Clearcut Area (ECA) for the appropriate watershed class;
- For "Retention" VQOs the maximum non-greened-up clearcut per cent is 3% (plus partial cutting for appropriate species groups);
- For "Partial Retention" VQOs the maximum non-greened-up clearcut per cent (in plan view) is 5% for slopes greater than 50% and 15% for slopes less than 50% (plus partial cutting for appropriate species groups).

Although this table only applies to the operable land base, the inoperable areas may affect visual management. This is dealt with by assigning all the VQO polygons to one of three "dispersion classes" depending on how the operable types are dispersed throughout the landscape unit. This assignment is done in order to incorporate the effect of (non harvested) inoperable forest in determining maximum area in a non-greened-up condition for a landscape unit. See point (b) in the next paragraph for a definition of the three dispersion classes.

The previous assumptions are used to derive the forest cover requirements in the table as follows:

- The VQO "maximum non-greened-up clear-cut percentages" are assigned on a planning cell/VQO basis (i.e., one calculation for all the partial retention in a planning cell) to account for the effects of slope and leading species;
- The values from (a) above are adjusted for the "contribution" of inoperable area to the landscape unit according to the dispersion class (class 1 — perfectly intermixed, class 2 — somewhat intermixed, class 3 — separate). For class 1 all of the inoperable area in the landscape unit is used when calculating the maximum non-greened-up clearcut percentage for the operable area (i.e., for a landscape unit of 100 hectares with 50 hectares operable and a 15% maximum for non-greened-up clearcuts, the 15% would become 30% of the operable area). For class 2 only half of the inoperable is used, and for class 3 no adjustment is made;
- The adjusted VQO cover requirements are then weighted by area to produce the final values by zone for Table A-10, "Forest cover requirements."

A.4 Forest Management Assumptions

2. Zone 3 — watershed classes 1 and 2 (small consumptive use watersheds and face units)

The entire land base has been classified into 6 watershed classes based on the draft Nelson Region "Watershed Harvesting Guidelines" (March, 1991) that were used in the Kootenay Lake analysis.

Class 1 — face units (springs, seeps, poorly defined catchment basins, etc.).

Class 2 — small watershed, licensed.

Class 3 — large watershed, licensed, with special concerns.

Class 4 — large watershed, licensed, no special concerns.

Class 5 — non-licensed watershed, special concerns.

Class 6 — non-licensed watershed, no special concerns.

A maximum additional "Equivalent Clearcut Area" (ECA) is specified for each watershed class.

The assumptions used to derive the forest cover requirements are as follows:

- The maximum ECA limits for each watershed class are:
 - Class 1 and 2, 15%;
 - Class 3, 25%;
 - Class 4 and 5, 30%;
 - Class 6, 40%.

These limits apply to the total area of the watersheds. The percentages for classes 3-6 are directly from the guidelines. The percentage for classes 1-2 is based on past experience in the Arrow TSA. The difference between the value specified in the guidelines (25%) and the value experienced (15%) is due to a combination of operational difficulties encountered in distributing the cut by aspect and elevation band, the influence of private land harvesting on adjacent Crown land, and the social and political realities of operating in domestic watersheds. The watershed ECA limits (in particular the use of experienced values versus guideline values for classes 1 and 2) are the subject of sensitivity analysis.

- (b) Full hydrological green-up occurs when a fully stocked stand reaches 7 metres in height for class 1 and 2 watersheds. This height was interpreted from recent research on hydrological green-up in the Southern Interior of British Columbia (Estimating Hydrologic Recovery in Southern Interior Watersheds - Chatwin, Eremko, and Toews, 1992). Most of the operable area in these small drainages is in the low to moderate snow pack zone and therefore the green-up height is lower than in other areas.

The proceeding assumptions are used to derive the forest cover requirements in the table as follows:

- assign the initial ECA percentage to each planning cell as specified above;
- adjust the percentage upwards for each cell by the ratio of total Crown area to operable area;
- select the lesser of the adjusted ECA as calculated in (ii) above or 50% (for class 1 and 2 watersheds) or 70% (for class 3-6 watersheds);
- convert the 7 metre height criteria to an age for each of analysis units (species site groups) and area weight these to produce a green-up age for the zone.

A.4 Forest Management Assumptions

3. Zone 4 — timber emphasis (watershed class 3-6, summer wildlife range)

While timber production is presently emphasized in this zone, integrated resource management considerations do have some effect on forest management. Wildlife considerations will likely play a larger role in decisions about timber availability in the future as harvesting begins in timber adjacent to previously harvested cutblocks. This should be reflected in the "Zone Forest Cover Constraints".

The assumptions used to derive the forest cover requirements are as follows:

- The maximum ECA limits for the appropriate watershed class (3-6) will be used. Since these are larger watersheds, with a substantial proportion of the operable area in the high elevation heavy snow pack zone, the height requirement for hydrological green-up will be 9 metres. (11 metres for heavy snow pack and seven metres for light -moderate, and an assumption of a 50-50 split in these drainages);
- A minimum of 30% of the zone will be maintained in height class 2 and greater (10.5 metres). This is from the summer range requirement of the "Logging Guidelines for Wildlife Habitat Classes" - Kootenay Region Ministry of Environment;
- Inoperable and ESA areas can contribute to the 40% height class 3 requirement but only if they are in the same biogeoclimatic subzone.

The above assumptions are used to derive the forest cover requirement in the table as follows:

- The maximum permitted area in non-greened-up clearcut is determined as described for zone 3 above;
- The summer range requirement (minimum area in 10.5 metres +) was determined in the following manner:
 - all calculations are done for each subzone within each planning cell;
 - the total forest area and the total inoperable forest area (inoperable forest + ESA reductions, + problem forest types) are calculated for each planning cell-subzone;
 - the total summer range requirement is calculated by taking 30% of the total forest area;
 - seventy per cent of the inoperable forest is considered to be suitable for summer range (i.e., not too steep), and this figure was determined by examining area slope summaries (from TRIM data) for the inoperable forest for those cells in this zone for which summaries were available. This percentage is slightly lower than the 75% used for the winter range (zone 5) but the difference was simply due to different terrain in different cells;
 - any remaining summer range requirement that is not satisfied by the inoperable forest is taken from the operable area;
 - the "operable summer range requirement" is totalled for all the planning cell-subzones in the zone and this number is divided by the total operable area to give the per cent cover requirement.

4. Zone 5 — wildlife winter range

This unit consists of areas where forest management is modified significantly in order to accommodate wildlife habitat considerations. The cover requirements are from the "Logging Guidelines for Wildlife Habitat Classes" — Kootenay Region, Ministry of Environment, October 1989. There is significant overlap between these winter range areas and the class 1 and 2 watersheds and the VQOs.

A.4 Forest Management Assumptions

The assumptions used to derive the forest cover requirements are as follows:

- The maximum percentage in non-greened-up clear-cut is from the watershed class limit (or a combination of watershed and VQO if applicable);
- The maximum percentage in height class 3 or more (19.5 metres) is 40% for deer winter range and 50% for caribou winter range, and this comes from the wildlife guidelines;
- Inoperable, ESA areas and problem forest types can contribute to the height class 3 requirements but only if they are in the same biogeoclimatic subzone.

The above assumptions are used to derive the forest cover requirement in the table as follows:

- The cover requirement percentage is assigned by planning cell according to whether it is deer or caribou winter range;
- The remainder of the winter range calculation is similar to the approach described for summer range in zone 4 stated on the previous page;
- The maximum area in non-greened-up clear-cut is determined by averaging (weighted by area) the values for the various watershed and VQO categories that make up the winter range, and the same approach is used to determine the green-up height of 7 metres which varied from 5 metres for the VQOs to 7 and 11 metres for the various watershed classes.

A.4.4 Unsalvaged losses

Unsalvaged losses are timber volumes destroyed or damaged by natural causes such as fire and disease. Estimated annual losses are deducted from the gross timber supply to determine the projected net volumes that will be harvested over time. Table A-11. shows the estimated average annual loss for the Arrow TSA.

Table A-11. Unsalvaged losses

Cause of loss	Gross losses in cubic metres per year	Annual unsalvaged losses in cubic metres per year
Insects	25 912	12 956
Disease (year 1)	12 300	6 150
Disease (year 100)		0
Fire	13 605	7 332
Wind damage		2 821
Wildlife leave trees		5 000
Total	51 817	34 259

Insects: This figure is for mountain pine beetle. It was produced from the Arrow District Protection records. It is for operable area only.

Fire: from Protection Branch records for the period 1983-1992.

Wind damage: From the 1981 Arrow Timber Supply Analysis.

Disease: The deductions in Table 11 are for white pine blister rust. It is to be applied as a "decreasing" deduction, starting out as 6150 cubic metres per year and decreasing in a straight line manner to zero in year 100. The rationale for this is as follows:

A.4 Forest Management Assumptions

- (a) White pine blister rust was introduced to the area after many of the presently mature stands became established. Therefore it has attacked the white pine in these stands at a later point in their development than it will in the future. The opportunity for replacement of white pine volume loss by other species before harvest is less in presently mature stands than it will be in the future. Furthermore in artificially regenerated stands white pine will either not be planted at all or blister rust resistant varieties will be used. The total volume loss in our stands due to white pine blister rust is much greater now than it will be in the future. In the future the effect will be the replacement of white pine volume with other species.
- (b) At present 3% of the net operable mature volume on the FIP file is white pine. According to a recent survey (Arrow TSA white pine survey-fall, 1992) the actual volume is 66% less than what is shown on the inventory file for undisturbed polygons.
- (c) The unsalvaged losses for year one were calculated as follows:

$619\,000 \text{ current AAC} \times 0.03 = 18\,570$ (proportional white pine contribution);

$18\,570 \times 0.66 = 12\,256$ metres per year gross loss;

$12\,256 \times 0.5 = 6150$ metres per year unsalvaged loss;

This assumes that about 50% of the white pine is salvaged.

No deductions were made for other diseases because the data does not distinguish between endemic and epidemic infestations. Surveys are underway and the results of these surveys will be taken into account in the next analysis.

Wildlife leave trees: Wildlife trees of the approximately 1500 hectares that are harvested by the clear-cut method each year in the Arrow TSA about 500 hectares presently have wildlife trees left. This averages to about 20 trees per hectare with an average volume of 0.5 cubic metres per tree which gives an annual loss of 5000 cubic metres.

A.4 Forest Management Assumptions

A.4.5 Not satisfactorily restocked (NSR) areas

Table A-12. summarizes the total area of current and backlog NSR in the Arrow TSA. Data was compiled using information from the History Record System downloaded into a database program. This allowed the openings on the system to be sorted into the appropriate species by site group.

The current NSR category includes Small Business Forest Enterprise Program (SBFEP) areas only since the information for other current licenses is recorded on the Major Licensee Silvicultural System (MLSIS) which cannot generate NSR reports. This is not considered to be a problem since all the current areas are expected to be regenerated within 5 years.

The analysis units used are for the original stand.

All NSR, current and backlog, will be restocked within 5 years.

Table A-12. *Not satisfactorily restocked (NSR) areas based on silviculture history records*

Analysis unit	NSR (area in hectares)		Total area (hectares)	Per cent of total
	backlog	current		
01	984	127	1 111	17.2
02	49	0	49	0.8
03	992	0	992	15.2
04	365	93	458	7.1
05	1 678	130	1 808	27.9
06	77	0	77	1.2
07	618	55	673	10.4
08	0	0	0	0.0
09	1 308	0	1 308	20.2
10	0	0	0	0.0
Total	6 071	405	6 476	100.0

The totals in Table A-12. are less than the area of NSR on the inventory file (6476 hectares versus 7481 hectares) since the history records are more up to date (the inventory file is updated to December 1989 for linework and label changes with existing labels projected to 1991). Although this gives the appearance of inconsistency it is dealt with by using this table to assign the operable and restocked inventory NSR to analysis units and to assign the rate of restocking. All of this type of NSR will be added back into the timber harvesting land base in accordance with the figures shown in Table A-13.

A.4 Forest Management Assumptions

Table A-13. Not satisfactorily restocked (NSR) area based on inventory records

Analysis unit	Zone - area in hectares					Total NSR (hectares)	Per cent of total
	1	2	3	4	5		
01	26.3	115.0	172.2	870.7	155.7	1 339.9	17.9
02							
03			268.2	878.0		1 146.2	15.3
04			123.8	405.1		528.9	7.1
05	42.8	187.0	279.9	1 668.1		2 177.8	29.1
06							
06		82.0	99.9	505.1	90.3	777.3	10.4
08							
09		159.4	194.2	982.0	175.6	1 511.2	20.2
10							
Total	69.1	543.4	1 138.2	5 309.0	421.6	7 481.3	100.0

Stands modified by some kind of disturbance, logging for example, or stands where the timber is scattered, constitute another type NSR found in the inventory. All operable inventory NSR area of this type, 6381 hectares in total, will also be added back into the timber harvesting land base. A stand's attributes (e.g., inventory type, site class, and age class) will be used to assign it to the appropriate analysis unit in this case.

A.4.6 Basic silviculture and regeneration assumptions

Table A-14. shows what analysis units are created after harvesting occurs in existing analysis units. Originally the intent was to create managed stand yield tables that would reflect the proportions identified in the second column of Table A-14. However, because of problems in obtaining accurate site indices from the inventory file, it became necessary to use VDYP-based yield tables for regenerated stands. Consequently, each existing analysis unit was regenerated back to the same analysis unit.

Table A-14. Regeneration assumptions

Existing analysis unit	Regenerated analysis unit(s) (and percentage)	Per cent natural	Per cent planted	Initial stocking (stems/hectare)	Regen delay(s) (years)	Regen analysis unit as modelled
01	01 (100%)	7	93	1 200	3	01
02	02 (100%)	12	88	1 200	4	02
03	03 (55%)	93	7	1 200	9	03
03	10 (32%)	100	0	900	7	03
03	05 (13%)	15	85	1 200	3	03
04	04 (60%)	100	0	1 200	8	04
04	09 (20%)	100	0	900	7	04
04	06 (20%)	10	90	1 200	4	04
05	05 (100%)	25	75	1 200	3	05
06	06 (100%)	35	65	1 200	7	06
07	07 (100%)	15	85	1 200	3	07
08	08 (100%)	15	85	1 200	6	08
09	09 (100%)	100	0	900	6	09
10	10 (100%)	100	0	900	7	10

A.5 Yield Estimates for Existing and Regenerated Stands

A batch version of the Variable Density Yield Prediction (VDYP) model, developed by the Inventory Branch of the B.C. Forest Service, was used to predict volume yields for both existing and regenerated stands. The batch VDYP model provides a complete volume curve for every forest stand in the timber harvesting land base, based on the species composition, height, age, stocking and geographic location of the stand. These curves are then aggregated into the analysis unit curves in Table A-15, by averaging the individual curves, weighted by the area of each stand that makes up the analysis unit.

Analysis unit level yield tables show volume yields for three categories of stands: existing immature (less than age 81 for lodgepole pine, age 121 for all other species), existing mature (more than age 80 for lodgepole pine, age 120 for all other species) and regenerated. Volume yields for regenerated stands are based on an average calculated on all existing stands within an analysis unit.

A.5 Yield Estimates for Existing and Regenerated Stands

Table A-15. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 1 Douglas-fir, Larch, Ponderosa pine Good and medium sites				Analysis unit 2 Douglas-fir, Larch, Ponderosa pine Poor site			
	Existing stand volumes		Regen		Existing stand volumes		Regen
	Immature	Mature	All		Immature	Mature	All
Maximum MAI (m ³ /ha/yr)	2.63	2.19	2.42	Maximum MAI (m ³ /ha/year)	1.63	0.95	1.49
Age				Age			
10	0	0	0	10	0	0	0
20	0	0	0	20	0	0	0
30	8	3	6	30	0	0	0
40	42	23	33	40	8	0	7
50	82	56	70	50	29	5	23
60	121	90	107	60	54	17	46
70	159	124	142	70	80	33	70
80	196	156	177	80	105	49	93
90	230	186	209	90	129	65	115
100	261	214	238	100	151	80	137
110	290	239	266	110	173	95	157
120	315	262	290	120	192	108	175
130	339	284	313	130	211	121	193
140	361	304	334	140	228	133	208
150	378	321	351	150	242	143	222
160	394	336	366	160	254	152	233
170	408	348	379	170	264	159	243
180	419	360	391	180	274	166	252
190	431	371	401	190	283	173	261
200	441	382	412	200	292	179	269
210	452	392	422	210	301	186	277
220	462	402	432	220	309	192	285
230	471	411	441	230	317	198	292
240	480	420	450	240	324	203	300
250	488	428	458	250	331	209	307
260	489	429	459	260	332	209	307
270	490	430	460	270	333	210	308
280	490	431	460	280	333	210	309
290	491	432	461	290	334	210	309
300	491	433	461	300	334	211	310
310	492	433	462	310	335	211	310
320	492	434	462	320	335	211	310
330	492	434	463	330	336	211	311
340	492	435	463	340	336	211	311
350	493	435	463	350	336	211	311

continued

A.5 Yield Estimates for Existing and Regenerated Stands

Table A-15. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 3 Spruce Good and medium sites				Analysis unit 4 Spruce Poor site			
	Existing stand volumes		Regen		Existing stand volumes		Regen
	Immature	Mature	All		Immature	Mature	All
Maximum MAI (m ³ /ha/yr)	2.51	2.43	2.41	Maximum MAI (m ³ /ha/year)	2.07	1.35	1.60
Age				Age			
10	0	0	0	10	0	0	0
20	0	0	0	20	0	0	0
30	0	0	0	30	0	0	0
40	13	11	10	40	2	0	1
50	48	45	42	50	18	1	8
60	98	93	90	60	59	6	28
70	143	139	134	70	98	24	54
80	184	179	175	80	137	46	83
90	219	213	210	90	171	74	112
100	250	243	240	100	200	100	139
110	276	268	266	110	226	123	163
120	299	290	288	120	248	144	184
130	320	310	309	130	269	164	205
140	339	328	328	140	288	183	223
150	354	344	344	150	305	200	240
160	368	357	357	160	319	215	256
170	380	369	369	170	333	230	270
180	390	380	380	180	344	243	282
190	399	389	389	190	355	255	294
200	407	397	397	200	365	266	304
210	414	405	405	210	374	276	314
220	421	412	412	220	382	286	323
230	427	418	418	230	389	295	332
240	433	424	424	240	396	303	339
250	438	429	429	250	402	311	347
260	441	432	432	260	406	315	351
270	444	435	435	270	410	320	355
280	446	437	438	280	413	323	358
290	448	439	440	290	416	327	362
300	450	441	442	300	418	330	365
310	452	442	444	310	420	333	367
320	453	444	445	320	422	336	370
330	455	445	447	330	424	338	372
340	456	446	448	340	425	341	374
350	457	447	449	350	426	343	376

continued

A.5 Yield Estimates for Existing and Regenerated Stands

Table A-15. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 5 Hemlock, Cedar Good and medium sites				Analysis unit 6 Hemlock, Cedar Poor site			
	Existing stand volumes		Regen		Existing stand volumes		Regen
	Immature	Mature	All		Immature	Mature	All
Maximum MAI (m ³ /ha/yr)	3.15	2.69	2.87	Maximum MAI (m ³ /ha/year)	2.06	1.59	1.78
Age				Age			
10	0	0	0	10	0	0	0
20	0	0	0	20	0	0	0
30	6	2	4	30	2	0	1
40	58	31	42	40	18	3	11
50	112	81	93	50	47	21	32
60	163	129	142	60	84	51	64
70	209	172	186	70	120	81	97
80	250	211	226	80	153	109	127
90	283	242	258	90	181	133	152
100	312	268	285	100	205	154	175
110	336	291	309	110	226	172	194
120	357	310	328	120	244	188	211
130	382	333	353	130	266	206	231
140	405	355	375	140	285	223	249
150	425	375	395	150	303	238	265
160	442	393	413	160	319	252	280
170	458	410	429	170	334	264	293
180	472	425	443	180	347	276	306
190	486	439	457	190	360	286	317
200	498	453	470	200	373	297	329
210	510	467	483	210	385	308	340
220	522	480	495	220	397	318	352
230	533	493	507	230	409	328	363
240	544	505	519	240	420	338	373
250	554	517	530	250	431	347	384
260	558	521	534	260	436	352	388
270	562	525	538	270	440	357	393
280	565	528	541	280	444	361	397
290	569	531	544	290	447	365	400
300	572	534	547	300	450	369	404
310	574	537	550	310	453	372	407
320	577	540	553	320	456	375	410
330	580	543	555	330	459	378	413
340	582	545	558	340	461	381	415
350	584	547	560	350	464	383	418

continued

A.5 Yield Estimates for Existing and Regenerated Stands

Table A-15. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 7 Lodgepole pine, White and Whitebark pine Good and medium sites				Analysis unit 8 Lodgepole pine, White and Whitebark pine Poor site			
	Existing stand volumes		Regen		Existing stand volumes		Regen
	Immature	Mature	All		Immature	Mature	All
Maximum MAI (m ³ /ha/yr)	2.51	2.71	2.54	Maximum MAI (m ³ /ha/year)	1.75	1.57	1.67
Age				Age			
10	0	0	0	10	0	0	0
20	0	0	0	20	0	0	0
30	17	18	16	30	2	1	2
40	58	65	58	40	20	3	13
50	100	110	100	50	45	21	35
60	137	149	138	60	75	51	65
70	169	184	172	70	102	79	92
80	199	215	202	80	127	104	117
90	226	244	229	90	150	128	140
100	250	269	254	100	171	149	161
110	273	292	277	110	191	169	181
120	294	314	298	120	209	187	199
130	315	334	318	130	227	205	217
140	329	348	332	140	240	218	230
150	339	359	343	150	250	230	241
160	346	367	350	160	258	239	249
170	350	372	355	170	263	246	255
180	352	374	357	180	266	251	259
190	351	374	356	190	267	254	260
200	353	377	359	200	270	259	264
210	356	380	362	210	273	263	268
220	359	383	364	220	276	268	271
230	361	386	367	230	279	272	274
240	364	389	370	240	282	275	278
250	366	391	373	250	284	279	281
260	368	393	374	260	286	281	282
270	370	395	376	270	288	283	284
280	371	397	378	280	289	284	286
290	373	398	379	290	291	286	287
300	374	400	381	300	292	287	289
310	376	401	382	310	293	289	290
320	377	402	383	320	294	290	291
330	378	403	384	330	295	291	292
340	379	404	385	340	295	292	292
350	380	405	386	350	296	292	293

continued

A.5 Yield Estimates for Existing and Regenerated Stands

Table A-15. Volume estimates (cubic metres per hectare) for existing and regenerated stands (concluded)

Analysis unit 9 Balsam ESSF - High Elevation				Analysis unit 10 Balsam ICH			
	Existing stand volumes		Regen		Existing stand volumes		Regen
	Immature	Mature	All		Immature	Mature	All
Maximum MAI (m ³ /ha/yr)	2.07	1.45	1.72	Maximum MAI (m ³ /ha/year)	2.17	1.64	2.04
Age				Age			
10	0	0	0	10	0	0	0
20	0	0	0	20	0	0	0
30	3	1	2	30	5	3	4
40	23	7	14	40	28	14	24
50	57	23	38	50	64	34	57
60	92	46	66	60	99	60	90
70	128	74	98	70	136	90	125
80	158	98	125	80	167	115	155
90	184	119	148	90	193	138	181
100	207	138	169	100	217	159	204
110	228	155	188	110	238	177	224
120	247	170	205	120	257	194	243
130	268	187	223	130	279	212	264
140	287	202	241	140	299	229	283
150	305	217	257	150	318	245	301
160	322	231	273	160	335	260	318
170	337	244	287	170	350	274	333
180	352	257	300	180	365	287	347
190	366	269	313	190	379	299	361
200	379	280	325	200	393	311	374
210	392	291	337	210	406	322	387
220	404	301	348	220	418	333	399
230	416	312	359	230	430	344	410
240	427	321	370	240	441	354	422
250	438	331	380	250	452	363	432
260	440	333	382	260	454	365	434
270	442	335	384	270	456	367	436
280	444	337	386	280	457	369	438
290	446	339	388	290	459	371	439
300	448	341	390	300	461	372	441
310	450	342	392	310	462	374	442
320	451	344	393	320	463	375	444
330	453	346	395	330	464	376	445
340	454	347	396	340	466	377	446
350	456	348	398	350	467	379	447