Arrowsmith TSA
Timber Supply Analysis

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Preface

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

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

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

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

This timber supply analysis for the Arrowsmith TSA began in December 1993. The information it contains is independent of the 1993 Clayoquot Sound land use decision, 1995 Vancouver Island Land Use Plan and the 1995 Clayoquot Scientific Panel recommendations relating to the Forest Practices Standards in Clayoquot Sound. The *Forest Act* requires that within 5 years after the AAC determination made by the Chief Forester as part of the Timber Supply Review, a new AAC must be determined, supported by a new timber supply analysis. The next analysis will incorporate official land use boundaries and new information based on experience in implementation of new forest management practices. This analysis will be undertaken as quickly as possible.

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

Executive Summary

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

The Arrowsmith TSA is situated on the southern portion of Vancouver Island in the Duncan and Port Alberni Forest Districts. As well as the Arrowsmith TSA, the forest districts are comprised of 5 Tree Farm Licences (TFLs), Timber Licences, Federal and Provincial Parks and private lands. The Arrowsmith TSA currently provides 8% of the total timber supply from Crown land in the two forest districts.

Since the last timber supply analysis in 1988, the land base for the Arrowsmith TSA has changed due to TSA boundary updates, timber licence reversions, land transfers to the Pacific Rim National Park, and area being transferred from adjacent TFLs to the TSA to meet commitments for the Small Business Forest Enterprise Program (SBFEP).

When the analysis was initiated the allowable annual cut for the Arrowsmith TSA was 498 250 cubic metres per year. The analysis does not assess the timber supply from Woodlot Licences (15 100 cubic metres per year including currently unallocated woodlot AAC) and deciduous stands (4000 cubic metres per year). Therefore, the analysis examines timber supply from a land base currently assigned an AAC of 479 150 cubic metres per year.

In June 1994, the allowable annual cut was temporarily reduced by 16 000 cubic metres to 482 250 cubic metres per year to account for the Clayoquot Sound Land Use decision, and to ensure forest management objectives in the remainder of the TSA were not compromised. Because this was a temporary reduction (Part 15 of the *Forest Act)*, and the land use decision was not finalized when this analysis was initiated, the area to which the temporary reduction applies was included in the land base for this analysis. Therefore the analysis does not assess the implication of the Clayoquot land use decision.

The Arrowsmith TSA covers a total area of about 169 000 hectares, of which approximately 75 000 hectares are considered available for timber harvesting under current management practices. The area is dominated by stands of Douglas-fir, western redcedar and hemlock, with minor proportions of balsam, pine and spruce. Approximately one-half of the timber harvesting land base has sites classified as poor quality for growing timber.

Based on current forest management assumptions, analysis results indicate that, to avoid large rates of decline in subsequent decades, the harvest level must be reduced immediately from the existing AAC by approximately 2%, or 10 150 cubic metres per year, to 469 000 cubic metres per year. After the first decade, the harvest forecast declines from this reduced level by about 10% per decade for 3 decades to reach 346 000 cubic metres per year, 10.1% below the long-term harvest level. This harvest is maintained for 12 decades and then rises to the steady long-term level of 385 000 cubic metres per year. An alternative short-term forecast would be to harvest at the existing AAC for one decade, but afterwards the decline would be faster (12% per decade).

Even if harvesting is reduced immediately to the steady long-term level, it cannot be maintained at that level without causing large timber supply disruptions in the future. Furthermore, the sensitivity analyses indicate that harvests below the long-term level cannot be avoided even if timber yield estimates and management assumptions used in the analysis are assumed to underestimate timber supply.

Executive Summary

The most important factor contributing to the decline from the initial harvest level is the magnitude of the area reverting to the timber harvesting land base from Timber Licences. Until the reverted areas reach green-up conditions, they will limit harvesting in adjacent areas. If the Timber Licence reversions were assumed not to limit harvests on adjacent areas the current AAC could be maintained for 10 years. Harvests over the medium term — between decades 4 and 15 — are determined mostly by the large area of stands on poor quality sites (51%) that have relatively older minimum harvestable ages, which delays the availability of second growth for harvesting.

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

Sensitivity analyses indicate that short-term timber supply is sensitive to changes in existing stand yields, green-up ages, forest cover requirements (cutblock adjacency and visual quality) and the size of the timber harvesting land base. Large reductions in the initial harvest level result from increased green-up ages and more restrictive forest cover requirements for cutblock adjacency.

Long-term timber supply is slightly sensitive to moderate shifts in area between management emphasis zones (forest cover requirements), and is sensitive to changes in land base, green-up ages, managed stand yields and forest cover requirements for visual quality.

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Introduction

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

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

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

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

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

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

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

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

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

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

1 Description of the Arrowsmith Timber Supply Area

The Arrowsmith TSA is situated on the southern portion of Vancouver Island within the Vancouver Forest Region (see Figure 1). The Arrowsmith TSA covers approximately 169 000 hectares and is administered by the Duncan and Port Alberni Forest Districts (see Figure 2).

Land tenure on southern Vancouver Island surrounding the Arrrowsmith TSA is diverse. There are 28 First Nation Bands with reserves or traditional territories, 5 Tree Farm Licences (TFL)* (25, 44, 46, 47 and 54), Timber Licences, Federal and Provincial Parks, and private lands. Duncan, Nanaimo, Parksville, Port Alberni, Qualicum Beach, Tofino, Ucluelet and Victoria are major population centres within the Arrowsmith TSA. Other communities and subdivisions are scattered throughout the Arrowsmith TSA.

The economy of the area is also diverse. Important resource-based sectors are agriculture, commercial and sport fishing, forestry, recreation and tourism. Within the forest sector there are three pulp and paper mills, numerous saw-log mills, a veneer and plywood mill and a rapidly expanding number of value-added industries. The Arrowsmith TSA currently provides 8% of the total timber supply from Crown forests in the two forest districts. Timber supply for the Arrowsmith TSA is currently apportioned as 38.3% to Forest Licences, 57.8% to Timber Sale Licences, 3.1% to Woodlot Licences and 0.8% to a Forest Service Reserve.

When the analysis was initiated the allowable annual cut for the Arrowsmith TSA was 498 250 cubic metres per year. The analysis does not assess the timber supply from Woodlot Licences (15 100 cubic metres per year including currently unallocated woodlot AAC) and deciduous stands (4000 cubic metres per year). Therefore, the analysis examines timber supply from a land base currently assigned an AAC of 479 150 cubic metres per year.

In June 1994, the allowable annual cut was temporarily reduced by 16 000 cubic metres to 482 250 cubic metres per year to account for the Clayoquot Sound Land Use decision, and to ensure forest management objectives in the remainder of the TSA were not compromised. Because this was a temporary reduction (Part 15 of the *Forest Act),* and the land use decision was not finalized when this analysis was initiated, the area to which the temporary reduction applies was included in the land base for this analysis. The analysis therefore does not assess the implications of the Clayoquot land use decision.

The Arrowsmith TSA lies within three biogeoclimatic zones: Coastal Douglas-fir, Coastal Western Hemlock and Mountain Hemlock. Forests available for harvesting are dominated by stands of Douglas-fir, western redcedar and hemlock.

Since the last timber supply analysis in 1988 the land base for the Arrowsmith TSA has changed. Differences are due to land exchanges (for example, Pacific Rim National Park), updating of TSA boundaries, areas reverting from Timber Licences to the Arrowsmith TSA and area transferred from adjacent TFLs to meet commitments for the Small Business Forest Enterprise Program (SBFEP).

Tree farm licence (TFL)
Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.

1 Description of the Arrowsmith Timber Supply Area

Figure 1. Map of the Arrowsmith Timber Supply Area and the Vancouver Forest Region.

1 Description of the Arrowsmith Timber Supply Area

Figure 2. Map of the Arrowsmith Timber Supply Area and the Duncan and Port Alberni Forest Districts.

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 1994. This file contains a considerable amount of data about the thousands of pieces of forest land that make up a TSA, including the geographic location, area and nature of the forest cover (such as presence or absence of trees, number of trees, species, age and timber volume).

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

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

Removal of data for areas not contributing to the timber supply does not imply withdrawal of these areas from the Arrowsmith TSA. The B.C. Forest Service still manages the entire area of the Arrowsmith TSA (except for certain designated lands) as a forest unit that contributes a mix of timber and non-timber values. Within that integrated resource context, the timber supply is managed.

This section describes the types of areas not contributing to the timber harvesting land base. Use of the term timber harvesting land base in this report does not mean that an area is open to unrestricted harvesting activities. Rather, it implies that sites in the area are occupied by timber of sufficient economic value, and are not overly environmentally sensitive, so that timber harvesting can be accommodated with due care for other resources.

The timber harvesting land base recommendations in the Vancouver Island Land Use Plan and Clayoquot Sound Land Use Decision have not been incorporated into this analysis. Also not included are the Clayoquot Scientific Panel recommendations relating to Forest Practices Standards in Clayoquot Sound. This analysis also does not take into account changes to management that may be required under the Forest Practices Code. Future analyses will account for land use decisions, changes in management practices and will be undertaken as quickly as possible.

Areas on which timber harvesting is not expected to occur, given current forest management in the Arrowsmith 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 and recreation areas) and forest land not administered as part of the Arrowsmith TSA (for example, Woodlot Licences*, Timber Licences and TFLs).

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.

Woodlot licence
Woodlot licences are included in the TSA and a portion of the AAC determined for the TSA is apportioned to woodlot licences. Each woodlot licence has an AAC determined for it on the basis of its timber inventory and productive capacity. These areas and all of the apportionment have been excluded from the analysis.

- non-forest areas — areas not capable of growing productive forest cover (for example, rock, swamp and alpine areas).
- non-commercial areas — areas occupied by non-commercial tree or brush species.
- environmentally sensitive areas (ESA)* — portions of the areas classified as sensitive are considered unavailable for timber harvesting.
- riparian areas* — river-, stream- and lake-side buffers for the protection of fish and wildlife habitat and water quality.
- Cowichan Lake Research Station — area set aside for the research station.
- Camper Creek — Crown land being transferred to TFL 46 in exchange for Nitinat Triangle Park lands.
- Parkinson Creek Park — land transferred from the former Sombrio Timber Licence to become part of a Class A provincial park.
- experimental plots — areas that contain research plots that may not be disturbed or are not available for harvesting using current management practices.
- 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.

Environmentally sensitive areas
Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to establishing a new tree crop, or areas where timber harvesting may cause avalanches.
Riparian area
Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Inoperable areas
Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.

- New Island Highway — areas removed from the productive forest land base for the New Island Highway.
- deciduous forest types — areas dominated by deciduous species, which are not currently used in the area evaluated in this analysis.
- non-merchantable forest types* — areas occupied by timber stands of low volume or with low timber growing potential.
- existing roads, trails and landings — forest land lost to timber production due to past access development and harvesting.
- not satisfactorily restocked (NSR)* areas — these areas are initially removed, but once replanted the portion of the NSR area still considered available for timber production is added back into the timber harvesting land base.
- future roads — future losses of productive forest land due to road construction. These areas are deducted over time as future harvesting occurs.

A more detailed description of these categories, including specific criteria for removal are located in Appendix A, "Description of Data Inputs and Assumptions."

Table 1 summarizes the areas in each category, and shows the area of timber harvesting land base.

Operability
A classification of the availability of an area for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Non-merchantable forest types
Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.
Not satisfactorily restocked (NSR)
An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the B.C. Forest Service, Silviculture Branch. If the expected regeneration delay (the period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees) has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.

2 Information Preparation

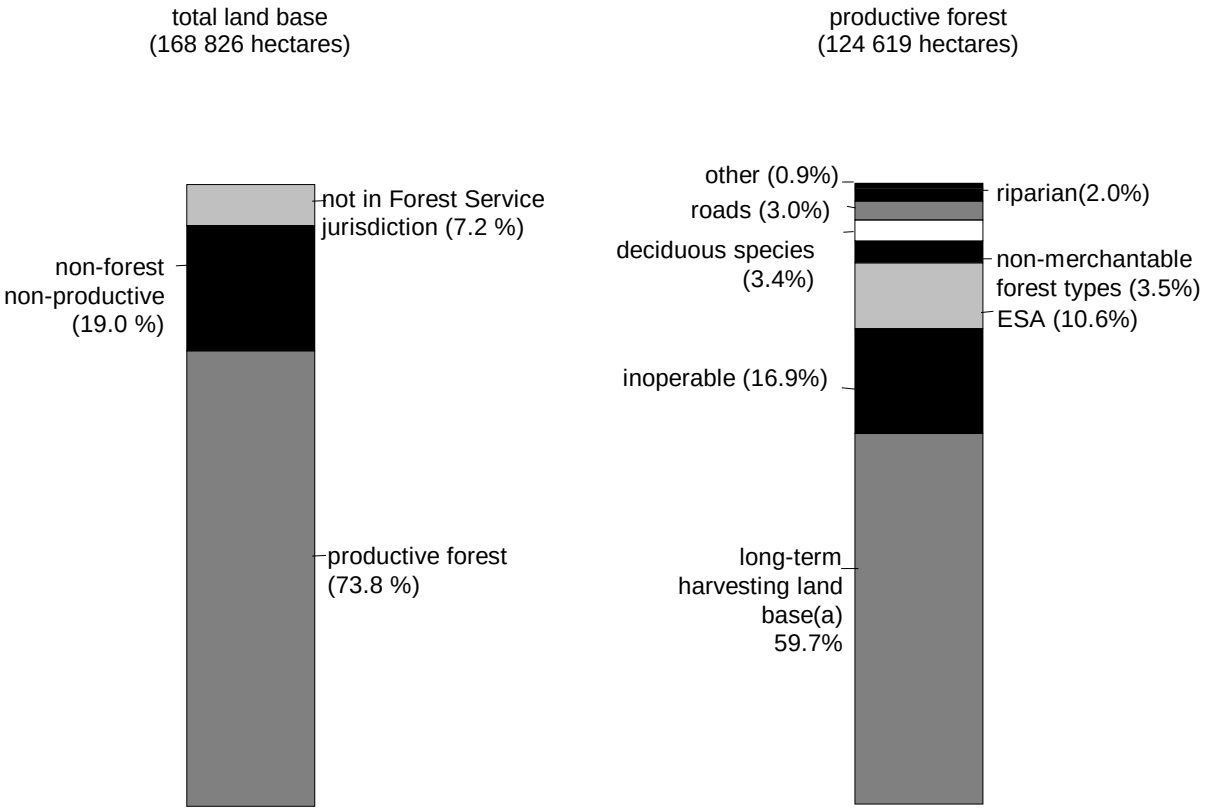
Table 1. Timber harvesting land base, Arrowsmith TSA

Classification	Area (hectares)	Per cent of total TSA area	Per cent of productive forest area
Total Arrowsmith TSA Area	168 826	100.0	
Not managed by B.C. Forest Service	– 12 105	7.2	
Non-forest	– 32 102	19.0	
Total Productive forest managed by Forest Service[a] (Crown forest)	124 619	73.8	100.0
Reductions To Productive Crown Forest			
Non-commercial cover (brush)	26	<0.1	<0.1
ESA	13 229	7.8	10.6
Riparian	2 448	1.5	2.0
Cowichan Lake Research Station	143	0.1	0.1
Camper Creek	605	0.4	0.5
Parkinson Creek Park	51	<0.1	<0.1
Experimental Plots	221	0.1	0.2
Inoperable	21 009	12.4	16.9
New Island Highway	82	<0.1	<0.1
Deciduous leading stands[b]	4 268	2.5	3.4
Non-merchantable forest types	4 340	2.6	3.5
Existing roads, skid trails and landings	2 953	1.7	2.4
NSR	1 446	0.9	1.2
Total current reductions[c]	– 50 821	– 30.1	– 40.9
Additions to land base			
NSR	1 446	0.9	1.2
Current timber harvesting land base	75 244	44.6	60.4
Future roads reductions (estimate)	– 808	– 0.5	– 0.6
Long-term timber harvesting land base (includes 7 544 hectares of Timber Licences)	74 436	44.1	59.7

(a) Productive forest area includes the 7544 hectares of Timber Licences in the harvesting land base.
(b) Alder has been included in this category. The timber supply analysis did not examine alder wood supply.
(c) The reductions to the productive Crown forest are sequential and each reduction is net of any overlap with categories listed above it.

2 Information Preparation

Figure 3 summarizes the total and productive land base categories for the Arrowsmith TSA. Figure 3 shows that about 74% of the Arrowsmith TSA is Crown forest land, of which 60% is available for timber harvesting (see Figure 4). Also, the two largest reductions to the timber harvesting land base are for inoperable area and environmentally sensitive areas (ESA). The timber harvesting land base accounts for about 44% of the total TSA land base (see Table 1).



(a) Includes NSR and Timber Licence areas.

Figure 3. Classification of the total and productive forest land bases — Arrowsmith TSA, 1995.

2 Information Preparation

Figure 4 shows a breakdown of the timber harvesting land base by dominant tree species and maturity. The timber harvesting land base in the Arrowsmith TSA is comprised mainly of Douglas-fir, redcedar and hemlock with a very small component (6%) of balsam, spruce and pine. Overall, there is an almost even split between stands younger (49%) and older (51%) than the minimum harvestable ages. Note that most of the Douglas-fir stands are located in the eastern portions of the Arrowsmith TSA (generally east of Port Alberni and Lake Cowichan) whereas most of the hemlock, cedar, balsam and spruce stands are located in the western portion.

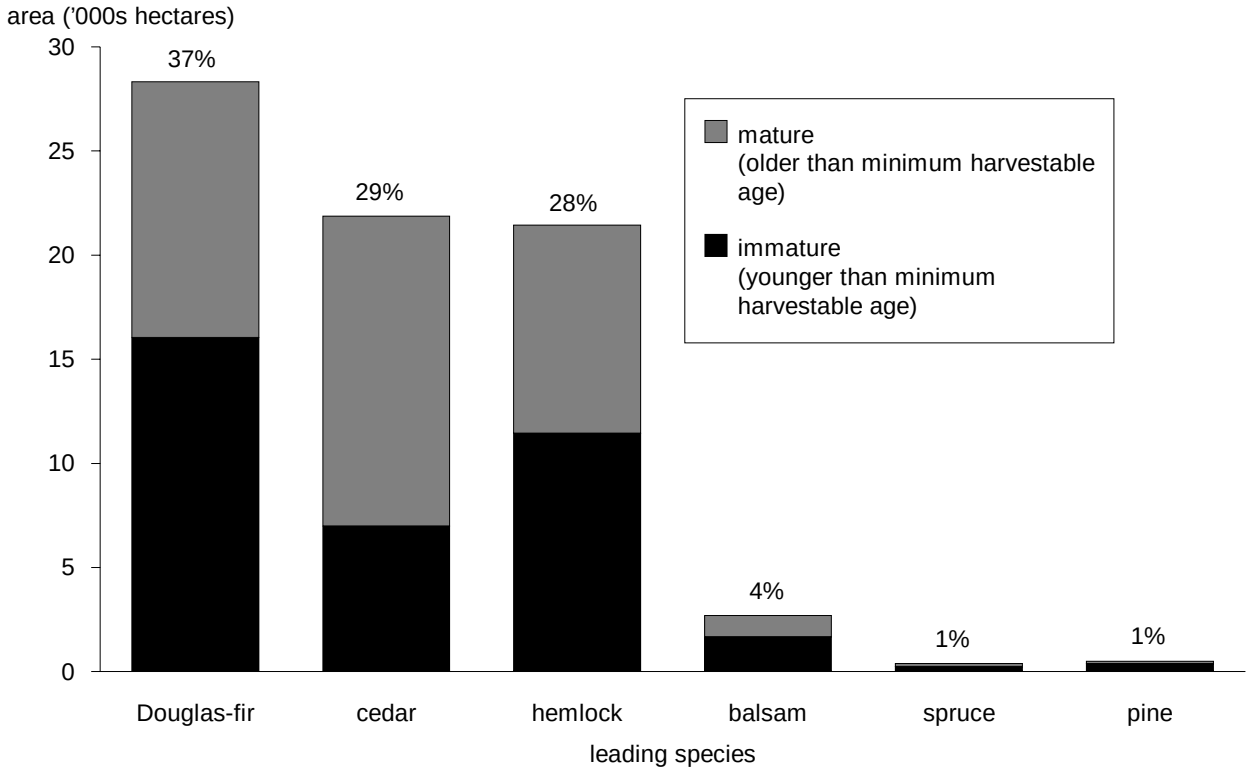


Figure 4. Area by dominant tree species and maturity — Arrowsmith TSA, timber harvesting land base, 1995.

2 Information Preparation

Figure 5 shows a breakdown of the timber harvesting land base by timber growing productivity, and maturity. Most of the forest consists of poor sites (48%) which are mostly cedar or hemlock stands (67%). Good and medium sites are dominated by Douglas-fir stands (56%).

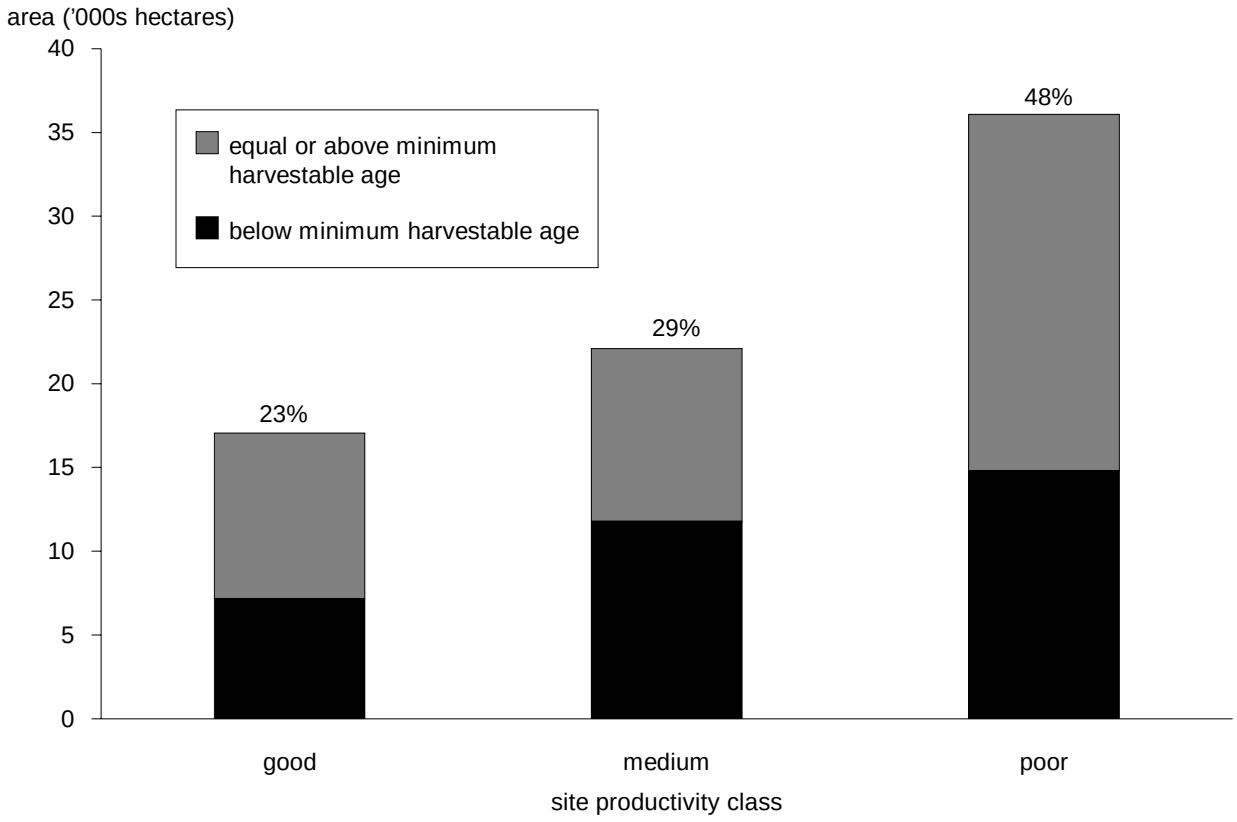


Figure 5. Area by site productivity and maturity — Arrowsmith TSA, timber harvesting land base, 1995.

2 Information Preparation

Figure 6 shows the current age class distribution for the Arrowsmith TSA timber harvesting land base. The area shown as aged zero and younger is comprised of 954 hectares of NSR and 7544 hectares of timber licences. The figure illustrates the large amount of young stands (age 1 to 80 years) and old stands (age 200 years and up). The young stands are dominated by Douglas-fir in the eastern portion of the Arrowsmith TSA; the older stands are dominated by western redcedar and hemlock stands in the western portion. The older stands are mostly of poor site quality. This east-west distinction by maturity class, and species composition could have significance if a specific mix of species from particular locations (harvest profile) is desired, since the bulk of currently available timber consists of very old western redcedar and hemlock in the western portion of the Arrowsmith TSA.

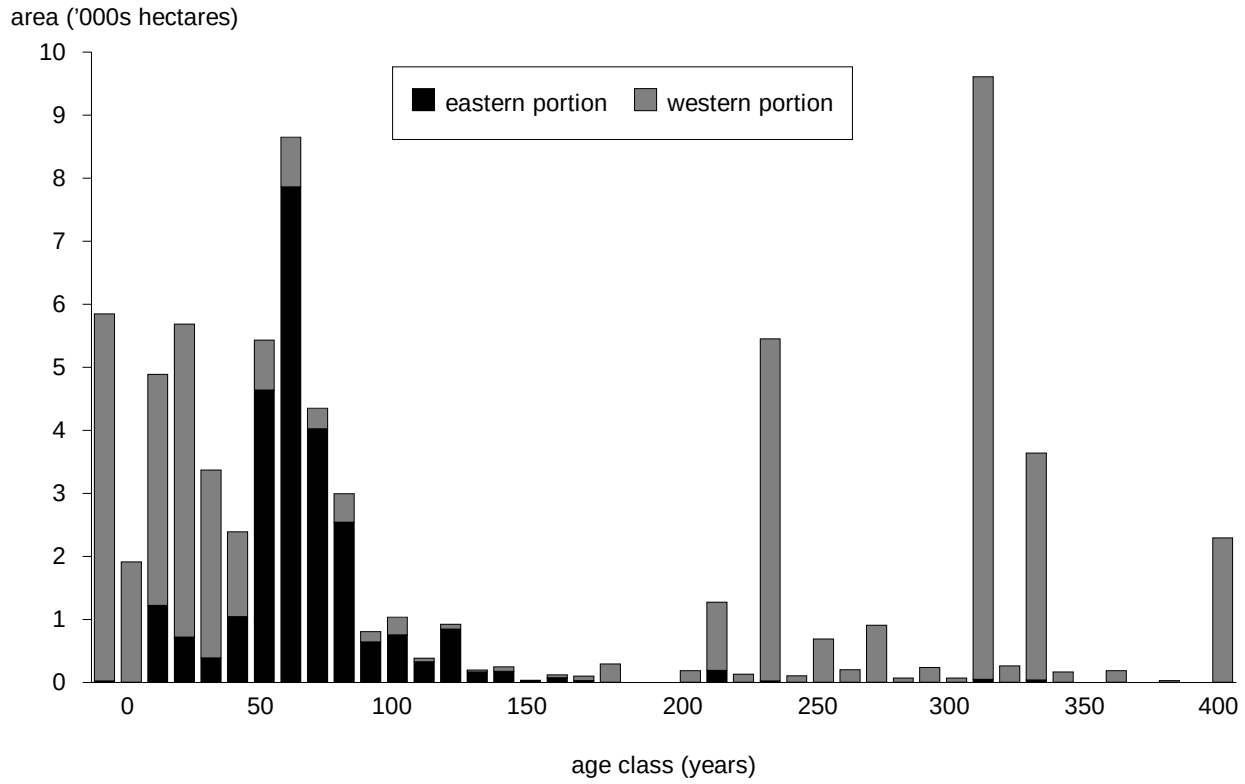


Figure 6. Current stand age composition — Arrowsmith TSA timber harvesting land base, 1995.

2.2 Timber growth and yield

Timber growth and yield refers to the prediction of the growth and development of 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. See Appendix A, "Description of Data Inputs and Assumptions" for more details on utilization.

Timber volumes applied to existing stands in this analysis are based on the Variable Density Yield Prediction (VDYP) model developed by the B.C. Forest Service, Inventory Branch. This model provides estimates of stand volume according to age. Timber volumes predicted for regenerated second-growth stands are based on the Table Interpolation Program for Stand Yields (TIPSY) model developed by the B.C. Forest Service, Research Branch. 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 prior to the implementation of the Forest Practices Code. The *Coast Planning Guidelines*, Vancouver Forest Region were used in the Arrowsmith TSA to guide operational planning. These guidelines served as an umbrella document for management initiatives and incorporated existing integrated resource management guidelines* such as the *Coastal Fisheries/Forestry Guidelines* and the *Landscape Management Guidelines*. Further details on the required management practices are found in the *Forest Licence Management Plan Guide*, Vancouver Forest Region and the *Development Plan Guide*, Vancouver Forest Region. Staff in the Duncan and Port Alberni Forest Districts and the Vancouver Forest Region defined current practices as described in the following management assumptions*.

- Basic silviculture levels — reforestation activities required to establish free-growing* stands. Most areas in the Arrowsmith TSA are harvested using a clearcut harvesting* system and restocked by planting or natural regeneration.
- Incremental silviculture levels — commercial thinning and fertilization are practiced in Arrowsmith TSA. However, at the time this analysis was performed insufficient data was available to determine the effects on managed stand yields.
- Immature plantation history — existing harvested and restocked areas that will be assigned a volume estimate based on managed stand yield tables.
- Utilization levels — the minimum size of tree that must be removed at harvest. These are specified by a maximum stump height and minimum diameters at the tree base and top.

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

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

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

Clearcut harvesting
A harvesting method whereby all trees that meet utilization standards are harvested. The harvested site is then regenerated to acceptable standard by appropriate means including planting and natural seeding.

- Minimum harvestable age — the time it takes for stand to achieve sufficient volume or condition to be harvested. The minimum harvestable age defines the youngest age a specific type of stand is expected to become harvestable. The actual age at which harvest occurs ranges upwards from the minimum depending on factors including the ages of other stands, limits on overall harvest level and forest cover requirements*. For this analysis the minimum harvestable ages were set as the age at which stands reach an top height of 30 metres in the Duncan Forest District, and a merchantable volume of 300 cubic metres per hectare in the east of the Port Alberni Forest District and 400 cubic metres per hectare in the west.
- Unconventional harvesting methods — 3424 hectares within the timber harvesting land base fall within areas that will be harvested using specialized long-line or helicopter systems. Harvesting in these areas is limited to ensure that at most 20% of the area is less than 3 metres tall (5-pass harvest system). Additionally, the minimum harvestable age was set as the time it takes for stands to attain a merchantable volume of 600 cubic metres per hectare which reflects the operability requirements for these stands.
- Cutblock adjacency* and green-up* — the *Vancouver Forest Region Coast Planning Guidelines* specify that previously harvested stands must reach a free-growing state or green-up of 3 metres in height, before adjacent stands may be harvested. To represent these guidelines, harvesting in these areas is limited to ensure that at most 25% of the area is less than 3 metres tall, (4-pass harvesting system). The guidelines also contain requirements for cutblock and leave area size. The purpose of the green-up period and cutblock adjacency requirements is to prevent timber harvesting from becoming overly concentrated in an area at any time.

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

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

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

- Visual quality — 34% of the timber harvesting land base is being managed for visual quality. Maintaining visual quality requires that visible evidence of harvesting be kept within limits. Guidelines are stated in terms of the maximum proportion of an area that may be less than 5 metres tall (the visually effective green-up condition). The proportion depends on the specific visual quality objective (VQO)* and the visual sensitivity*. Areas managed for visual quality fall into three categories: 1) retention VQO* where visible evidence must be minimal; 2) partial retention VQO* where harvesting may be noticeable, but not dominant; and 3) modification VQO* where harvesting may be visually dominant, but must blend with the natural landscape. Appendix A, "Description of Data Inputs and Assumptions" contains a detailed description of the specific objectives that apply to these categories.
- Forest health and unsalvaged losses* — expected timber losses due to fire, pest (insect, disease and animals) and wind damage. Unsalvaged losses were estimated to be 3062 cubic metres per year. Also, managed stand yields for Douglas-fir were adjusted to account for the incidence of *Phellinus weirii* root rot in plantations.

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

The above discussion outlines three main forest management emphases zones within the Arrowsmith TSA:

- Integrated Resource Management (IRM) where cutblock adjacency objectives apply.
- Areas where unconventional harvesting systems are employed, and where objectives are similar to the IRM zone but cutblock adjacency is more restrictive.
- Visual quality management.

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

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

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

Partial retention VQO
Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity.

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

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

2 Information Preparation

At the time of analysis, all forested areas in the Arrowsmith TSA were managed according to the *Vancouver Forest Region Coast Planning Guidelines.* As outlined, some areas were subject to additional guidelines to emphasize specific resource values such as visual quality.

Figure 7 displays the per cent composition of the timber harvesting land base according to the main management emphasis and zones.

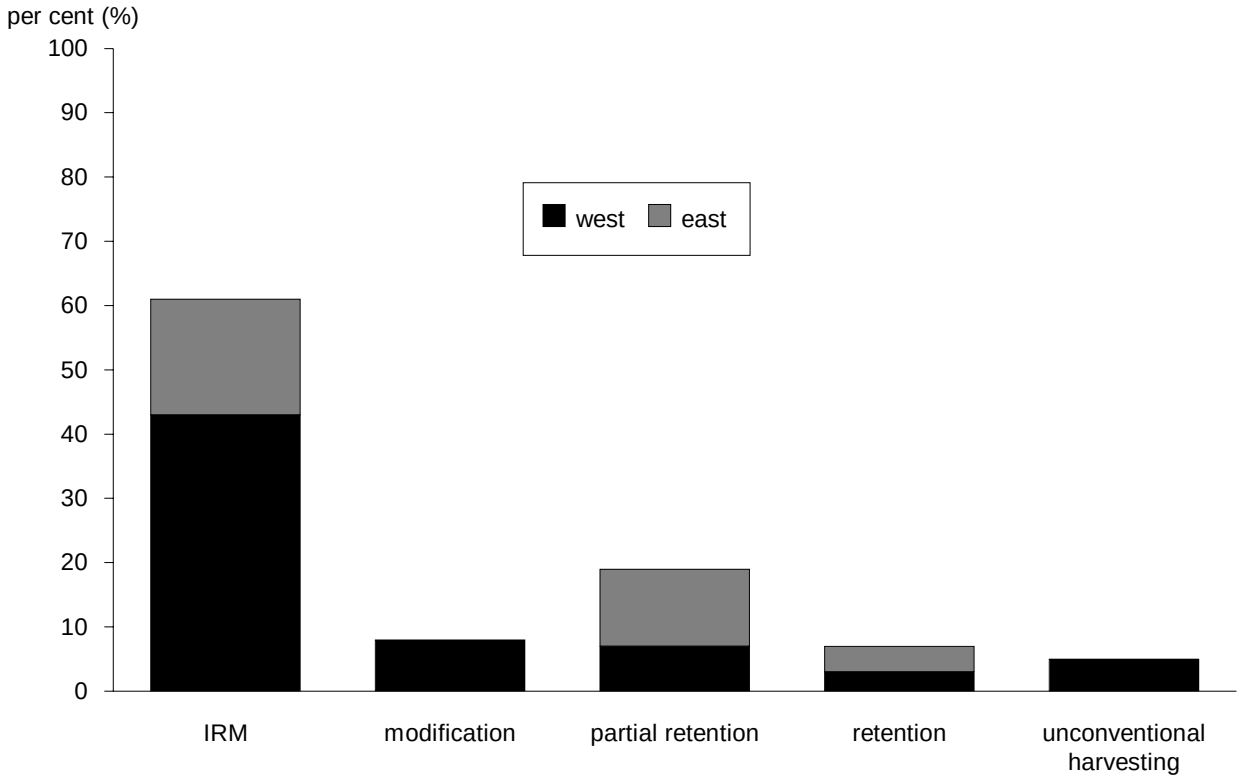


Figure 7. Composition of the timber harvesting land base by major management emphasis and zone — Arrowsmith TSA, 1995.

3 Analysis Methods

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

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

This type of analysis is used to determine the timber supply implications of a particular timber harvesting regime. The results of the analysis are especially important in determining allowable annual 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 information gives field staff only very limited guidance in the design of operational activities such as harvesting block location and silviculture planning, it does help ensure that the timber harvest level supports, rather than hinders, sustainable forest management in the field.

4 Results

This section presents results of the timber supply analysis for the Arrowsmith 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 Analyses."

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

4.1 Base case harvest forecast

Figure 8 shows the base case harvest forecast*. The initial level of 469 000 cubic metres per year is 10 150 cubic metres per year (2.0%) lower than the current AAC. After the first decade, the harvest falls by about 10% per decade until the beginning of decade 4 when it reaches 346 000 cubic metres per year, about 10.1% below the long-term harvest level*. The harvest level remains at this level for 12 decades before rising to the long-term harvest level of 385 000 cubic metres per year. Overall, there is a 18% decline from the initial harvest level to the long-term level achieved in decade 16. The long-term level is 26.6% higher than could be achieved if future stands were predicted to grow at the same rate as did the existing older forest. The long-term level reflects predictions of higher timber growth due to forest management.

The estimated unsalvaged losses to fire, wind and pests is approximately 3000 cubic metres per year and has been subtracted from all harvest forecasts shown in this report.

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

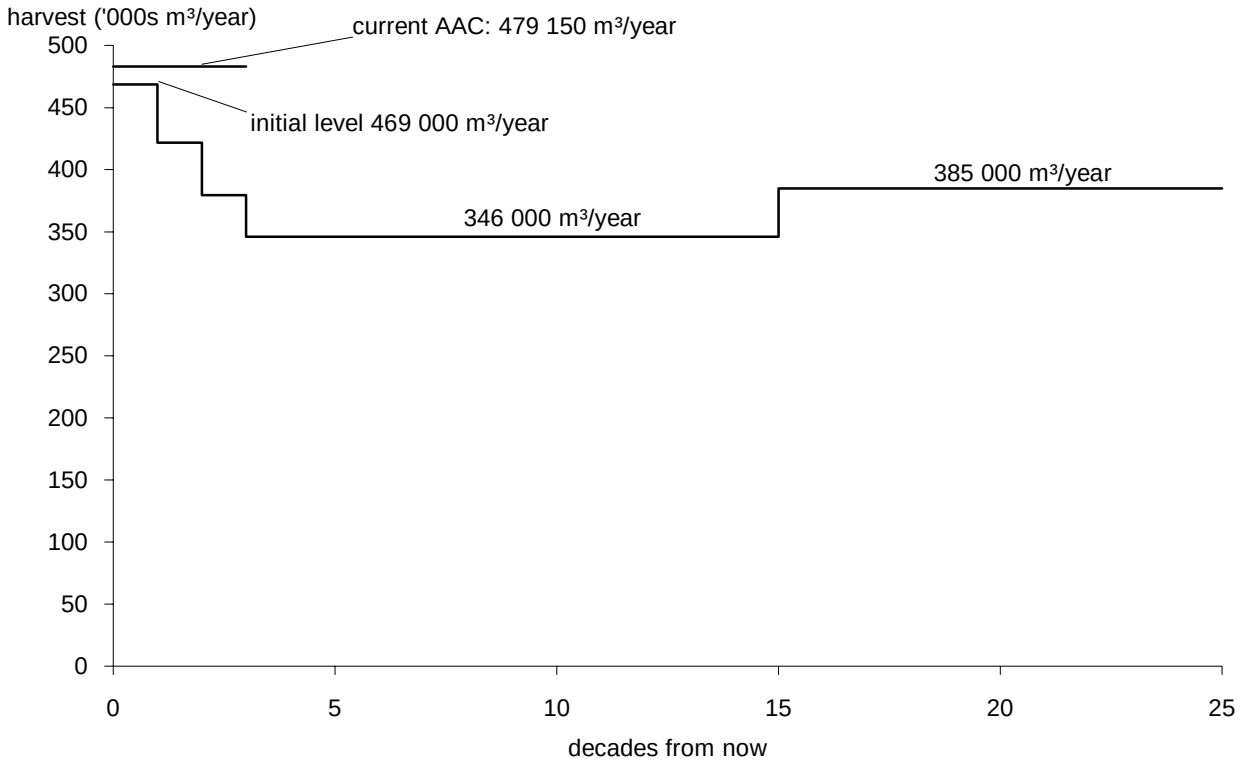


Figure 8. Base case harvest forecast — Arrowsmith TSA, 1995.

The base case harvest forecast shown is only one of many possible harvest flows given current forest management assumptions. Alternative harvest flows such as starting the harvest at a different level, delaying the decline, or reducing the rate of decline will be discussed in Section 5.1, "Alternative initial harvest levels and harvest flows over time."

Several important factors affect the timber supply forecast. The most important is that during the second decade 50% of the Timber Licence area, which constitutes 5% of the long-term harvesting land base, reverts back to the Arrowsmith TSA. Since these areas will require some time to reach a green-up condition, harvesting in adjacent areas will be limited. The amount of area that can be harvested in the first decade is limited so that in the second decade, forest cover objectives* can be met. However, if the Timber Licences were assumed not to limit harvesting in adjacent areas, harvests could start at the current AAC with subsequent declines of 10% per decade.

Another important factor affecting the timber supply forecast is the transition of harvesting from existing stands to second-growth stands in the IRM zones during decades 10 through 15. The decline to a harvest below the long-term harvest level (decades 4 through 15) occurs because there is not yet sufficient timber available from second-growth stands to offset the decreasing timber supply available from existing stands. The shortage of available second-growth timber during this time is compounded by the forest cover requirements in the partial retention and retention VQO zones.

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

4 Results

A harvest forecast beginning at the current AAC is possible, however the harvest must drop by at least 12% after the first decade. Therefore, reducing the initial harvest level to below the AAC reduces the rate of decline to the second decade harvest level.

The long-term level is defined as the harvest that will maintain timber growing stock* at an even level so that harvesting can continue at a constant level in perpetuity (Figure 9). A continually declining growing stock would signify that timber is being harvested at a rate above the productive capability of the land.

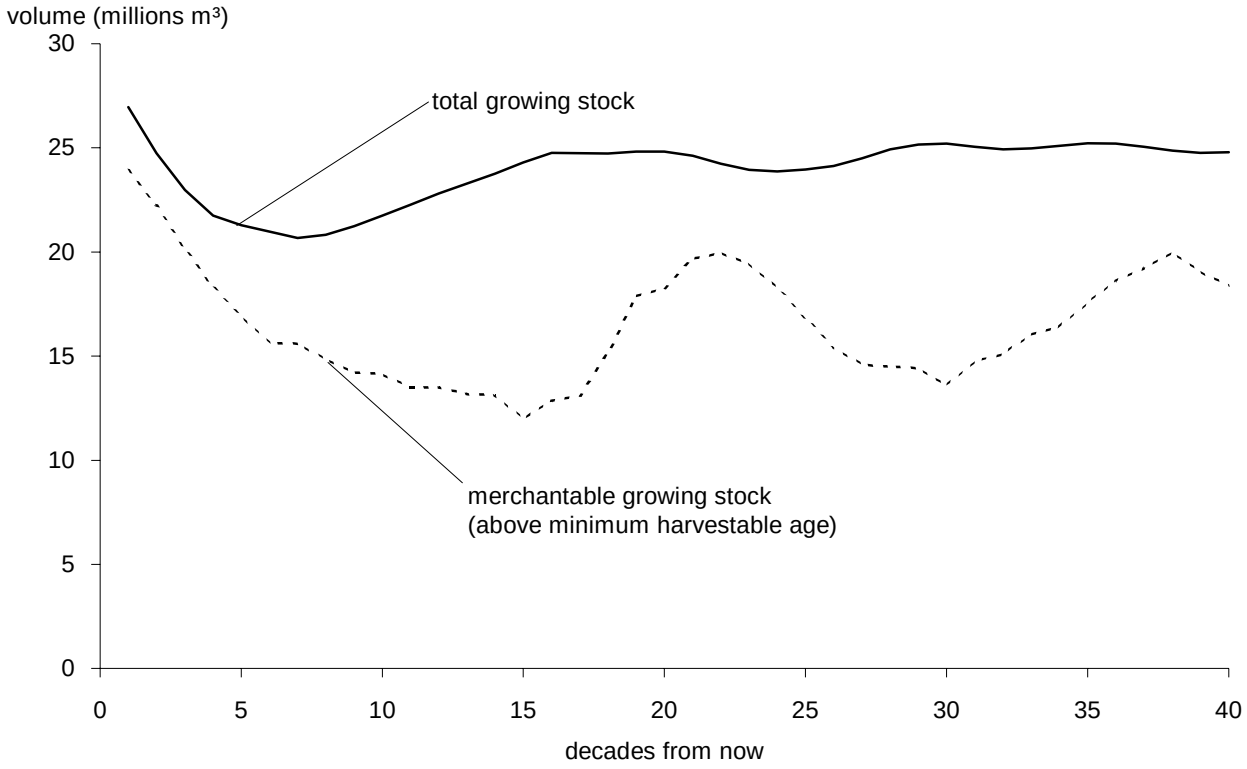


Figure 9. Changes in timber growing stock over time — Arrowsmith TSA base case, 1995.

The long-term harvest level is not the same as a theoretical maximum sustainable harvest level based on harvesting at the age of maximum average growth, or maximum mean annual increment (MAI)*. The theoretical level, about 449 000 cubic metres per year, is not achieved since the projected harvest of areas often does not occur at ages which would maximize volume yield over the long term. This results because of the applied minimum harvestable ages, forest cover objectives and the imposed harvest flow pattern. Also, harvest forecasts are reduced by the estimated volume losses to fire, pests and other destructive agents.

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

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.

4.2 Area, average volume and average age harvested

Figure 10 shows how the annual area harvested would change over the next 400 years, if the base case harvest forecast were followed. Figure 11 shows changes in the average volume per hectare harvested over the same period. These two graphs show relatively stable timber supply flow patterns for the first 15 decades. Initially the area harvested is somewhat higher, reflecting a higher annual harvest level, while the average volume per hectare harvested is relatively constant.

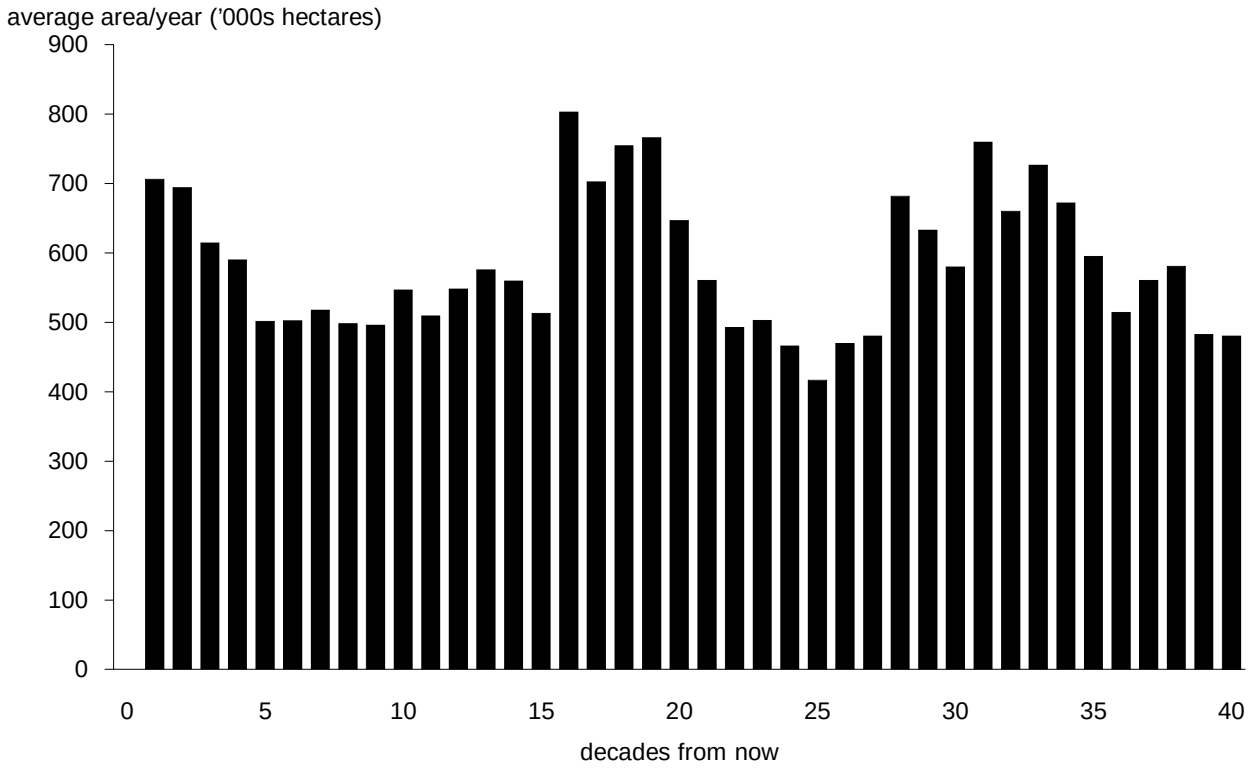


Figure 10. Area harvested over time — Arrowsmith TSA base case, 1995.

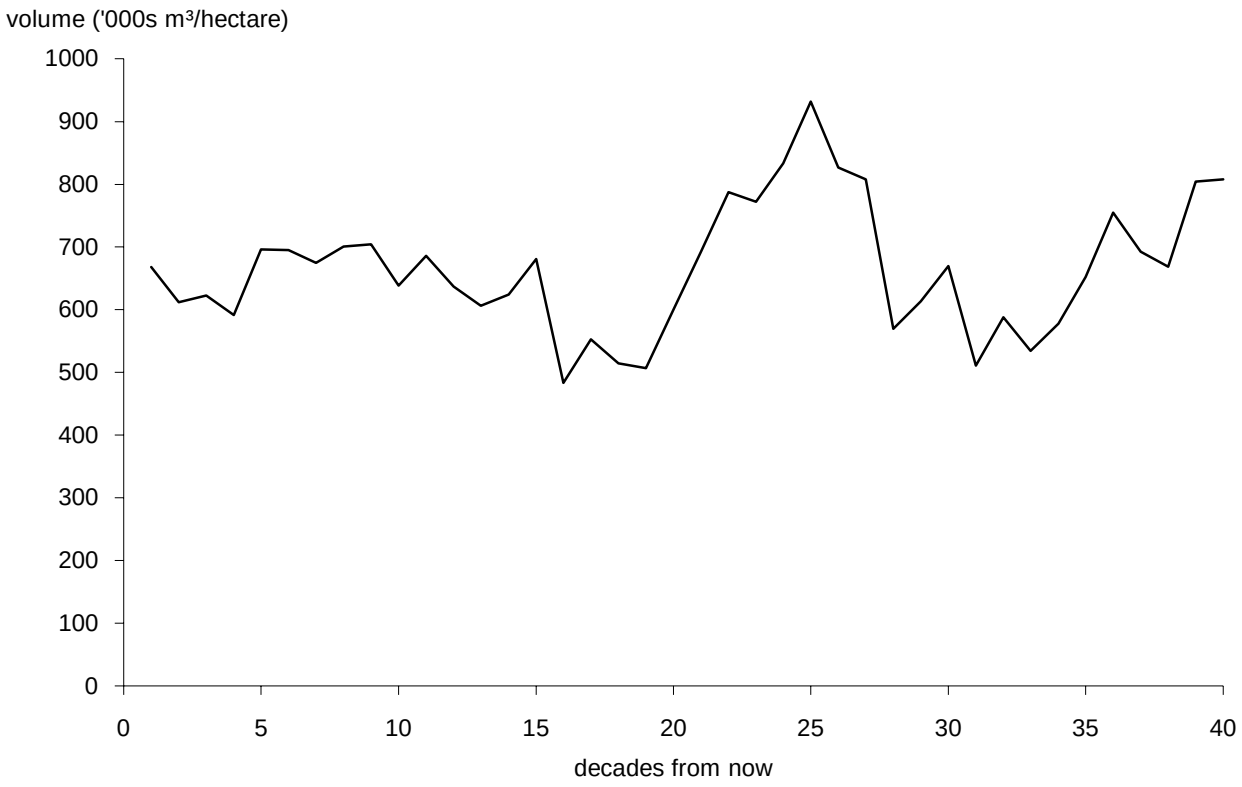


Figure 11. Average volume harvested over time — Arrowsmith TSA base case, 1995.

After period 15, a fluctuating pattern becomes apparent in both area and average volume per hectare harvested. In 15 decades from now, the majority of the harvest comes from poorer quality sites that will have just reached minimum harvestable age. Since these sites are predicted to produce relatively small volumes per hectare, the corresponding area harvested to meet the harvest target is higher. Conversely, in 24 decades from now, the harvest comes mostly from higher quality sites that are projected to produce high volumes per hectare. Therefore, at that time, the area harvested is lower. The fluctuating pattern continues into the future, corresponding to the different timing of availability and timber production in different types of forest.

Figure 12 shows changes in the average harvested age over the next 400 years. The graph illustrates the transition from existing to managed forest stands during the first 15 decades. Also, during the second decade there is temporary dip caused by the reversion of approximately 3400 hectares of recently harvested timber licences to the timber harvesting land base. Because this area is in a non-greened up condition, harvesting in many areas is constrained and achieving the harvest requires harvesting of many stands that are less than 200 years old.

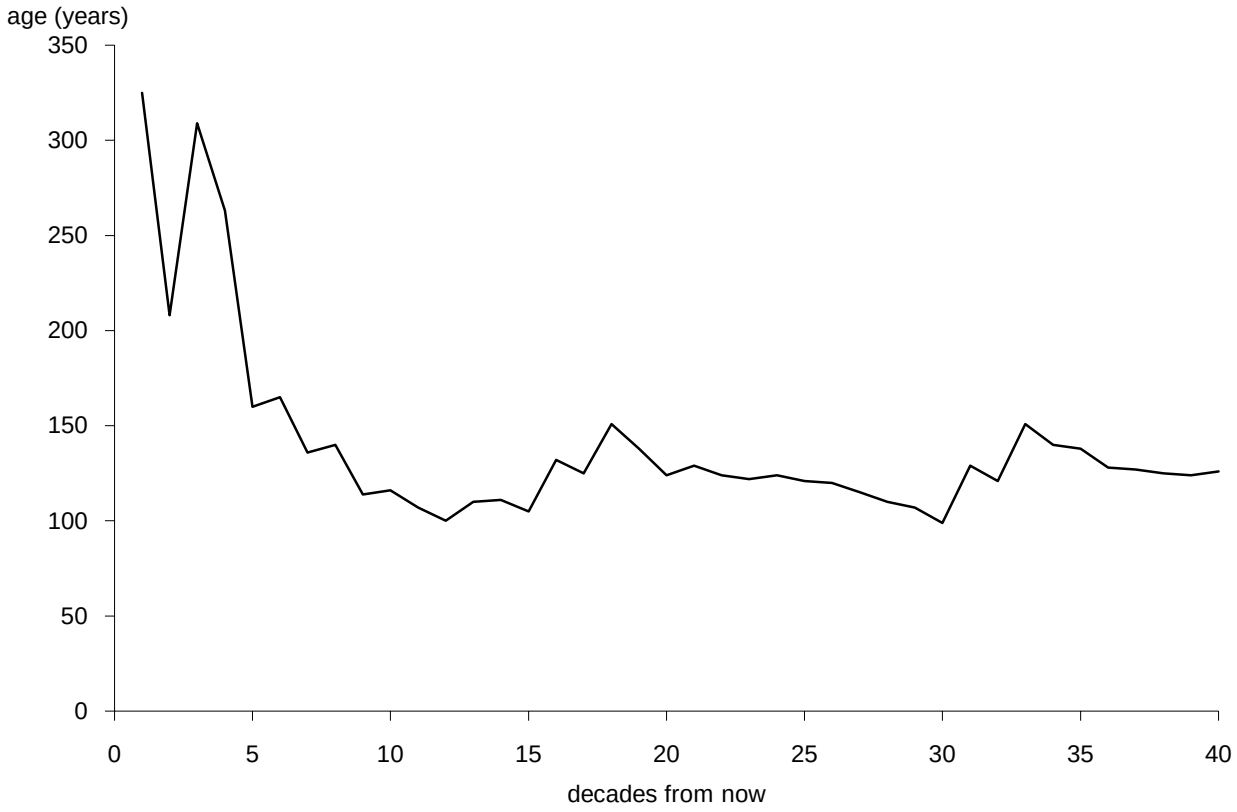


Figure 12. Average age harvested over time — Arrowsmith TSA base case, 1995.

The periodic peaks that appear from decade 15 onwards are due to older stands being harvested from partial retention and retention VQO zones, and from forests that have relatively old minimum harvestable ages (for example, the minimum harvestable age for Douglas-fir poor sites is 117 years while that for good sites is 45 years).

4.3 Age class composition over time

The charts in Figure 13 show how the age composition of forests within the timber harvesting land base would change over the next 250 years under the base case harvest forecast.

Currently, the timber harvesting land base comprises almost equal areas of forest at or above minimum harvestable age and areas younger than harvestable age. Most of the merchantable forest exceeds 200 years of age. Over time most of the very old forest is harvested, and the bulk of the area remains 120 years old or younger. The disturbance limits in the partial retention and retention VQO zone restrict the rate at which the forest can be harvested. This results in some stands being maintained in older age classes throughout the forecast period.

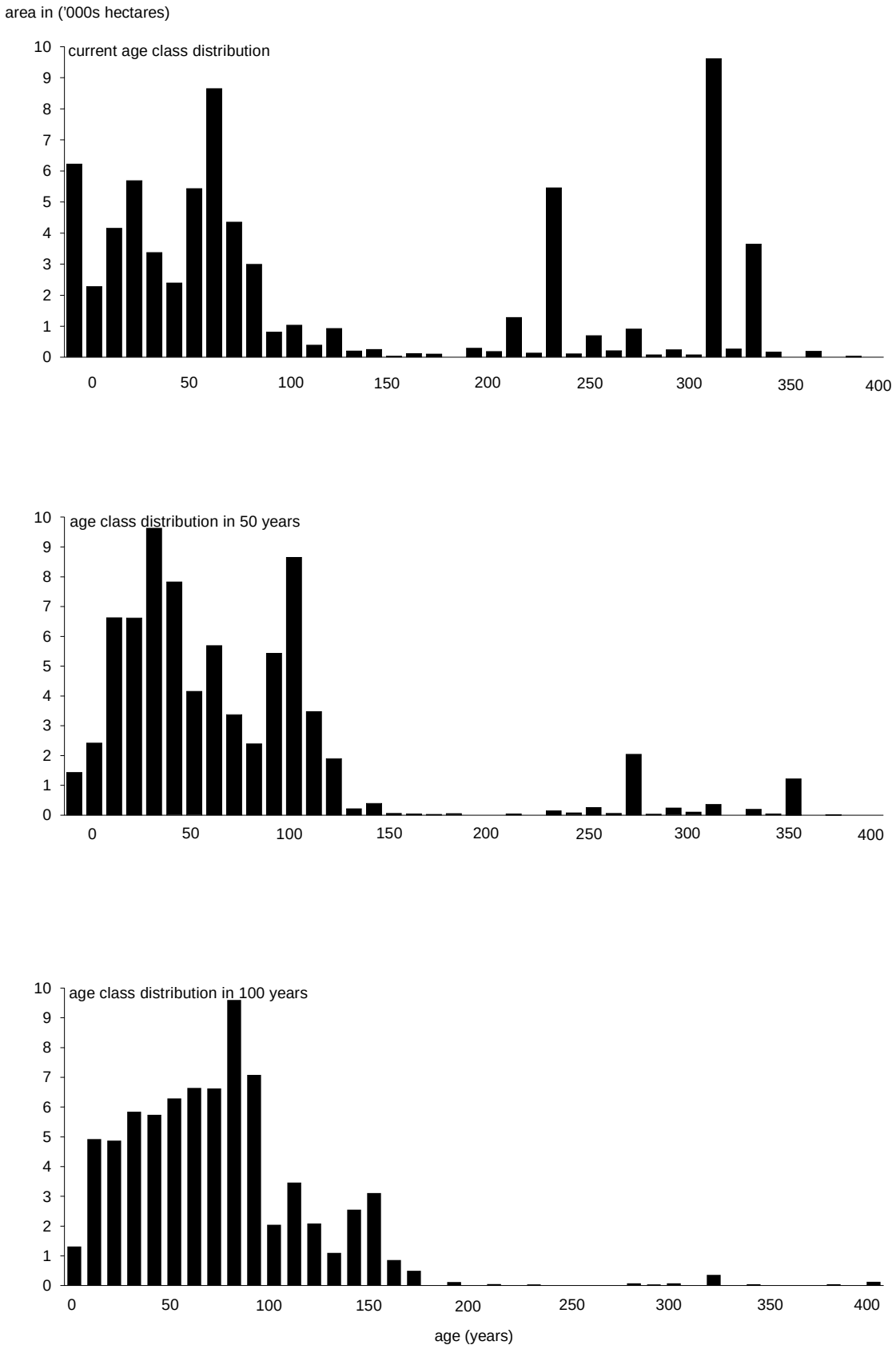


Figure 13. Stand age class composition over time — Arrowsmith TSA base case, 1995.

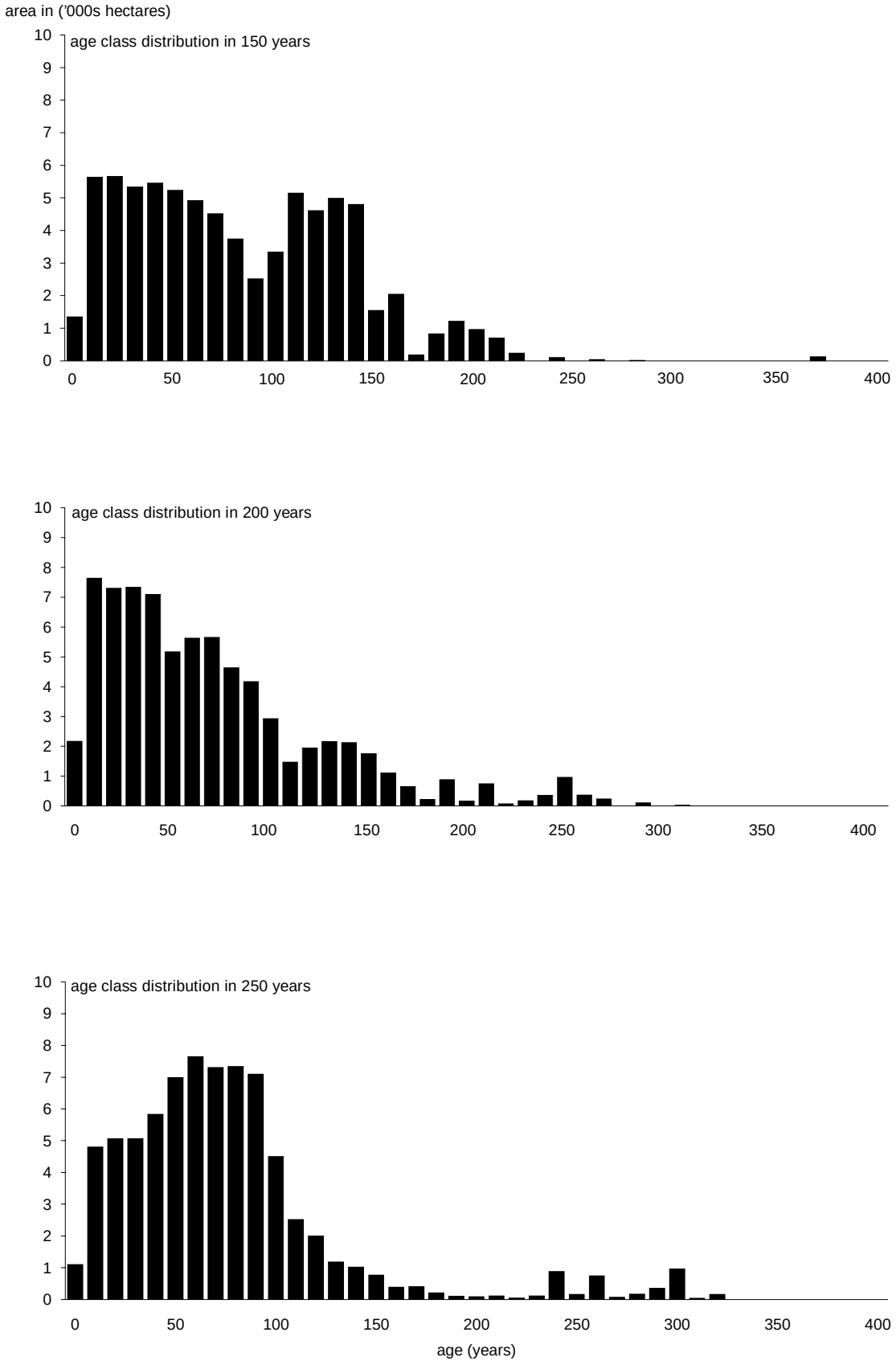


Figure 13. Stand age class composition over time — Arrowsmith TSA base case, 1995 (concluded).

5 Timber Supply Sensitivity Analyses

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

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

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

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

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

In this section, results of several sensitivity analyses are discussed. The results that are based on current forest management assumptions (shown in Figures 8 to 13) are referred to as the base case.

5.1 Alternative initial harvest levels and harvest flows over time

The base case harvest forecast shown in Figure 8 was defined using criteria such as maximum rate of decline per decade, avoidance of large harvest shortfalls, and maintenance of a fairly constant growing stock level over the long term. While the last of these criteria is linked to maintaining the productivity of forest land, and is therefore a legislated requirement, the other criteria are not requirements, rather they are attempts to avoid both excessive changes from decade-to-decade, and significant timber shortages in the future which might limit future options. However, there are many possible harvest flows, with different decline rates, starting harvest levels, and potential trade-offs between short-term and long-term harvests.

5 Timber Supply Sensitivity Analyses

The initial harvest level of the base case harvest forecast, shown in Figure 8 and discussed in Section 4, "Results," is about 2% below the current AAC. The solid line in Figure 14 shows the result of setting the initial harvest level at the current AAC. After the first decade the harvest must fall by 12% to avoid violating forest cover objectives in the second decade. Harvest levels then decline by 13% and 6.5% respectively, in the third and fourth decades. The harvest follows the base case level from decade 4 onwards. In summary, if harvests start at the current AAC there is a larger decline from the first to the second decade, and a slightly lower harvest in the medium term (decades 4 — 15).

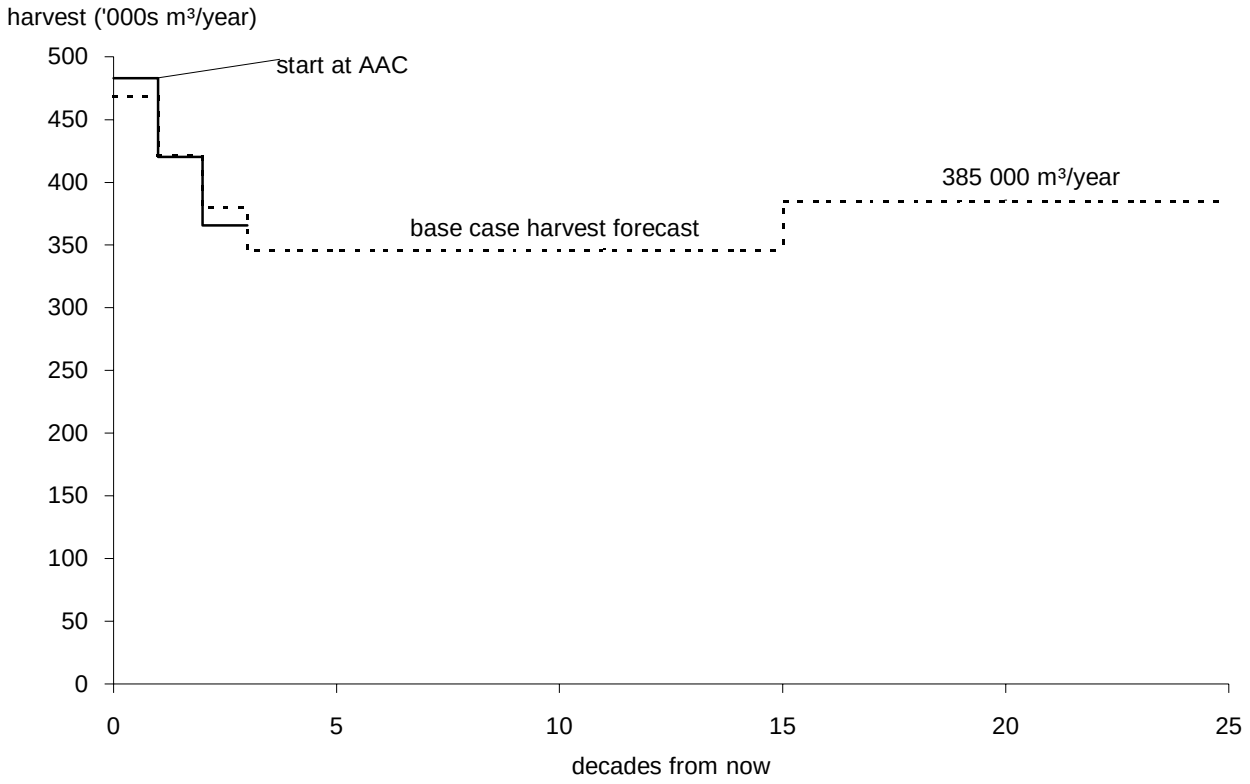


Figure 14. Alternative harvest flow patterns using base case data, starting at current harvest level — Arrowsmith TSA, 1995.

5 Timber Supply Sensitivity Analyses

The harvest forecast resulting when the initial rate of harvest is set at the steady long-term harvest level is shown by the dashed line in Figure 15. The steady long-term harvest level cannot be maintained for the entire 250 year analysis horizon. The timber supply shortfalls between decades 10 and 15 occur both because the partial retention and retention VQOs restrict availability of merchantable timber to achieve forest cover objectives, and there is insufficient second-growth timber available in the IRM and modification VQO zones.

The solid line in Figure 15 shows that if the initial harvest level is set at the long-term harvest level, avoiding the severe timber supply disruption between decades 10 and 15 requires a 10% reduction to 346 000 cubic metres per year during decades 6 though 15.

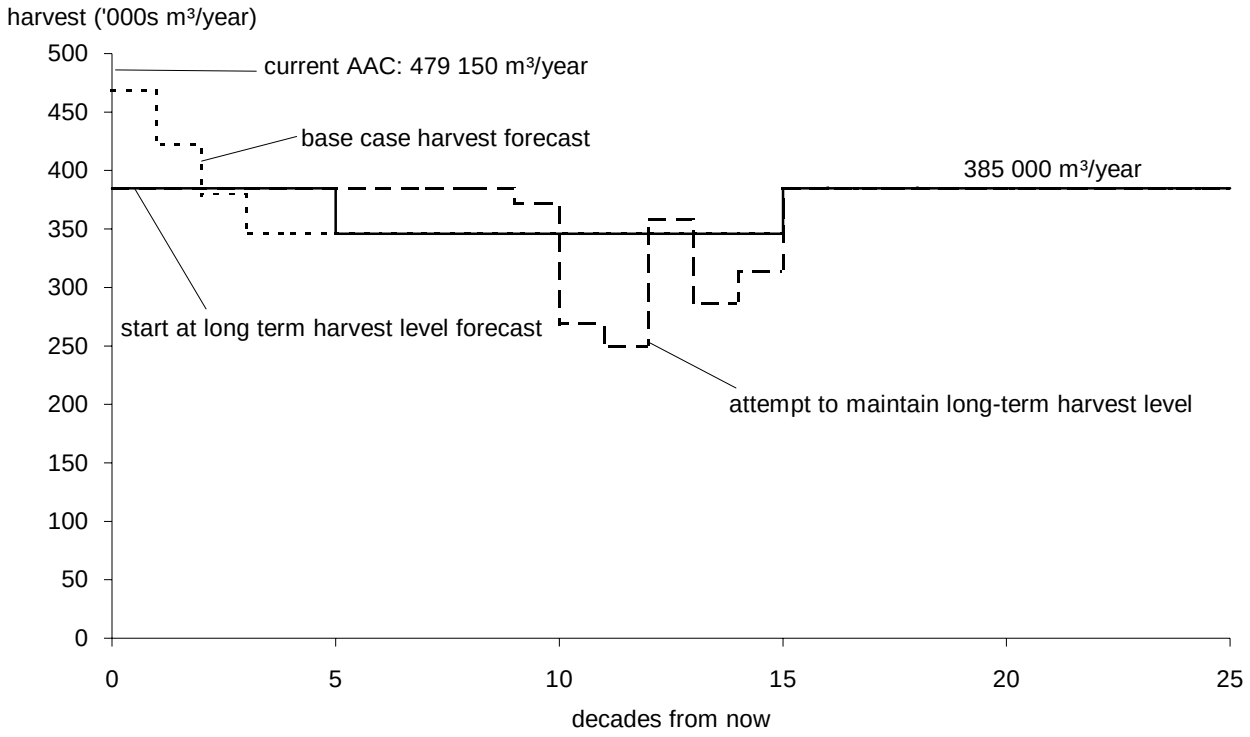


Figure 15. Alternative harvest flow patterns using base case data, starting at long-term harvest level — Arrowsmith TSA, 1995.

5 Timber Supply Sensitivity Analyses

The alternative harvest flows shown in this section illustrate that the initial harvest can be set at levels higher than the base case, but rates of harvest during the second decade must be reduced to meet forest cover requirements. Forest cover requirements limit timber supply due to the 5% increase in the timber harvesting land base from Timber Licence reversions.

The long-term harvest level cannot be maintained over the entire 250-year horizon. This occurs because of the combination of limited availability of timber from existing old-growth stands (to meet forest cover objectives for VQOs) and from second-growth stands (primarily due to the large area of poor sites with long minimum harvestable ages).

Although alternative harvest flows are shown only for the base case, a variety of alternatives are also possible for each of the sensitivity harvest forecasts presented in the following sections. In general, where increased growing stock is available for harvest compared to the base case, it allows increased harvests during the medium term to fill in the trough from decade 4 to 15, or increases in the initial harvest level. The decline in the harvest rate to the long-term level is accomplished by a series of gradual reductions, rather than by pursuing an alternative such as maintaining the highest level in the short term with sudden and large reductions in the future.

5.2 Uncertainty in land base available for harvesting

Defining the timber harvesting land base involves several assumptions about the types of forest land that are available for harvesting. The forest cover inventory and an operability classification were used to approximate which stands are merchantable and physically operable. Since approximations were used to define the land base, and because the inventory itself contains uncertainty, there is some uncertainty about how much area actually falls within the harvesting land base under current management. In the Arrowsmith TSA, the timber harvesting land base could be larger or smaller than expected if any of the areas listed in Table 1 are different than what is expected. For example, the timber harvesting land base could be larger because of enhanced technology, or smaller if harvesting costs increase and reduce the economic feasibility of harvest operations, or if road access over private land to harvestable timber is not successfully acquired.

Other potential sources of uncertainty about the area considered available for timber harvesting include:

- the size of streamside buffers needed to protect riparian habitat. Stream buffer widths used for the base case are the widths suggested in the *British Columbia Coastal Fisheries/Forestry Guidelines*. Increased experience with fish/forestry interactions may indicate different sized buffers are required.
- more restrictive harvesting practices may be required to protect biodiversity and old-growth stands.
- outcomes of land use planning processes such as the *Vancouver Island Land Use Plan*. The Timber Supply Review process focuses on current forest management, not on future management and land use decisions made in public planning processes. However, this analysis provides information useful to understanding the general implications of these decisions.

5 Timber Supply Sensitivity Analyses

Figure 16 displays the effects on timber supply of the uncertainty about the size of the harvesting land base. The land base was increased and decreased, proportionately across all management zones and forest types*, by 10%. An increased land base would allow harvesting at the current AAC (479 150 cubic metres per year) for the first decade, followed by declines of 10% per decade to a harvest level 10% above the base case levels from decade 4 onwards. The harvest level during decades 4 through 16 is 10.4% below the higher long-term harvest level of 391 000 cubic metres per year.

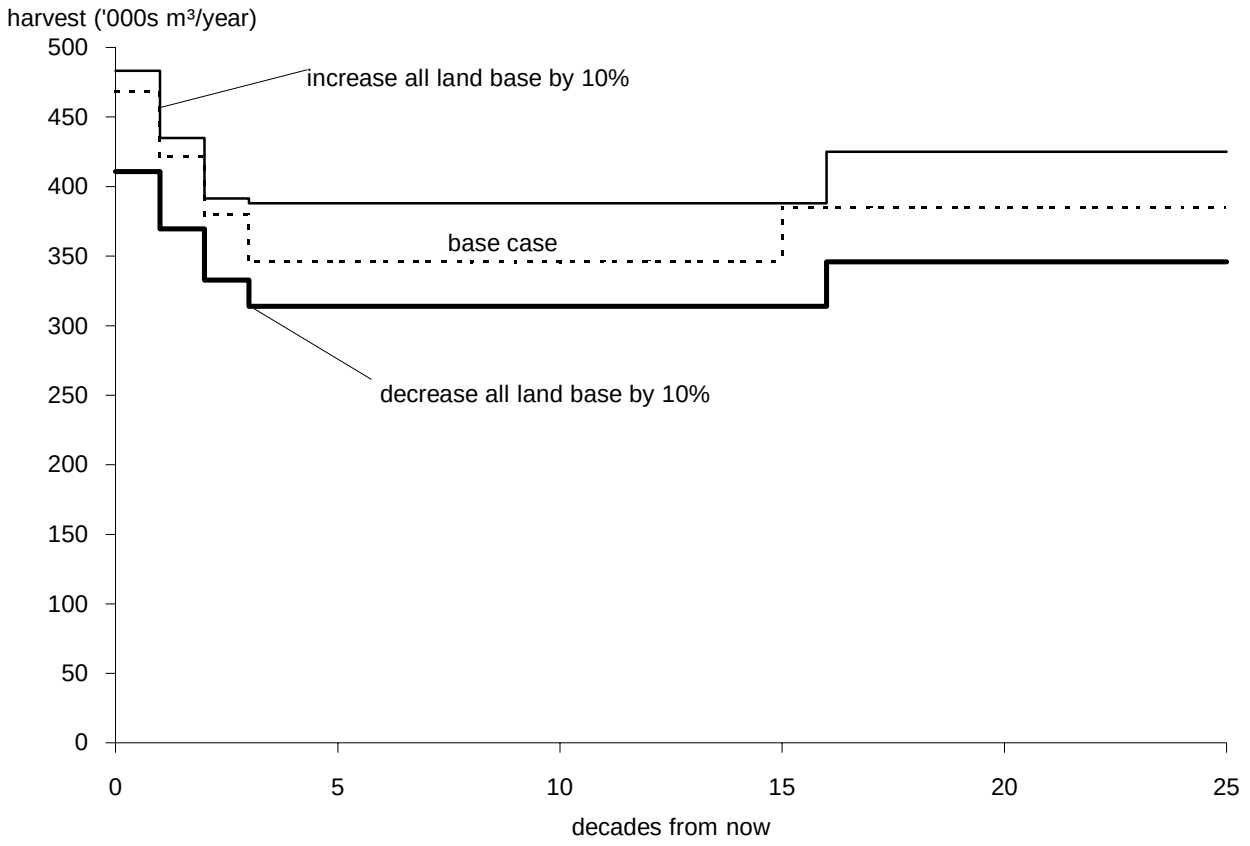


Figure 16. Harvest forecasts if the timber harvesting land base were 10% different than the base case — Arrowsmith TSA, 1995.

A 10% decrease in the land base results in the starting harvest level being 14% below the current AAC (11% below the base case harvest forecast). The harvest forecast then declines by 10% after decades 1 and 2, and 5.6% after decade 3. Harvests between decades 4 and 16 are 9% below the base case harvests during the same period, while the long-term harvest level is 10% lower.

Timber supply over the next several decades is sensitive to a 10% change in the size of the timber harvesting land base. An increased land base would allow initial harvesting at the current AAC; a smaller land base would require a significant reduction in the immediate harvest level to avoid future timber supply disruptions. Long-term timber supply (50 years and onward) is sensitive to increases and decreases in land base, the change being proportionate to the change in land base.

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

5.3 Uncertainty in existing stand yield estimates

Uncertainty in timber yield estimates arises due to the statistical process used to develop growth and yield models, uncertainty in the forest inventory (including site index*), and potential differences between assumed and actual timber utilization. The volumes are more accurate when averaged over large areas than they are for estimating volumes in a specific stand. The following sensitivity analyses examine the effect on the harvest forecast of uncertainty about the volume of timber in existing unmanaged stands (greater than 30 years old) on the timber harvesting land base.

Figure 17 shows the harvest forecasts that result if the estimated timber yields from existing stands are increased and decreased by 10%. If volumes are 10% greater then those estimated for the base case, the current AAC of 479 150 cubic metres per year can be maintained during the first decade. After the first decade, the harvest level declines by 10% per decade to a level of 371 000 cubic metres per year. This level is maintained until decade 15 when the harvest level increases to the base case long-term harvest level (385 000 cubic metres per year).

If existing yields were actually 10% lower than estimated for the base case, the initial harvest level would be 425 000 cubic metres per year, or 9% lower than the base case. During decades 2 through 4 the harvest level declines by 10% per decade until it reaches 324 000 cubic metres per year. This harvest level is maintained through to decade 15, when it increases to the base case long-term harvest level.

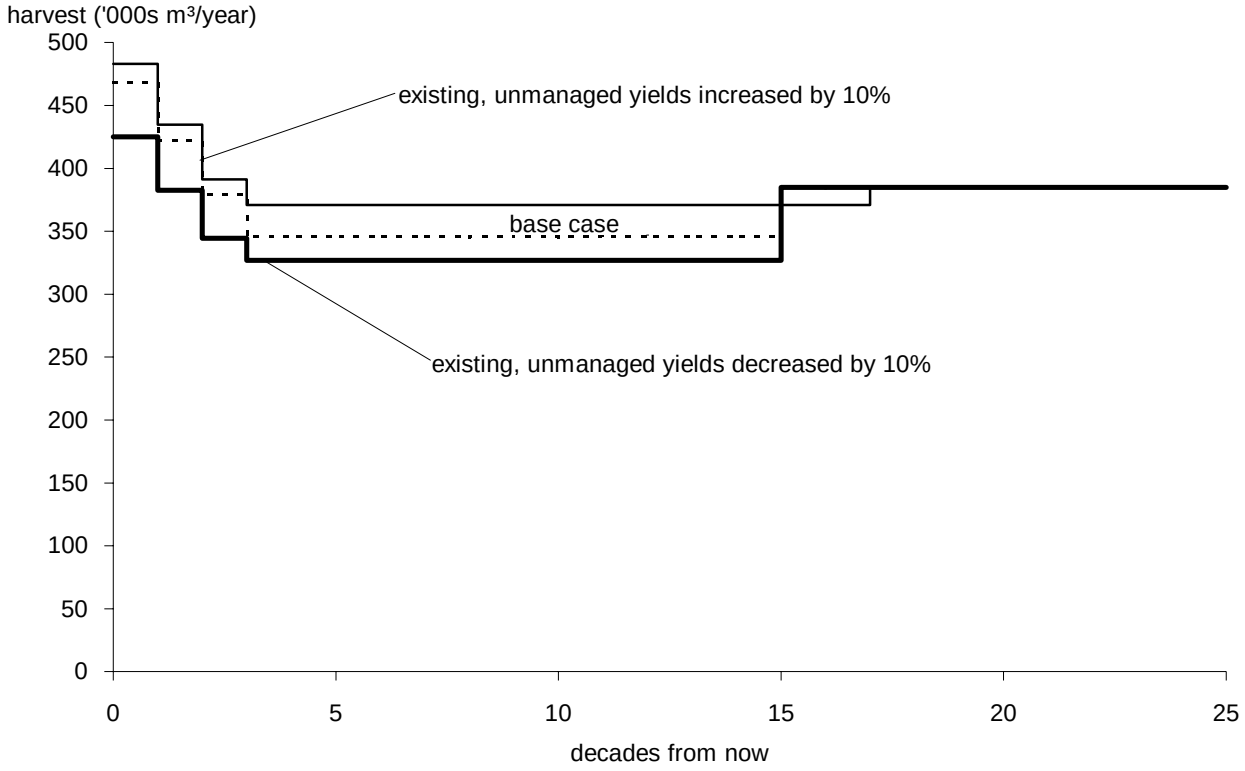


Figure 17. Harvest forecast for 10% uncertainty in existing stand volumes — Arrowsmith TSA, 1995.

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.

The results show that the short-term harvest forecast is sensitive to a 10% increase and decrease in existing stand volume estimates. Increased volumes allow harvests at the current AAC during the first decade, and a reduction in the trough in decades 4 through 16 to within 4% of the long-term harvest level. Decreased volumes require the initial harvest to be reduced significantly, and increase the depth of the trough by 5.7%. Changes to the existing stand yield volumes do not affect the long-term harvest level because volume estimates for managed, regenerated stands were not changed.

5.4 Uncertainty in managed stand yield predictions

Uncertainty in managed stand yield estimates is due to factors such as use of inventory data from existing mature forests to estimate site productivity and predict the growth and yield of future regenerated stands, uncertainty about the effect of replacing existing forests with different tree species after harvesting, and the effects of soil degradation, forest insects and disease on future forest productivity.

The following sensitivity analyses examine the effects that uncertainty in the estimated yields from managed stands (includes existing stands less than 30 years old) have on the harvest forecast.

Figure 18 shows the harvest forecasts that result if managed stand yield estimates are increased and decreased by 10%. Increased yields show no impact in the short term (decades 1 through 3), since the harvest comes from existing stands. Starting in decade 4 the higher managed stand volumes allow harvests to increase by 7.2% above the base case levels. After period 15 when most of the harvesting occurs in regenerated stands, the harvest level is increased to 425 000 cubic metres per year or about 10% higher than the base case.

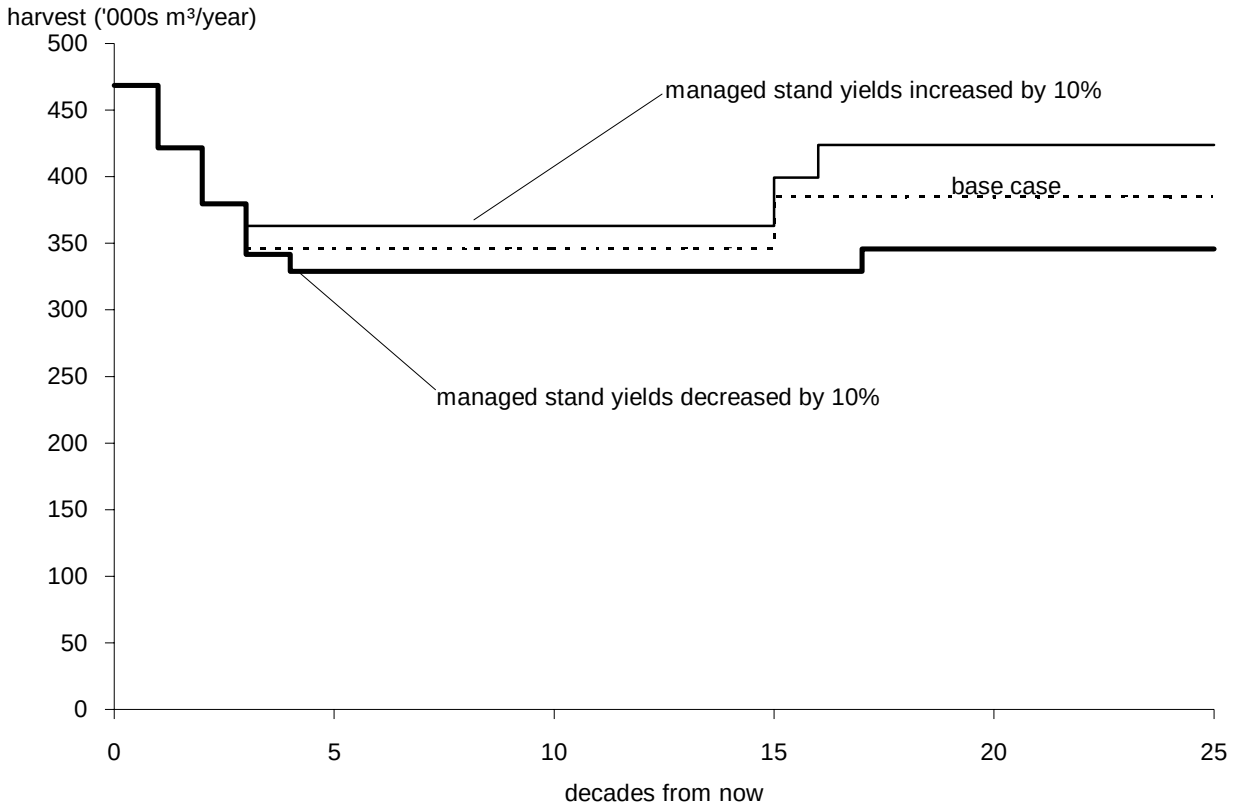


Figure 18. Harvest forecast for 10% uncertainty in managed stand yields — Arrowsmith TSA, 1995.

If second-growth managed yields are decreased by 10%, then harvest levels from decades 3 to 17 are reduced by 5% and the long-term harvest level is reduced by 10%.

In summary, changing regenerated yield estimates has negligible impact in the short term. However, long-term harvest levels are sensitive to changes in managed stand yield estimates.

5.5 Uncertainty in minimum harvestable ages

Minimum harvestable ages are an estimate of the time needed for a stand to reach a merchantable condition. Minimum harvestable ages define when second-growth will be available for harvest, and therefore to some extent 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. For this analysis the minimum harvestable ages for each forest type ranged from 45 years on good productivity sites up to 165 years on poor productivity sites.

Figure 19 shows the effect on the harvest forecast if all minimum harvestable ages are 20 years older or younger than in the base case for all forest types. Increases or decreases have negligible to small effects on the short-term and long-term harvest forecast. Short-term timber supply is not affected by changes in minimum harvestable age because of the amount of older stands available for harvest. However, the intermediate timber supply is increased by 8.6% if ages are younger, and decreased by 7.2% if ages are older. Decreases to minimum harvestable ages result in a small reduction in the long-term harvest level, since projected harvests would occur when stands are at younger ages, with slightly lower average productivity than in the base case. The opposite occurs if minimum harvestable ages are older. That is, stands would be harvested at slightly older ages, when average productivity is higher.

The impact of increasing and decreasing minimum harvestable ages by 10 years, not shown here, was to the increase and decrease harvest levels in the trough (decades 4 to 15) by less than 3% relative to the base case.

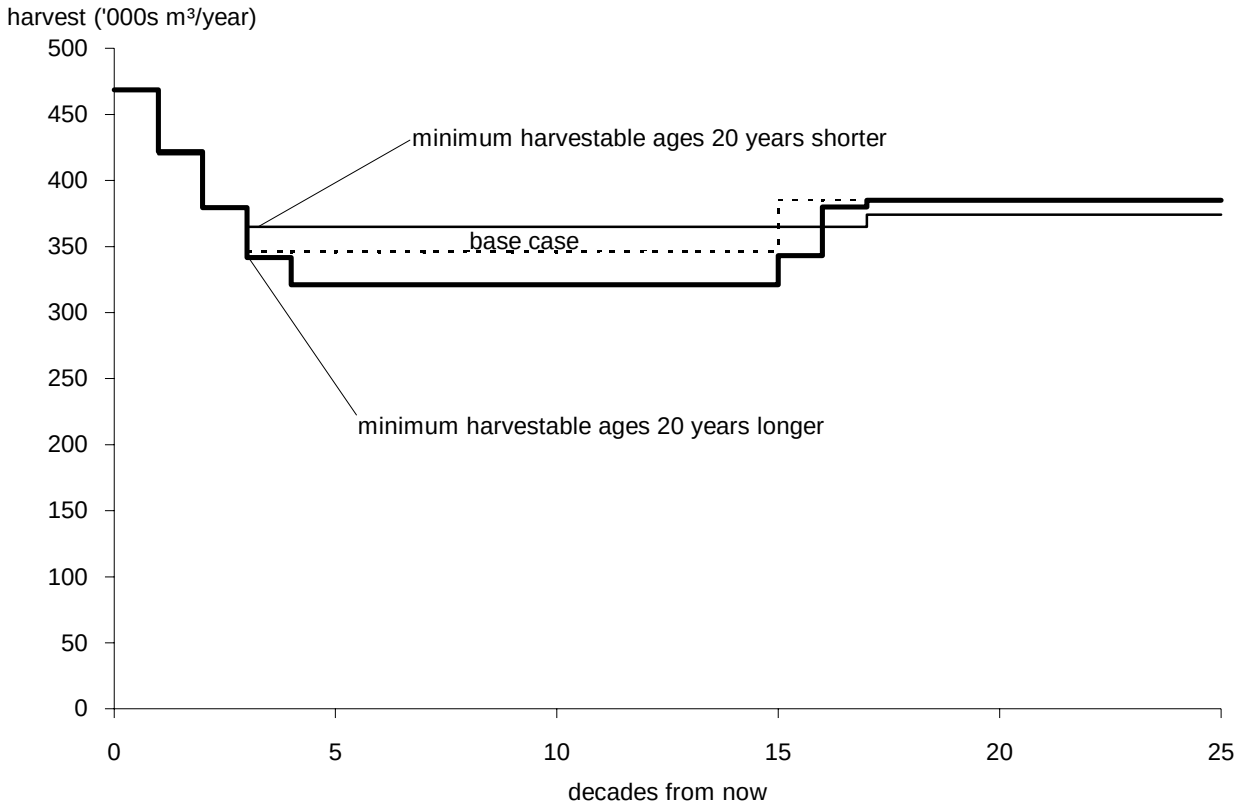


Figure 19. Harvest forecasts if minimum harvestable ages are 20 years different than the base case — Arrowsmith TSA 1995.

Extending minimum harvestable ages delays when second-growth stands become available for harvest. As noted in Section 4.1, "Base case harvest forecast," harvest levels during decades 10 through 15 depend on availability of second-growth stands. Delaying the availability of second-growth stands therefore decreases the timber supply during the trough from decades 4 to 15. Conversely, reducing minimum harvestable ages makes second-growth stands available earlier and increases the timber supply during decades 4 to 15. Since there is currently a significant area of old forest above minimum harvestable age, changes to minimum harvestable ages do not affect short-term timber supply.

5.6 Uncertainty in green-up ages

The forest cover objectives for visual quality and adjacency applied in this analysis involve estimates of when second-growth stands will reach green-up conditions, normally expressed as the desired height of a stand. Green-up age, the time needed to reach the desired condition, is determined using a growth and yield model. The total green-up period includes both the green-up age and the regeneration delay*, or time taken to establish a stand after harvesting. Uncertainty about green-up ages arises because the desired green-up condition may not accurately reflect actual needs, and because uncertainties about growth and yield mean that stands may reach the desired condition sooner or later than estimated.

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

5 Timber Supply Sensitivity Analyses

Figure 20 shows that potential short-term timber supply is very sensitive to uncertainty about green-up age. If green-up ages are 5 years shorter than in the base case, it would be possible to harvest at the current AAC (479 150 cubic metres per year) for 20 years before declining to just above base case harvest levels in decade 4. After decade 15, the harvest level increases to 3% above the base case long-term harvest level. An alternative harvest forecast, if green-up ages are 5 years shorter, is to follow the base case for decades 1 through 3, and use the surplus of available merchantable volume to increase harvests in the decade 4 — 15 trough by 6%. The long-term harvest level is again 3% greater than in the base case.

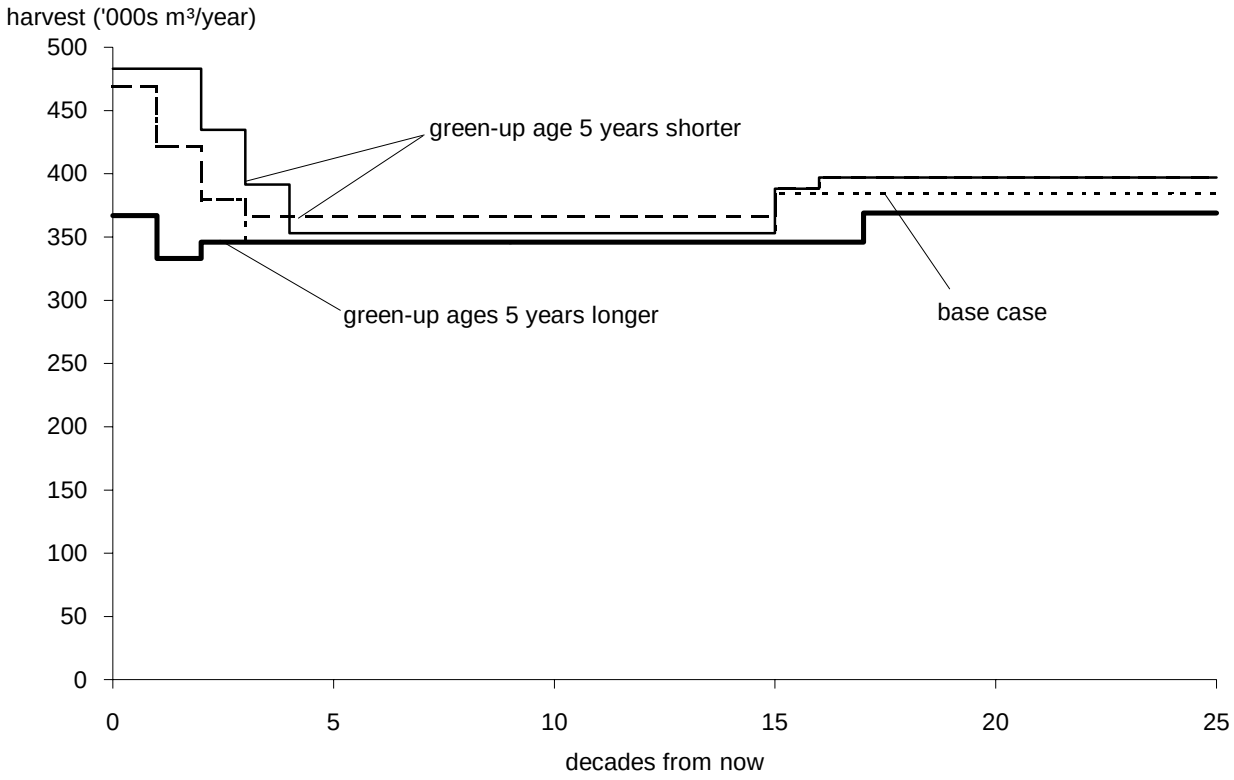


Figure 20. Harvest forecasts if green-up ages are 5 years different than the base case — Arrowsmith TSA, 1995.

If green-up ages are longer by 5 years than in the base case, harvests over the first 2 decades must decline to avoid violating forest cover requirements. The initial harvest levels drops to 367 000 cubic metres per year, or 22% below the base case. The harvest level then decreases by about 9% in decade 2. After decade 2 the harvest level increases to 346 000 cubic metres where it is maintained for 15 decades before rising to the long-term harvest level of 369 000 cubic metres per year, about 4% below that of the base case.

5 Timber Supply Sensitivity Analyses

The effects of increasing and decreasing green-up ages by 10 years were also examined and are shown in Figure 21. If green-up ages are 10 years shorter, the current AAC can be achieved for 3 decades, the trough between decades 4 and 16 in base case is eliminated, and the long-term harvest level is increased by about 7%. An alternative harvest forecast follows the base case level for the first 2 decades, after which the harvest is maintained at 2% below the associated long-term harvest level until rising to the long-term level after decade 15.

Longer green-up ages result in an initial harvest level 37% below the base case (295 000 cubic metres per year). The harvest level then declines over 2 decades to 252 000 cubic metres per year and then increases over 3 decades to 340 000 cubic metres per year. This harvest level is maintained through to decade 18 when it increases to the long-term level, 7.5% below that of the base case.

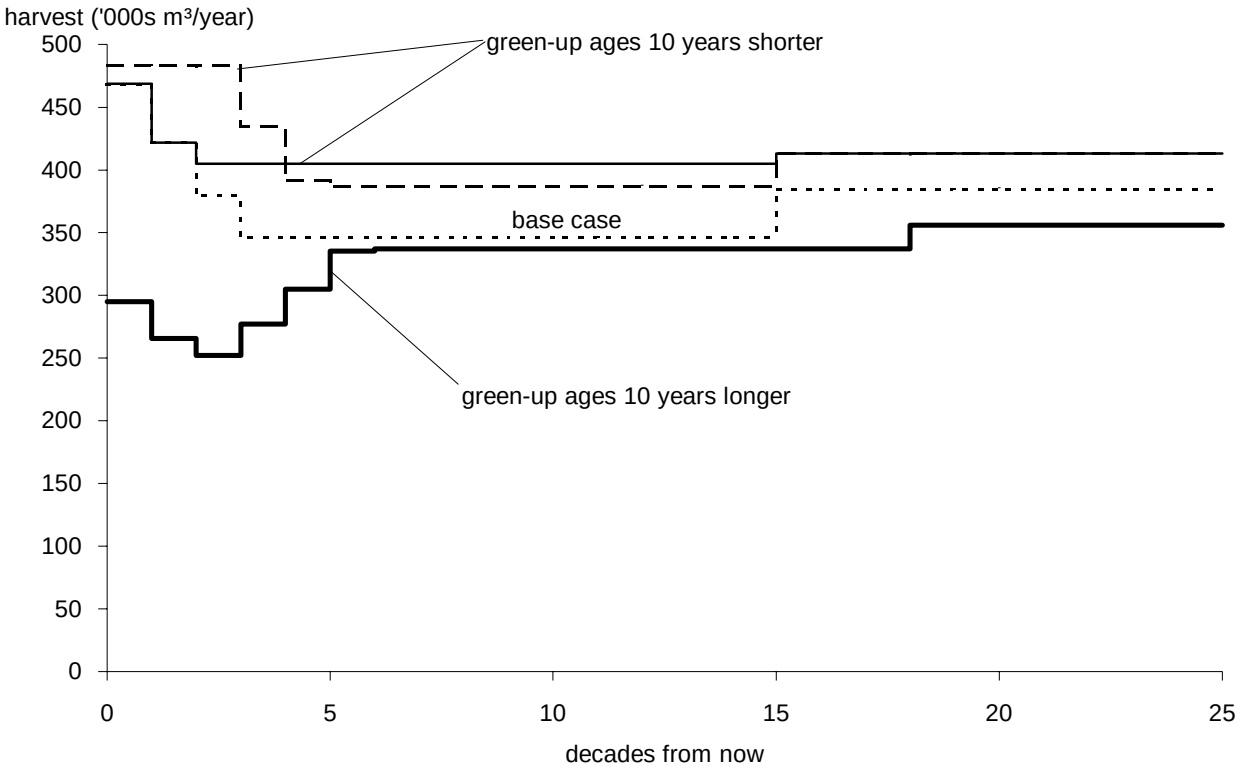


Figure 21. Harvest forecasts if green-up ages are 10 years different than the base case — Arrowsmith TSA, 1995.

Overall, fairly small uncertainty in green-up ages has large effects on timber supply over the next 50 years. The effects of this uncertainty are substantial particularly due to the reversion of Timber Licence areas to the timber harvesting land base which limits harvesting in adjacent areas until the reverted areas green-up. If the Timber Licence area is assumed not to restrict harvesting in adjacent areas, and green-up ages on the rest of the area are longer, the first decade harvests must still decrease to almost the same level as shown in Figure 21, but subsequent harvests begin to increase in decade 2. For example, if green-up ages are 10 years longer, then the initial harvest is 315 000 cubic metres per year. In decade 2 the harvest begins to increase rather than decline as shown in Figure 21. Long-term timber supply is only moderately sensitive to changes in green-up ages.

5.7 Uncertainty in cutblock adjacency requirements

In the base case harvest forecast, cutblock adjacency and green-up objectives in the integrated resource management zones were represented by forest cover requirements that allow a maximum of 25% of the timber harvesting land base to be forested with stands less than 3 metres tall at any time (see Section 2.3, "Management practices"). This requirement is commonly referred to as a 4-pass harvesting system because it allows 100% of the timber harvesting land base to be harvested over 4 entries (passes). This forest cover requirement should be viewed only as an average that applies to areas with no overriding management concern such as visual quality or wildlife habitat. Site specific forest cover requirements will vary from this average. There is some uncertainty that the average forest cover requirement used in this analysis accurately represents actual cutblock adjacency and green-up objectives.

This sensitivity analysis examines the effect of altering the adjacency forest cover requirements in the integrated resource management (IRM) zones. Figure 22 shows the results of using 3-pass (maximum of 33% younger than green-up age) and 5-pass (maximum of 20% younger than green-up age) harvesting systems in the IRM zones.

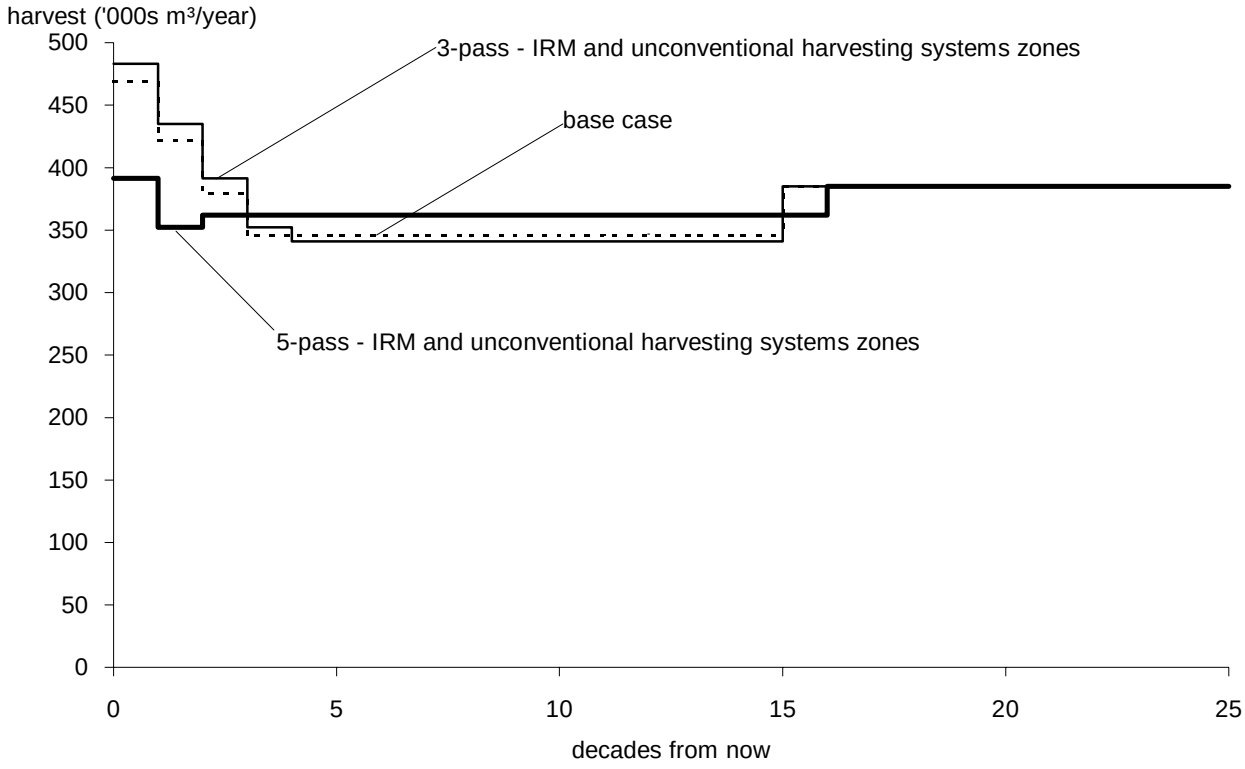


Figure 22. Harvest forecasts if cutblock adjacency forest cover requirements are different than the base case — Arrowsmith TSA, 1995.

If cutblock adjacency forest cover requirements are relaxed to represent a 3-pass system, a harvest level of 479 150 cubic metres per year, the current AAC, can be achieved for the first decade. The harvest level then declines by 10% per decade for 3 decades. For decades 4 through 15 the harvest level remains 1% below the base case harvest level before rising to slightly above the base case long-term harvest level. It is also possible to follow the base case harvest forecast under a 3-pass system. Therefore, while a 3-pass system would increase short-term supply by making forest cover requirements less restrictive, it would not increase overall supply over the next 15 decades.

Under a more restrictive cutblock adjacency forest cover requirement (5-pass), the initial harvest is 17% below the base case for one decade to avoid violating forest cover requirements. The harvest level of 391 000 cubic metres per year then declines by 10% for one decade before rising to about 5% above the base case harvest level shown for decades 4 to 15. At decade 16 the harvest level rises to the base case long-term harvest level. While a 5-pass system restricts harvests over the first few decades, to avoid violating forest cover requirements, it does not substantially change the cumulative supply over the next 15 decades. The reasons overall timber supply is not greatly affected are that some stands are allowed to grow longer, and thus contain more volume when they are harvested, and that the timing of harvest for other stands (with older minimum harvestable ages) is not affected by the cover requirement.

In summary, short-term timber supply is sensitive to changes in cutblock adjacency forest cover requirements. Long-term timber supply is unaffected by changes to the forest cover requirement representing cutblock adjacency guidelines.

5.8 Uncertainty in forest cover objectives for visual quality

Visual quality objectives (VQO) are stated in terms of the degree to which forestry activities should be visible. The B.C. Forest Service, Recreation Branch has provided a range of visible disturbance limits for each VQO category (stated as a maximum per cent area younger than green-up age). Different disturbance limits will meet a particular objective for visual quality (for instance, partial retention), depending on the terrain and forest in the area.

Uncertainty about forest cover objectives may arise from the inventory, from estimates of how well different disturbance limits may meet visual objectives, and from estimates of how non-harvestable forest may contribute to visual quality. This section investigates how uncertainty in the forest cover guidelines for visual quality affects timber supply.

In the base case the VQO forest cover requirements were set at the mid-point of the allowable disturbance ranges. This sensitivity analysis examines the effect on timber supply of both relaxing and tightening forest cover requirements to the maximum and minimum limits of the allowable disturbance ranges (Figure 23). The forest cover requirements are said to be relaxed when they are at the maximum of the allowable disturbance range, and tightened when they are at the minimum of the allowable disturbance range. See Appendix A, Section A.3.1, "Forest cover requirements" for a more detailed description of forest cover requirements.

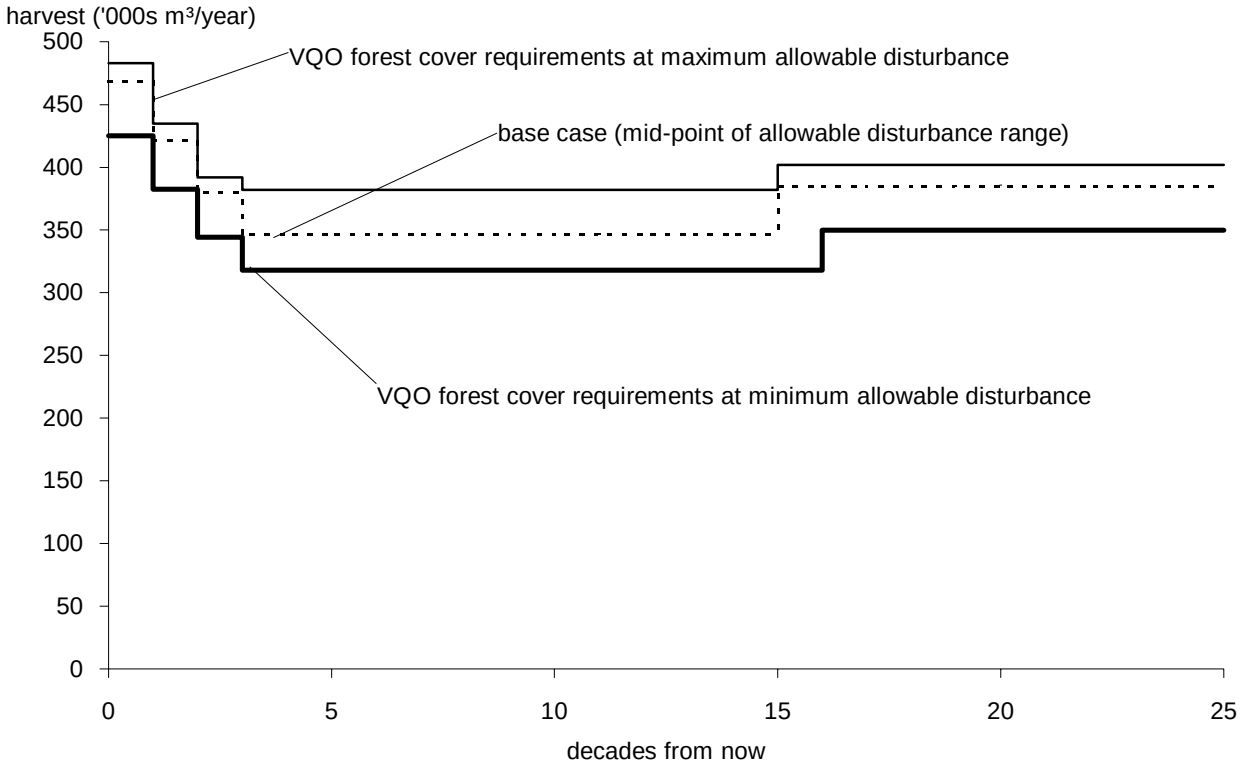


Figure 23. Harvest forecasts if VQO forest cover requirements are different than the base case — Arrowsmith TSA, 1995.

Relaxing the VQO forest cover requirements allows the harvest to start at the current AAC. After the first decade the harvest falls by 10% per decade to 382 000 cubic metres per year in the fourth decade which is then maintained for 12 decades. From decade 15 onwards, the harvest level rises to 402 000 cubic metres per year which is about 4% above the base case long-term harvest level. When the VQO forest cover requirements are tightened the initial harvest level is about 11% less than the current AAC and 9% below the base case starting level. The harvest level then declines over 4 decades to 318 000 cubic metres per year. This level is maintained until decade 16 when the harvest level increases to 350 000 cubic metres per year, or 9% below the base case long-term harvest level.

The results show that timber supply is sensitive in the short- and long-term to changes in the forest cover requirements for VQOs.

5.9 Uncertainty in forest cover objectives

Classification of areas into the management zones discussed in Section 2.3 "Management practices", is subject to several sources of uncertainty. The recommended classifications used for the analysis have not yet been approved, and final decisions on management emphasis will be made through the *Vancouver Island Land Use Plan*, a public process.

To assess the possible effects of uncertainty in management zone classifications, area was shifted to both the next more, and next less, restrictive forest cover class (more restrictive here means less area can be younger than the green-up age, and green-up age is based on 5-metre instead of 3-metre height criterion). To examine the effects of more restrictive classification, 25% of the area in each zone was shifted to the next more restrictive zone (for example, 25% of the area in partial retention VQO zones was shifted to retention VQO zones, see Table 2). Conversely, to examine the effects of less restrictive classification, 25% of the area in each zone was shifted to a less restrictive zone.

Figure 24 shows how potential harvest levels would be affected by a change in the relative area in each management zone and associated forest cover requirement.

Table 2. Shifts in management zones for less restrictive and more restrictive management emphasis

Geographic location	Less restrictive zone	Base case zone	More restrictive zone
East	Partial retention VQO	Retention VQO	Retention VQO
East	IRM	Partial retention VQO	Retention VQO
East	IRM	IRM	Partial retention VQO
West	Partial retention VQO	Retention VQO	Retention VQO
West	Modification	Partial retention VQO	Retention VQO
West	IRM	Modification VQO	Partial retention VQO
West	IRM	IRM	Modification VQO

If areas are shifted to a less restrictive forest cover classification, the initial rate of harvest is the current AAC. From decade 2 onwards, harvest levels remains slightly above base case levels (3% for decades 2 to 15; 1% after decade 15). If area is shifted to more restrictive forest cover classifications, the harvest starts at 401 000 cubic metres per year (14% below the base case initial level). The harvest level then declines for two more decades to just below base case harvest level of 346 000 cubic metres per year. From decade 4 onwards, the harvest level remains slightly below the base case harvest levels (4% for decades 4 to 15; 5% after decade 15).

Overall, timber supply is slightly sensitive to shifts in areas between forest cover categories. An exception is the short-term timber supply reduction caused by shifting area to more restrictive forest cover categories. The critical factor that accounts for the lack of sensitivity is that most (66%) of the Arrowsmith TSA timber harvesting land base falls within the integrated resource management (IRM) zones. Furthermore, shifts from the IRM zone to the modification zone restrict timber supply only slightly, since only the green-up criterion changes (from 3 metres to 5 metres), thereby increasing green-up ages while the maximum area younger than green-up age remains the same. If shifts in area to even more restrictive forest cover categories were to occur (for example, 25% of the area of IRM zone shifted to the retention VQO zone), changes to timber supply would be more substantial.

The base case employs the best current estimates of management emphasis; this sensitivity analysis was performed only to indicate impact of these estimates on timber supply.

5 Timber Supply Sensitivity Analyses

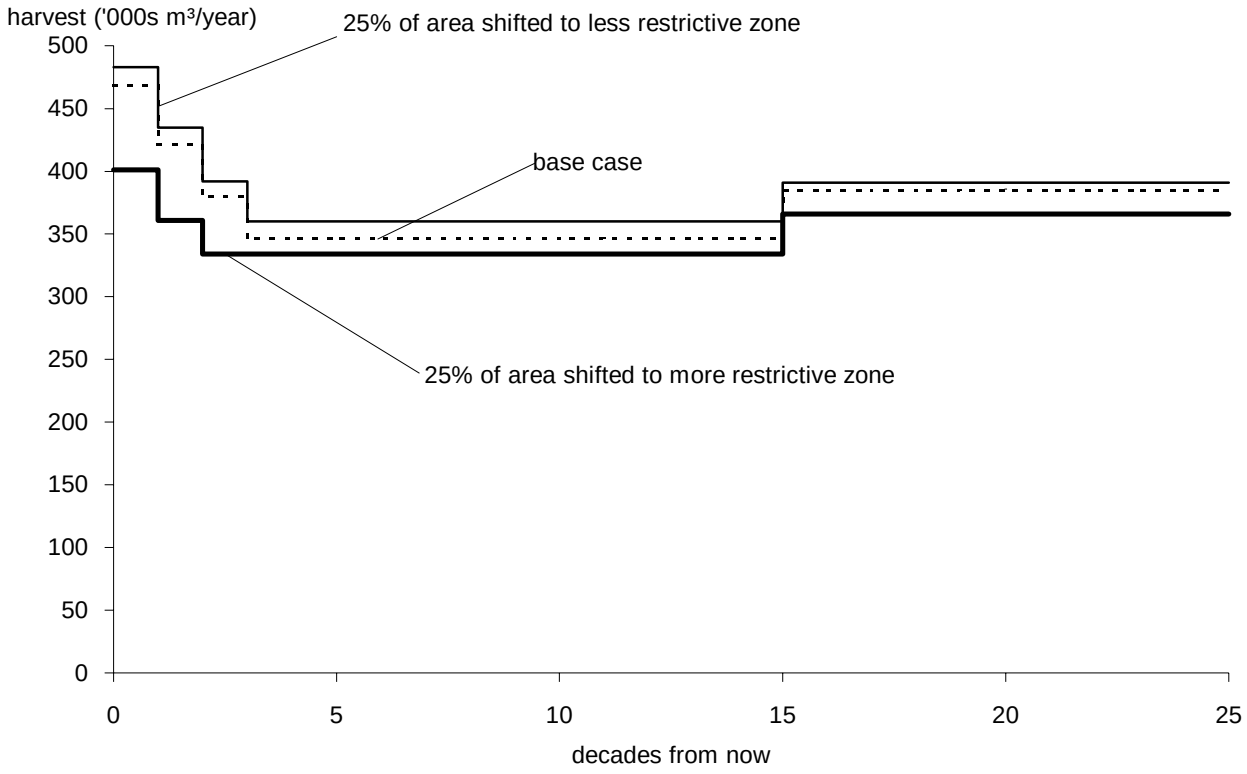


Figure 24. Harvest forecasts if 25% of each zone is shifted to the next less/more restrictive forest cover category — Arrowsmith TSA, 1995.

6 Summary and Conclusions

The results of this timber supply analysis for the Arrowsmith TSA suggest that an immediate small reduction from the current AAC of 479 150 cubic metres per year would be necessary in the short term to avoid either more substantial harvest level reductions in the near future, or severe timber shortages further in the future. Using current forest inventory and timber growth information, and assuming continuation of forest management practices from the time of data preparation, a harvest of 469 000 cubic metres per year — 10 150 cubic metres or 2% below the current AAC — could be maintained for 10 years. After the first decade, the harvest falls by 10% per decade for the next 3 decades to 346 000 cubic metres per year, about 10.1% below the sustainable long-term harvest level. The harvest level remains at this level for 12 decades before rising to the long-term harvest level of 385 000 cubic metres. The long-term harvest level is 19.6% less then the current AAC. While it is possible to begin harvesting at the current AAC, larger declines (12%) are required during the following 2 decades to avoid violating forest cover requirements.

It is not possible to avoid harvests below the base case long-term level during the medium term (decades 4 through 15). Even initiating harvests at the long-term level requires that harvests drop to 39 000 cubic metres per year below the long-term level from decade 6 through 15.

Several factors contribute to the decline from the initial level shown in the base case timber supply forecast. The most important factor is that the initial harvest level is well above the long-term harvest level. Another contributing factor is the large area of Timber Licences that revert to the timber harvesting land base over the next 20 years. Until these areas reach green-up conditions, harvests from adjacent areas in the Arrowsmith TSA are restricted. Therefore, harvests must decline in order to avoid violating forest cover requirements. However if the reverted areas were assumed not to restrict harvesting of adjacent areas, the current AAC could be achieved for one decade.

The trough during decades 4 to 15 results because there is insufficient mature second-growth available for harvest from the IRM zones, primarily during decades 10 to 15. The largest limitation to timber supply at that time is that approximately half the timber harvesting land base is of poor site quality where stands have relatively old minimum harvestable ages and low volumes per hectare.

This analysis employs the best current estimates for all variables used to describe forest management in the Arrowsmith TSA. Nevertheless, varying degrees of uncertainty surround most of the estimates. Table 3, on the following page, summarizes results of the sensitivity analyses showing the short- and long-term impacts of these uncertainties.

The results of the sensitivity analysis indicate that the current AAC could be maintained in the short term, with subsequent moderate harvest level declines, if existing stand yields or the timber harvesting land base are larger, green-up ages are shorter or if forest cover requirements (cutblock adjacency and VQOs) are relaxed relative to the base case. Conversely, short-term timber supply is moderately reduced if existing stand yields or the timber harvesting land base are smaller, if VQO forest cover requirements are more restrictive, or if area is shifted to management zones with more restrictive forest cover requirements. Short-term timber supply is very sensitive to green-up ages, and application of a 5-pass system to represent cutblock adjacency forest cover requirements.

The long-term harvest forecast is slightly sensitive to shifts in areas to either more or less restrictive forest cover requirements, and sensitive to changes in green-up ages, the size of the timber harvesting land base, managed stand yield predictions and VQO forest cover requirements.

6 Summary and Conclusions

Table 3. Summary of the short- and long-term timber supply impacts[a] from the sensitivity analyses

Sensitivity analysis	Change	Short-term impact	Long-term impact
Existing stand yields	+ 10%	Start at AAC	NIL
	– 10%	Start 9% below base case level	NIL
Managed stand yields	+ 10%	NIL	LTHL[b] increased by 10%
	– 10%	NIL	LTHL decreased by 10%
Land base	+ 10%	Start at AAC	LTHL increased by 10%
	– 10%	Start 12% below base case level	LTHL decreased by 10%
Green-up age	+ 5 years	Start 22% below base case level	4% decrease in LTHL
	– 5 years	Start at AAC for 2 decades	3% increase in LTHL
Green-up age	+10 years	Start 38% below base case level	7.5% decrease in LTHL
	– 10 years	Start at AAC	7% increase in LTHL
Minimum harvestable ages	+20 years	Negligible	Negligible
	– 20 years	Negligible	Negligible
Adjacency - IRM zones	3 - pass system	Start at AAC	NIL
	5 - pass system	Start 17% below base case level	NIL
VQO forest cover requirements	Maximum	Start at AAC	4% increase in LTHL
	Minimum	Start 9% below base case harvest level	9% increase in LTHL
25% area change in IRM and VQO class	+25%	Start at AAC	1% increase in LTHL
	– 25%	Start 14% below base case level	5% decrease in LTHL

(a) Short term is defined as impact on the first decade base case harvest level (469 000 cubic metres per year). Long term is defined as the impact on the long-term harvest level (385 000 cubic metres per year).
(b) LTHL - Long-Term Harvest Level

7 References

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8 Glossary

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

Clearcut harvesting A harvesting method whereby all trees that meet utilization standards are harvested. The harvested site is then regenerated to acceptable standard by appropriate means including planting and natural seeding.

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

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

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

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

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

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

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

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

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

8 Glossary

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.

Inoperable areas — Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.

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

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

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

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

Modification VQO — Alterations may dominate the visual landscape, but should blend with natural features. Up to 25% of the visible area can be altered by harvesting activity.

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

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

8 Glossary

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.
Regeneration delay	The period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees.
Retention VQO	Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity.
Riparian area	Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Site index	A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.
Timber harvesting land base	The portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The harvesting land base is defined by deducting non-contributing areas from the total land base according to specified management assumptions.
Timber supply area (TSA)	An integrated resource management unit established in accordance with *Section 6* of the *Forest Act*.
Tree farm licence (TFL)	Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.
Unsalvaged losses	The volume of timber killed or damaged annually by natural causes (e.g., fire, wind, insects and disease) and not harvested.
Visual quality objective (VQO)	Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.
Visual sensitivity	A measure of the level of concern for the scenic quality of a landscape. Visual sensitivity ratings take into account the physical character of the landscape, as well as viewer related factors such as the number of viewers and the angle, position, and distance from which the landscape is viewed.
Woodlot licence	Woodlot licences are included in the TSA and a portion of the AAC determined for the TSA is apportioned to woodlot licences. Each woodlot licence has an AAC determined for it on the basis of its timber inventory and productive capacity. These areas and all of the apportionment have been excluded from the analysis.

Appendix A

Description of Data Inputs and Assumptions

Introduction

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

During the information gathering process, separate data packages (methods and inputs) were assembled by the Duncan and Port Alberni Forest District staff. These data packages have been consolidated into one document for the Arrowsmith TSA. However, where applicable, district level data and inputs are presented in this appendix (for example, basic silviculture and regeneration assumptions).

A.1 Zone and Analysis Unit Definition

A.1.1 Definition of management zones

Based on different harvesting and silvicultural practices, the timber harvesting land base was divided into two broad zones: east and west. Within these zones further division was made for forest cover requirements (IRM or pass system for cutblock adjacency objectives, and modification, partial retention and retention for visual quality objectives).

Zone boundaries were defined using inventory timber supply block (TSB), recreation (RECREATE) and ownership (OWNER, OWNRCHAR) forest inventory codes. Within the recreation field, zones were defined using the management codes. Both approved and recommended codes for VQOs were used in the analysis. While it was acknowledged that not all stands with recommended codes have been approved by forest district management, district staff recommended their use for this analysis.

Table A-1. shows the attributes, area and per cent composition of the Arrowsmith TSA by zone. Figure A-1 shows the general location of timber supply blocks within the Arrowsmith TSA.

Table A-1. Zone attributes, area and per cent composition of the Arrowsmith TSA by zone

Zone	Location	Timber supply block	Forest cover requirement	Area (hectares)	Per cent TSA
1	East	Cowichan/Naniamo	IRM[a]	13 554	18
2	East	Cowichan/Naniamo	Partial retention VQO	9 010	12
3	East	Cowichan/Naniamo	Retention VQO[b]	3 206	4
11	West	Barkley	IRM	32 666	43
12	West	Barkley	Modification VQO	6 083	8
13	West	Barkley	Partial retention VQO	5 396	7
14	West	Barkley	Retention VQO[b]	1 884	3
21	West	Barkley	IRM – unconventional logging[c,d]	3 446	5
Total				75 245	

(a) Modification VQO area was placed in the IRM zone since the area involved was very small.
(b) Preservation VQO area was placed in the retention VQO zone.
(c) All VQO areas were treated as an IRM zone. Actual VQO prescriptions will be managed through Pre-Harvest Silvicultural Prescriptions (PHSP).
(d) Unconventional logging was defined as areas where helicopter and long-line harvesting systems will be employed. The areas are situated in the western zones of the Port Alberni Forest District and are identified on the inventory file as 'OPERABLE' codes B and C.

A.1 Zone and Analysis Unit Definition

Figure A-1. Location of the timber supply blocks within the Arrowsmith TSA, 1995.

A.1 Zone and Analysis Unit Definition

A.1.2 Analysis unit definition

To simplify timber supply modelling given the high number of unique forested stands in the Arrowsmith TSA, as well as to reflect the precision of inventory sampling, individual stands are grouped into analysis units. Analysis units are defined by forest cover (inventory type group), site quality (new site class), and silvicultural prescription. Each analysis unit is assigned its own timber volume projection (yield table). Separate yield curves for existing and regenerated stands were produced for each analysis unit.

Table A-2. documents the variables used to define each analysis unit. Type groups are B.C. Forest Service, Inventory Branch categories that denote the dominant tree species as well as other species present. Site groups were assigned using new site class 'NSITE' values from the inventory file. Analysis unit yield tables were created using data for all the stands from the same geographical zone (east or west).

Table A-2. Definition of analysis units

Analysis unit	Site class	Inventory type groups	Location	Area	Per cent TSA	Mean site index (metres at 50 years)
1. Fir	G	1	East	4 673	6	34.97
2. Fir	M	1	East	6 793	9	28.23
3. Fir	P	1	East	3 211	4	19.97
4. Fir Mix	G	2-8, 27-32	East	2 062	3	33.35
5. Fir Mix	M	2-8, 27-32	East	4 663	6	27.38
6. Fir Mix	P	2-8, 27-32	East	2 785	4	19.32
7. Other Conifer	all sites	9-26	East	1 583	2	21.77
11. Fir/Fir Mix	G	1-8, 27-32	West	1 977	3	35.78
12. Fir/Fir Mix	M	1-8, 27-32	West	1 684	2	27.84
13. Fir/Fir Mix	P	1-8, 27-32	West	942	1	19.19
14. Hemlock/Balsam	G/M	15, 19	West	4 980	7	21.77
15. Hemlock/Balsam	P	15, 19	West	3 876	5	13.69
16. Cedar/Hemlock	G	9-14, 16, 17	West	3 365	4	29.35
17. Cedar/Hemlock	M	9-14, 16, 17	West	8 250	11	20.97
18. Cedar/Hemlock	P	9-14, 16, 17	West	20 219	27	14.03
19. Balsam/Spruce	all sites	18, 20-26	West	735	1	22.29
21. Unconventional	all sites	1-32	West	3 446	5	16.42
Total				75 245		

A.2 Definition of the Timber Harvesting Land Base

The timber harvesting land base was determined by deducting from the total Arrowsmith TSA area, all areas considered to be currently unavailable for timber production. Also, all the areas associated with Timber Licences (TLs) were removed from the land base. These Timber Licence areas and the not satisfactorily restocked (NSR) areas were then added back to establish the current timber harvesting land base. Harvesting operations will subsequently result in the removal of some of the initial area because of road construction and other long-term productivity losses. All these categories are summarized in Table 1 of the main report.

A.2.1 Not managed by B.C. Forest Service

Ownership codes on the inventory file are used to determine which areas are not under Forest Service jurisdiction. Ownership codes, as defined by the Ministry of Forests, Inventory Branch, denote both ownership and administrative designation. Areas such as Crown grants and Indian Reserves are not administered by the provincial government. Most land in the Arrowsmith TSA inventory file is administered by the provincial government but not all is managed by the Forest Service. For example, the Ministry of Environment, Lands and Parks administers Provincial parks. Further, some forest land administered by the Ministry of Forests 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 Licence initially comes from an AAC determined for a TSA, but upon allocation that allowable harvest is administered as part of the woodlot, not the TSA.

Tree Farm Licence (TFL) areas are managed — and have their allowable annual cuts determined — separately from TSAs. This land does not contribute to the Arrowsmith TSA harvesting land base.

Timber Licence (TL) areas are managed separately from TSAs. However, once harvested and regenerated to a free-growing state, the areas revert to the Arrowsmith TSA timber harvesting land base. The inventory file for this analysis contained incorrect information on the land base associated with TLs. Therefore, the TL land base from the inventory was excluded. TLs were accounted for by using forest district records and adding the areas back into the timber 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.

A.2.2 Non-forest land

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

A.2.3 Non-commercial cover

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

A.2.4 Environmentally sensitive areas (ESAs)

Environmentally sensitive areas include areas which have moderate to high non-timber values such as wildlife and water, and areas which because of geological and topographical conditions are prone to excessive site degradation if harvested. For this analysis, the timber harvesting land base was reviewed by both forest districts which provided inputs and methodology for conducting ESA netdowns.

Table A-3. summarizes the actual ESA reductions by type, forest district and area.

Table A-3. Amount of ESA deduction by type and forest district

ESA type	Level[a]	Duncan Forest District	Port Alberni Forest District	Total for TSA
Soils	Es1	1 733.56	3 488.00	5 221.56
	Es2	705.75	925.46	1 631.21
Recreation	All	848.20	3 700.00	4 548.20
Wildlife	All	965.82	488.00	1 453.80
Regeneration	All	26.00	162.00	188.00
Soils/wildlife[b]	All	178.47	0.00	178.47
Avalanche	All	8.04	0.00	8.04
Total		4 465.84	8 763.46	13 229.28

(a) For most ESA deductions lists of stand polygon numbers, by mapsheet, were provided with specific reduction factors. This precludes the listing of deductions by level.
(b) Some planning cells contained both soils and wildlife ESAs. Neither ESA type were more constraining so a reduction factor was estimated to account for both ESA type.

A.2.4.1 ESAs — Duncan Forest District

ESAs were assessed and assigned codes at two Forest Inventory Planning (FIP) levels in the Duncan Forest District portions of the inventory file. These FIP levels are: planning cell polygons (PLANCELL) and recreation polygons (RECREATE). The following sections describe the various ESAs, and their associated FIP level, for the Duncan Forest District.

Soils and wildlife ESAs

Soil and wildlife ESAs were assessed and inventoried, using ESA codes, at the forest planning cell level. The reduction factor for Es1 was 90% and 20% for Es2. The reduction factor for Ew1 was 90% and Ew2 50%. Areas considered to be ideal habitat but requiring further study were called Ew zones and assigned a netdown factor ranging between 20% and 70%. Where there was a combination of soils and wildlife ESA, the proportion was assessed and a reduction factor (per cent) was assigned. Table A-4. lists the ESA planning cell code, the associated ESA and the reduction factor for soils and wildlife ESAs in the Duncan Forest District.

A.2 Definition of the Timber Harvesting Land Base

Table A-4. Reductions for soils and wildlife ESAs — Duncan Forest District

ESA code	Associated ESA	Reduction per cent
Z999	none	0
S000	none	0
S001	Es1	90
S002	Es2	20
W001	Ew1	90
W002	Ew2	50
W003	Ew zone	20
W004	Ew zone	30
W005	Ew zone	40
W006	Ew zone	50
W007	Ew zone	60
W008	Ew zone	70
C001	Es2w2	50
C002	Es1w (zone 0.2)	90
C003	Es1w (zone 0.3)	90
C004	Es2w (zone 0.3)	30
C005	Es1w (zone 0.4)	90
C006	Es2w (zone 0.4)	40
C007	Es1w (zone 0.5)	90
C008	Es2w (zone 0.5)	50
C009	Es2w (zone 0.6)	60
C010	Es1w (zone 0.7)	90
C011	Es2w (zone 0.7)	70

Note: Additional ESA inventory on the forest cover polygon level is listed in Table A-5.

Table A-5. Reductions for soils and wildlife ESA on the forest cover polygon level — Duncan Forest District

Mapsheet	Forest cover polygon	ESA code	Reduction factor (%)
092C050	06, 07, 08	Es1	90
	04, 15	Es2	50
	05	Es1 and Es2	80% at 90 20% at 50

A.2 Definition of the Timber Harvesting Land Base

Recreation ESAs

Recreation ESAs and associated netdowns were assessed and assigned reduction factors on the forest cover polygon level of the inventory. Some special exclusions to the recreation ESAs were identified on the planning cell level of the inventory file. Table A-6. lists the netdowns associated with recreation values in the Duncan Forest District.

Table A-6. Reductions for recreation ESAs — Duncan Forest District

Mapsheet	ESA	Total hectares	Reduction per cent	Notes[a]
092B062	Er1	190	90.0	exclude planning cell polygons
	Er2	42	50.0	8527 and 8525. Only 9 hectares to remain in planning cell polygon 8524
092B063	Er2	33	3.0	
092B081	Er1	17	90.0	exclude planning cell polygons 8542 and 8575
	Er2	55	50.0	
	Er2	156	10.0	
092B082	Er2	58	50.0	
092B091	Er2	376	50.0	
	Er2	801	0.5	
	Er2	203	5.0	
092B092	Er2	31	50.0	
092C059	Er2	104	50.0	
	Er2	164	5.0	
092C079	Er2	105	0.5	
	Er2	145	5.0	
	Er2	31	10.0	
	Er2	33	25.0	
092C089	Er1	26	90.0	
	Er2	28	10.0	
092C090	Er1	51	90.0	
	Er2	168	50.0	
	Er2	128	25.0	
092C099	Er1	8	90.0	
092F010	Er1	3	90.0	
092G001	Er1	53	90.0	Subtract 35 hectares from planning cell polygon 8516
	Er2	7	50.0	

(a) See Appendix B, Section B.2.1 "Description of Duncan Forest District ESA Table Notes." These notes provide a breakdown of the planning cell polygons at the forest cover level.

Regeneration ESAs

Regeneration ESAs were assessed and assigned reduction factors of 90% for Ep1 and 50% for Ep2. Table A-7. lists polygons that are to be excluded from the calculation of the area of Ep netdowns.

Table A-7. Polygons to be excluded from regeneration (Ep) netdowns — Duncan Forest District

Mapsheet	Inventory file level	Polygon
092B062	forest cover	043 151
092G001	forest cover	128
092C059	planning cell	8512[a]

(a) See Appendix B, Section B.2.1 "Description of Duncan Forest District ESA Table Notes." These notes provide a breakdown of the planning cell polygons at the forest cover level.

A.2.4.2 ESAs — Port Alberni Forest District

ESAs were assessed and assigned codes at two Forest Inventory Planning (FIP) levels in the Port Alberni Forest District portion of the inventory file. These FIP levels are: planning cell polygons and forest cover polygons. The following sections describe the various ESAs, and their associated FIP level, for the Port Alberni Forest District.

Soils ESAs

Soils ESAs were assessed and assigned codes at two FIP file levels for the Port Alberni Forest District. In the Barkley Timber Supply Block (TSB) and mapsheets 092F036, 092F037, 092F046 and 092F047 of the Naniamo TSB, soils ESAs were assigned on the FIP file planning cell level. For the remainder of the Nanaimo TSB and the Cowichan TSB, soils ESAs were assigned on the forest cover level. Table A-8. lists reduction factors for the soils ESAs in the Port Alberni Forest District.

Table A-8. Soils ESA netdowns for the Port Alberni Forest District

Forest cover level	Timber supply block	Mapsheets	ESA code	Reduction factor (%)
Planning cell polygon	Nanaimo	092F036 092F037 092F046 092F047	Z999	0
			S002	50
			S003	
			S001	90
Forest cover level	Cowichan	All	Es2	20
	Nanaimo	All, except those on the planning cell polygon level	Es1	90

Note: No netdowns were taken for soils ESAs in the Barkley TSB (planning cell level) as there was considerable overlap with the inoperable netdowns. Note that inoperability was only assessed in the Barkley TSB and it was more constraining than the soils ESAs.

Wildlife ESAs

Wildlife ESAs were assessed and summary information was provided for the analysis. This summary is presented in Table A-9.

Table A-9. Wildlife ESA netdowns for the Port Alberni Forest District

Mapsheet	Analysis unit	Age class	Area (hectares)
092E068	18 C/H Poor	7-9	55.0
092F006	18 C/H Poor	7-9	112.0
092F020	2 12 Fd-Fd/Fd Mix Medium	1 and 3	102.0
092F028	2 12 Fd-Fd/Fd Mix Medium	6	28.0
092F036	2 12 Fd-Fd/Fd Mix Medium	3	28.0
092F046	2 12 Fd-Fd/Fd Mix Medium	3	57.0
092F046	1-21 All	8-9	100.0
092F047	2 12 Fd Fd/Fd Mix Medium	3	28.0
092F047	1-21 All	8-9	67.0

Avalanche ESAs

Avalanche ESAs were listed as Ea1 and Ea2, and were subject to a 100% reduction.

Regeneration ESAs

Regeneration ESAs were assessed at the forest cover FIP file level. The Ep1 reduction was 90% and the Ep2 reduction was 50%. The following forest cover polygons were excluded from the Ep netdowns (after review by forest district staff).

- mapsheet 092B062 — forest cover polygons 42 and 151;
- mapsheet 092C059 — forest cover polygons 156 and 156;
- mapsheet 092G001 — forest cover polygon 128.

Recreation ESAs

Recreation ESAs were assessed from recreation and landscape inventories. Netdowns were derived from two sources; fields 12 and 13 of the forest inventory "RECREATE" code and an additional listing of forest cover polygons with associated reduction factors. Table A-10. lists the Recreation Features Inventory Codes and associated netdowns for the Port Alberni Forest District. Table A-11. lists the additional recreation netdowns by mapsheet, recreation polygon number and reduction factor.

Table A-10. Recreation features inventory codes and reduction factors for the Port Alberni Forest District

Feature significance (RECREATE field 12)	Management class (RECREATE field 13)	ESA designation	Reduction factor (%)
A, B and C	0	Er1	100
A and B	1	Er2	50
C	1	Er2	50

Table A-11. Netdowns by recreation polygon for the Port Alberni Forest District

Mapsheet	Recreation polygon number	Reduction factor (%)
092C093	17 20	70
092C095	45	100
092E029	02 04 06	100
092E030	02 14	100
092E039	02 10 12 13	100
092E040	13	50
	17	100
092E059	04	100
	19	50
092F006	14	100
092F011	23	100
092F021	05	50
092F022	11 12	100
092F023	08	100
092F024	06	50
092F026	03 05 24	100
092F027	04 08	100
092F028	09	100
092F029	08	100
092F031	02	100
	03 04	50
092F036	08 14 15 31 35 38	50
092F037	03 18	50
092F039	08 10	100
092F046	06 08 11 19 22	50
092F047	20 21 25 26	50

A.2.5 Riparian areas

Riparian areas are for streamside management and fisheries protection. For this analysis, the timber harvesting land base was reviewed by both forest districts which provided inputs and methodology to account for riparian values.

A.2.5.1 Duncan Forest District riparian deductions

In conjunction with the Ministry of Environment, Lands and Parks, forest district staff identified all major class A, B and C streams as defined in the *Coastal Fisheries/Forestry Guidelines.* For major class B and C streams a 100% reduction was made for stands within 20-metre lineal distance of the streams. For major class A streams a 100% reduction was made for stands within 30-metre lineal distance of the streams.

Table A-12. lists the area reductions for Class A, B and C streams within the Duncan Forest District. Additional riparian areas were deducted through wildlife ESAs but these areas are reported as part of the wildlife ESA deductions. These deductions are reported as wildlife ESAs to ensure no double counting in the deduction process.

Table A-12. Area netdowns for class A, B and C streams — Duncan Forest District

Mapsheet	Streams class B and C (hectares)	Streams class A (hectares)	Total (hectares)
092B031	0.6	0.0	0.6
092B032	1.2	0.0	1.2
092B041	7.2	0.0	7.2
092B042	3.2	0.0	3.2
092B052	4.0	0.0	4.0
092B062	5.6	0.0	5.6
092B071	16.0	0.0	16.0
092B072	1.2	0.0	1.2
092B081	39.2	7.5	46.7
092B082	2.0	0.9	2.9
092B091	47.2	0.0	47.2
092B092	12.8	0.0	12.8
092C050	2.8	0.0	2.8
092C059	11.2	0.0	11.2
092C068	9.6	1.8	11.4
092C078	14.0	6.0	20.0
092C079	14.0	12.0	26.0
092C099	0.8	0.0	0.8
092F010	6.0	0.0	6.0
092G001	7.0	3.0	10.0

A.2.5.2 Port Alberni Forest District riparian deductions

Fisheries and streamside management inventories were assessed in collaboration with Ministry of Environment, Lands and Parks staff. Tables A-13. and A-14. present summaries of the land base deductions associated with each of the inventories.

Table A-13. Fisheries management deductions for the Port Alberni Forest District

Mapsheet	Analysis unit	Age class	Area (hectares)
All	1, 11 Fd Fd/Fd mix Good	All	73.7
All	2, 12 Fd Fd/Fd mix Medium	All	210.6
All	7, 14 Hemlock Only G/M	All	200.0
All	7, 16 C/H Good	All	73.7
All	7, 17 C/H Medium	All	473.9
All	7, 19 B/S	All	21.0

Table A-14. Streamside management deductions for the Port Alberni Forest District

Mapsheet	Analysis unit	Age class	Area (hectares)
All	1, 11 Fd Fd/Fd mix Good	All	81.0
All	2, 12 Fd Fd/Fd mix Medium	All	232.0
All	7, 14 Hemlock Only G/M	All	220.0
All	7, 16 C/H Good	All	81.0
All	7, 17 C/H Medium	All	521.0
All	7, 19 B/S	All	23.0

A.2.6 Reduction for specific geographically defined areas

Several areas in the Arrowsmith TSA, under inventory ownership code 62-C, are not available for timber management. Reasons for excluding these areas from the timber harvesting land base are: volumes harvested do not contribute to the allowable annual cut; or ownership has changed, and has not yet been updated on the inventory file. This section identifies areas that are excluded from the timber harvesting land base.

A.2 Definition of the Timber Harvesting Land Base

Cowichan Lake Research Station

The area has been set aside for a provincial forest research station. This area does not contribute to the timber harvesting land base or the allowable annual cut. The research station is situated in the Duncan Forest District on mapsheet 092C090. The stands to be excluded are forest cover polygons 35 through 62.

Experimental plots

Several research plots have been developed in the Port Alberni Forest District. These research plots are not under current management practices and harvested volumes may not be available to mills for processing, i.e., destructive sampling processes. Therefore, these areas are excluded from the timber harvesting land base and Table A-15. lists their location within the Arrowsmith TSA.

Table A-15. Location of experimental plots in the Port Alberni Forest District

Mapsheet	Forest cover polygon	Reduction (per cent)
092F046	338 339	80
	343	70
	403	50
092F047	180 182 187 188 196	100
	195	85
	194	70
	244	65
	430	60
092F020	336	85
	338	80
	391	70
	342	60

Camper Creek

Crown land is being transferred from the Arrowsmith TSA to Tree Farm Licence 46 as part of a land exchange for the Nitinat Park lands. The land being transferred is in the Duncan Forest District and is identified in the inventory file as all area within mapsheet 092C058, ownership 62 (OWNER) and ownership sub code C (OWNRCHAR).

Parkinson Creek Park

Areas from the former Sombrio Timber Licence have reverted to the Arrowsmith TSA and are now part of the Parkinson Creek Class A Park. Table A-16. lists the stands to be excluded from the Arrowsmith TSA.

Table A-16. Parkinson Creek Park area exclusion

Mapsheet	Forest cover polygon	Reduction factor
092C059	16	20
	17	40
	19	20
	20	60
	32	10
	55	30
	63	50
	67	15

New Island Highway

Development of the New Island Highway in the Port Alberni Forest District has led to areas being removed from the timber harvesting land base. These areas are listed in Table A-17.

Table A-17. New Island Highway exclusions

Mapsheet	Forest cover polygon	Area (hectares)
092F038	366	2.0
	365	1.2
	361	1.0
	360	1.0
	364	0.2
	359	0.5
	357	1.0
	296	0.4
092F037	253	2.5
	233	2.2
	237	0.3
	823	3.2
	238	1.0
	244	0.3
	223	0.4
	245	0.3
	246	0.2
092F046	107	0.3
	098	0.4
	191	0.2
	197	1.3
	199	1.4
	194	1.5

continued

Table A-17. New Island Highway exclusions (concluded)

Mapsheet	Forest cover polygon	Area (hectares)
092F047	626	1.0
	625	2.5
	624	0.4
	323	1.8
	682	1.0
	622	2.3
	630	0.9
	638	3.0
	639	2.4
	142	4.1
	649	0.2
	135	3.5
	138	5.0
	211	1.5
	291	1.3
	139	2.1
	286	0.4
	287	1.2
	285	5.4
	283	1.0
	281	1.0
	280	2.3
	478	3.1
	194	0.6
	240	1.8
	202	1.0
	203	1.8
	351	1.0
	205	1.0
	045	6.4
	043	1.3

A.2.7 Inoperable areas

Areas defined as physically or economically inoperable were not considered as part of the timber harvesting land base. Characteristics used in defining operability include slope, topography (for example, presence of gullies, exposed rock), difficulty of road access, soil instability, elevation and timber characteristics. The areas defined as inoperable are situated in the Port Alberni Forest District and are identified in the inventory file under the 'OPERABLE' label by 'I' and 'M' field codes. Records with 'I' or 'M' operability codes that were also identified as NSR were not removed from the timber harvesting land base.

A.2 Definition of the Timber Harvesting Land Base

A.2.8 Deciduous leading species and non-merchantable forest types

Several types of forest are not currently used because they contain non-commercial tree species, low timber volumes, or have low productive potential for timber. Currently, deciduous species are not harvested as part of the AAC (there is limited harvesting for fire wood consumption). Coniferous stands that have not reached a minimum height by a specified age are also not considered available for harvesting. Areas classified as having low productivity are also removed from the timber harvesting land base. The specific criteria used to remove stands from the timber harvesting land base are listed below:

- stands that are age class projected (AGECL_PR) 6 (121 years) or greater and are not greater than height class projected (NHTCL_PR) 2 (19.5 metres) were excluded from the timber harvesting land base.
- stands that are low site (NSITE = L) were excluded from the timber harvesting land base.
- stands in deciduous-leading inventory type groups (I_TYPGRP = 33-42) were excluded from the timber harvesting land base.

Note that alder timber supply was not evaluated as part of this analysis.

A.2.9 Existing unclassified roads, trails, and landings

To account for productive land lost to date during timber harvesting and road building, and not reclassified as non-forest land, 7% of the areas accessed were considered not to contribute to further timber production. The following criteria were used for the existing unclassified roads, trails, and landings reductions:

- 7% reduction after all land base deductions discussed to this point;
- Duncan Forest District is currently considered 80% roaded. Starting with the youngest age class, and working in ascending order of age class, 80% of the Duncan Forest District land base was reduced by 7%;
- Port Alberni Forest District is currently considered 50% roaded. Starting with the youngest age class, and working in ascending order of ages class, 50% of the Port Alberni land base was reduced by 7%;
- the 7% figure was derived from forest district studies and is consistent with estimates used in other parts of the Vancouver Forest Region.

A.2.10 Future roads, trails, and landings

To account for the loss of productive forest land during future timber harvesting and development in the Arrowsmith TSA, 3% of the conventional (zones 1 — 14) and 1% of the unconventional (zone 21) timber harvesting land base is not considered to contribute to further timber production after it is harvested for the first time. Future losses were estimated from current PHSPs and current management practices that include rehabilitation of some roads and landings. It was estimated that all areas in the eastern zones (zones 1 — 3, mostly the Duncan Forest District) will be roaded within 80 years, and in the western zones (zones 11 — 21, mostly the Port Alberni Forest District), 110 years. The appropriate reduction by zone was applied, during the above noted time frames during the modelling of timber supply forecasts.

A.2.11 Not satisfactorily restocked (NSR) areas

There are a total of 1545 hectares in the timber harvesting land base with a type identity of 4, 7 or 9. District records show that there are 1595 hectares of current and backlog NSR area. Using the inventory file area, and after all other deductions (for example roads, ESA) the remaining NSR area is 1446 hectares. Assuming the net inventory file NSR area best illustrates the timber harvesting land base, the NSR areas associated with the district records were pro-rated. NSR areas are assumed to be restocked over time, according to the schedule shown in Table A-18. and are expected to grow according to managed stand yield tables.

Table A-18. Schedule and area of current and backlog NSR

Zone	Analysis unit	Current NSR (hectares)	NSR backlog and years before areas are restocked (hectares)			Total NSR area (hectares)
			1-10	11-20	21-30	
1	3	4.2	17.6			21.8
	4	10.8				10.8
	5	65.2				65.2
	6	8.2	1.6			9.8
	7	21.6	0.9			22.5
2	3	0.1	0.5			0.6
	4	6.6				6.6
	5	60.6				60.6
	6	0.1				0.1
3	3	0.2	1.0			1.2
	4	1.6				1.6
	5	23.8				23.8
	6	0.8	0.2			1.0
	7	0.1				0.1
11	11	1.6				1.6
	12	9.0				9.0
	13	16.5				16.5
	14	174.5				174.5
	15	21.5	50.0			71.5
	16	16.4				16.4
	17	242.2	30.8	30.8	14.2	318.0
	18	148.0	3.7			151.7
	19	10.1	4.3			14.4
12	12	0.3				0.3
	13	2.9				2.9
	14	122.7				122.7
	15	0.0	10.3			10.3
	16	5.6				5.6
	17	57.7	7.3	7.3	3.4	75.7
	18	30.8	0.9			31.7
	19	7.1	3.0			10.1

continued

Table A-18. Schedule and area of current and backlog NSR (concluded)

Zone	Analysis unit	Current NSR (hectares)	NSR backlog and years before areas are restocked (hectares)			Total NSR area (hectares)
			1-10	11-20	21-30	
13	11	0.1				0.1
	12	7.7				7.7
	13	0.5				0.5
	14	44.5				44.5
	15	0.2	8.2			8.4
	16	3.9				3.9
	17	43.2	5.5	5.5	2.5	56.7
	18	19.9	0.6			20.5
	19	1.8	0.8			2.6
14	13	6.6				6.6
	15	6.4	0.4			6.8
	17	0.3	1.7	1.7	0.8	4.5
	18	13.1				13.1
	19	10.6	0.2			10.8
21	21	0.1				0.1
Total		1 229.7	149.5	45.3	20.9	1 445.4

A.2.12 Timber licence reversions

Timber Licences (TLs) are a form of timber tenure that gives the holder exclusive right to harvest merchantable timber from defined areas of Crown land. After the area is harvested and reaches a free-growing condition the land reverts to Forest Service jurisdiction. The timber cut from TLs is not part of the allowable annual cut of a TSA. There are 8911 hectares of current Timber Licences (TLs) in the Arrowsmith TSA. Of this, 7544 hectares would contribute to the timber harvesting land base as defined for this analysis. These areas are anticipated to be harvested over the next 60 years and therefore revert to the Forest Service in a stocked and free-growing condition, and become part of the future timber harvesting land base, over the next 6 decades of the analysis horizon.

For this analysis the inventory file records associated with TLs were not up-to-date. Therefore, the TL land base from the inventory file was excluded. TLs were accounted for by using forest district records and adding the areas back into the timber harvesting land base. These areas are net of the land base reductions discussed above, for example, ESAs. The schedule and areas reverting to the timber harvesting land base from TLs are listed in Table A-19.

A.2 Definition of the Timber Harvesting Land Base

Table A-19. Schedule and areas associated with timber licence reversions

Zone	Analysis unit	Years until reversion							
		0-5	5-15	11-20	21-30	31-40	41-50	51-60	Total
11	11	6.0	6.4	1.8	1.8	1.8	1.8	1.8	21.4
	12	6.0	10.6	1.8	1.8	1.8	1.8	1.8	25.6
	13	14.0	19.7	4.2	4.2	4.2	4.2	4.2	54.7
	14	261.0	241.1	79.6	79.6	79.6	79.6	79.6	900.1
	15	176.3	216.4	53.2	53.2	53.2	53.2	53.2	658.7
	16	369.0	306.1	112.5	112.5	112.5	112.5	112.5	1 237.6
	17	637.0	576.4	194.5	194.5	194.5	194.5	194.5	2 185.9
	18	444.0	391.9	124.7	124.7	124.7	124.7	124.7	1 459.4
	19	1.0	19.9	0.2	0.2	0.2	0.2	0.2	21.9
12	12		0.2						0.2
13	11		4.0	0.6	0.6	0.6	0.6	0.6	7.0
	12		6.9	0.6	0.6	0.6	0.6	0.6	9.9
	13		5.3	1.4	1.4	1.4	1.4	1.4	12.3
	14		5.1	25.4	25.4	25.4	25.4	25.4	132.1
	15		0.8	17.0	17.0	17.0	17.0	17.0	85.8
	16		1.2	35.9	35.9	35.9	35.9	35.9	180.7
	17		2.6	61.9	61.9	61.9	61.9	61.9	312.1
	18		0.6	39.7	39.7	39.7	39.7	39.7	199.1
	19		1.4						1.4
14	11		3.4						3.4
	12		5.8						5.8
	13		2.5						2.5
	14		0.1						0.1
	16		1.1						1.1
	17		8.6						8.6
	18		10.3						10.3
	19		6.8						6.8
Total		1 914.3	1 855.2	755.0	755.0	755.0	755.0	755.0	7 544.5

A.3 Forest Management Assumptions

A.3.1 Forest cover requirements

This analysis did not involve an explicit spatial evaluation of timber supply. However, the computer model used (FSSIM Version 4.2) can incorporate forest cover requirements that specify either the maximum proportion of an area allowed in a disturbed condition (usually defined by the height of young trees), or the minimum required area of old-age forest. Pass systems for timber harvesting can be linked to stand-level adjacency concerns; that is, experience may show that a certain number of harvest passes may be necessary to meet adjacency guidelines. Therefore, forest cover guidelines can approximate the effect of adjacency guidelines as well as broader forest level goals. For this analysis, forest cover requirements were assigned based on the Vancouver Forest Region, *Coastal Harvesting Guidelines*, and forest cover guidelines for visual quality management (VQO guidelines) provided by the Ministry of Forests, Recreation Branch.

The management zones used in this analysis were developed on the basis of forest cover guidelines and silvicultural regimes. The following sections describe the management zones in respect to forest cover guidelines.

Zones 1 and 11 — Integrated resource management zones

These zones are described as Integrated Resource Management (IRM) zones where general wildlife habitat management or forest cover requirement needs are satisfied through the use of a 4-pass harvesting system. The 4-pass harvesting cycle requires that before an area can be harvested, trees in adjacent areas be at least 3-metres tall. Also, the harvesting system allows up to 25% of the operable area in the zone to be cut during any of the passes of the cycle.

Zone 21 — Unconventional harvesting methods

Zone 21 consists of areas where unconventional harvesting methods (helicopter and long-line system) will be employed. This zone encompasses areas with all management emphases represented in the analysis (that is, 4-pass and VQO). The majority of the area is subject to IRM guidelines (4-pass harvesting system).

Rather than subdividing this zone by management emphasis, which would create some very small subzones (less than 50 hectares), forest cover requirements in the non-conventional zone were determined to be satisfied by using a 5-pass harvesting system, and by managing VQO forest cover requirements through PSHPs. Additionally, the 5-pass harvest system represents the restricted access in areas where unconventional harvesting systems are employed (current management practices restrict the level of harvest to less than 50 hectares per year).

The 5-pass harvesting cycle requires that before an area can be harvested, trees in adjacent areas be at least 3 metres tall. Also, the harvesting system allows up to 20% of the operable area in a landscape unit to be cut during any of the passes of the cycle.

Zones 2, 3, 12, 13 and 14 — VQO forest cover requirement zones

In zones that have visual quality objectives (VQO), the forest cover requirements are based on provincial guidelines for managing forest cover in visually sensitive areas. These guidelines define the maximum per cent of the landscape that may not meet green-up requirements, and the stand height required to meet visual green-up. The visually effective height was defined as 5 metres. The maximum per cent area that may fail to meet green-up requirements at any time varies from 1% to 5% for retention VQOs, 6% to 15% for

partial retention VQOs and 16% to 25% for modification VQOs. No visual absorption capability (VAC) ratings were available so mid-points were used for all VQO management zones. Using VQO class mid-points, default dispersion values and calculated green/operable ratios, the final maximum area not meeting green-up conditions for each zone was calculated according to the methods outlined in Recreation Branch Technical Report 1993:1, *Procedures for Factoring Recreation Resources into Timber Supply Analyses.*

Table A-20. Forest cover requirements by zone for the Arrowsmith TSA

Zone	Definition of green-up (metres)	Green–up age[a] (years)	VAC range	Mid-point VAC	Green operable ratio	Adjusted maximum area not green–up[b]
1 East–IRM	3	12				25.00
2 East–Partial retention	5	15	6 - 15	10.0	1.37	10.83
3 East–Retention	5	15	1 - 5	3.0	1.42	3.28
11 West–IRM	3	14				25.00
12 West–Modification	5	20	16 - 25	20.5	2.00	25.13
13 West–Partial retention	5	19	6 - 15	10.0	1.81	11.81
14 West–Retention	5	18	1 - 5	3.0	2.22	3.82
21 West–Unconventional harvesting	3	15				20.00

(a) See Section A.3.7, "Green-up assumptions" for the methodology used to calculate green-up age.
(b) Maximum area not green-up is not adjusted for zones using pass harvesting systems.

No old-growth or biodiversity forest cover requirements were identified by the forest district staff.

A.3.2 Utilization levels

Harvesting is assumed to be carried out to a utilization level of 17.5 cm diameter at breast height (1.3 metres) for all species.

A.3.3 Utilization standards

Utilization standards are a maximum 30 cm stump height and a 10 cm inside-bark diameter at tree top, less decay.

A.3 Forest Management Assumptions

A.3.4 Unsalvaged losses

Table A-21. shows the estimated average annual loss to catastrophic events such as wildfires, and wind damage. Regeneration of these areas is expected to occur within the standard regeneration delay of 2 to 3 years. Estimated annual losses are deducted from the gross harvested volume to determine the projected net volumes that will be harvested over time.

Table A-21. Unsalvaged losses

Cause of loss	Annual unsalvaged loss (m^3/year)
Fire	1 062
Wind damage	2 000
Total	3 062

In the Douglas-fir plantations there is an incidence of root rot and the current volume losses are non-catastrophic. To account for these losses the Operational Adjustment Factor (OAF) for managed stand yield predictions for Douglas-fir was increased to 16.9% from the 5% used for other species.

A.3.5 Harvest profile

Harvest profile consists of any specific characteristics desired in the timber harvest, and normally refers to the tree species composition of the harvest. In some areas, mills require certain species mixes. The purpose of harvest profile restrictions is to examine if the desired species mix can be attained with existing timber supply.

A harvest profile for species composition targets was not applied for the Arrowsmith TSA. However, the unconventional harvesting zone and analysis unit were targeted to be harvested whenever area was available, while meeting forest cover requirements. The objective of this harvest profile was to provide a regular harvest from the zone. That is, the harvest from the zone will, after an adjustment period, become constant. Regularity and harvests under 50 hectares per year are the basis of current management assumptions and practices for the unconventional harvesting zone.

A.3.6 Silviculture and regeneration assumptions

The Arrowsmith TSA is composed of two forest districts with district silvicultural programs. These programs include assessment of the local sites and conditions, and determination of the appropriate silvicultural regimes for regenerating harvested stands. Tables A-22. and A-23. show the analysis units regenerated after harvesting occurs in existing analysis units for the Duncan and Port Alberni Forest Districts. The site indices for the analysis units in each forest district are listed in Table A-24. Table A-24. also shows the amount of area each forest district contributes to each analysis unit.

Managed stand yield tables were created for each forest district reflecting the amount of planting and natural regeneration, species conversion and silvicultural treatments (see Tables A-22. and A-23.). The managed stand yield tables also reflect the site index for the forest district (see Table A-24.). Final managed stand yield tables for the Arrowsmith TSA were estimated by using area-weighted volumes from both forest district yield tables (the sum of the proportions of the district areas times the district volumes). The resultant managed stand yield tables are listed in Section A.5, "Volume Estimates for Managed Stands." The regeneration assumptions shown below apply to all zones. Regeneration delays for each analysis units are shown in Table A-25.

A.3 Forest Management Assumptions

All stands under 31 years of age are assumed to be under managed stand silvicultural regimes. This includes all NSR and TL reversions areas.

Note that incremental silviculture is currently being performed within the Arrowsmith TSA by both forest districts (fertilization and thinning treatments). However, insufficient data was available when the analysis was initiated to create managed stand yield tables that would represent these treatments.

Table A-22. Regeneration assumptions — Duncan Forest District

Analysis unit	Description (existing yield)	Planted			Natural			Initial stocking and spacing
		Fd	Cw	Hw	Fd	Cw	Hw	
1 East	Fd – G	70	20	10				plant @ 900 sph 100% – space @ 2 m ht to 700 sph
2 East	Fd – M	70	20	10				plant @ 900 sph 100% - space @ 2 m ht to 700 sph
3 East	Fd - P	80		20				plant @ 900 sph 100% - space @ 2 m ht to 600 sph
4 East	Fd Mix - G	80		20				plant @ 900 sph 100% - space @ 2 m ht to 700 sph
5 East	Fd Mix - M	70	20	10				plant @ 900 sph 100% - space @ 2 m ht to 700 sph
6 East	Fd Mix - P	80		20				plant @ 900 sph 100% - space @ 2 m ht to 600 sph
7 East	Other Conifer - All	50	30				20	natural @ 3000 sph plant @ 900 sph 100% - space @ 2 m ht to 700 sph
11 West	Fd/Fd Mix - G	40	30	30				plant @ 900 sph 100% - space @ 2 m ht to 600 sph
12 West	Fd/Fd Mix - M	20	40	40				plant @ 900 sph 100% - space @ 2 m ht to 600 sph
13 West	Fd/Fd Mix - P	20	40	40				plant @ 900 sph No spacing
14 West	H/B - G/M	30	30	40				plant @ 900 sph 100% - space @ 2 m ht to 600 sph

continued

Note: Fertilization and thinning treatments are currently being performed. However, there was insufficient data to create managed stand yield tables that would represent these treatments.

A.3 Forest Management Assumptions

Table A-22. Regeneration assumptions — Duncan Forest District (concluded)

Analysis unit	Description (existing yield)	Planted			Natural			Initial stocking and spacing
		Fd	Cw	Hw	Fd	Cw	Hw	
15 West	H/B - P	20	30	25			25	plant @ 900 sph natural @ 1500 sph No spacing
16 West	C/H Mix - G	20	40	40				plant @ 900 sph 100% - space @ 2 m ht to 600 sph
17 West	C/H Mix - M		40	60				plant @ 900 sph 100% - space @ 2 m ht to 600 sph
18 West	C/H Mix - P		50	30			20	plant @ 900 sph natural @ 2000 sph No spacing
19 West	B/S		20	80				plant @ 900 sph No spacing
21 West	Not applicable							

Note: Fertilization and thinning treatments are currently being performed. However, there was insufficient data to create managed stand yield tables that would represent these treatments.

A.3 Forest Management Assumptions

Table A-23. Regeneration assumptions — Port Alberni Forest District

Analysis unit	Description (existing yield)	Planted			Natural			Initial stocking and spacing
		Fd	Cw	Hw	Fd	Cw	Hw	
1 East	Fd - G	100						plant @ 1500 sph 100% - space @ 2 m ht to 600 sph
2 East	Fd - M	100						plant @ 1500 sph 100% - space @ 2 m ht to 600 sph
3 East	Fd - P	80			20			plant @ 1500 sph natural @1500 sph No spacing
4 East	Fd Mix - G	70	30					plant @ 1500 sph 100% - space @ 2 m ht to 600 sph
5 East	Fd Mix - M	70	30					plant @ 1500 sph 100% - space @ 2 m ht to 600 sph
6 East	Fd Mix - P	55	25			10	10	plant @ 1500 sph natural @3000 sph No spacing
7 East	Other Conifer - All	35	15	20		15	15	plant @ 1500 sph natural @ 3000 sph No spacing
11 West	Fd/Fd Mix - G	40	30	30				plant @ 1500 sph 100% - space @ 2 m ht to 750 sph
12 West	Fd/Fd Mix - M	20	40	40				plant @ 1500 sph 100% - space @ 2 m ht to 750 sph
13 West	Fd/Fd Mix P	20	40	40				plant @ 1500 sph No spacing
14 West	H/B - G/M		20	80				plant @ 900 sph No spacing

continued

Note: Fertilization and thinning treatments are currently being performed. However, there was insufficient data to create managed stand yield tables that would represent these treatments.

A.3 Forest Management Assumptions

Table A-23. Regeneration assumptions — Port Alberni Forest District (concluded)

Analysis unit	Description (existing yield)	Planted			Natural			Initial stocking and spacing
		Fd	Cw	Hw	Fd	Cw	Hw	
15 West	H/B - P		10	40		5	45	plant @ 900 sph natural @ 4000 sph No spacing
16 West	C/H Mix - G		40	60				plant @ 900 sph 100% - space @ 2 m ht to 750 sph
17 West	C/H Mix - M		40	60				plant @ 900 sph 100% - space @ 2 m ht to 750 sph
18 West	C/H Mix - P		10	40		15	35	plant @ 900 sph natural @ 4000 sph No spacing
19 West	B/S Mix - All		20	80				plant @ 900 sph No spacing
21 West	Helicopter - All		15	35		20	30	plant @ 900 sph natural @ 4000 sph No spacing

Note: Fertilization and thinning treatments are currently being performed. However, there was insufficient data to create managed stand yield tables that would represent these treatments.

A.3 Forest Management Assumptions

Table A-24. Site index and per cent area by forest district

	Site index			Per cent area in timber harvesting land base	
Analysis unit	**Duncan**	**Port Alberni**	**TSA**	**Duncan**	**Port Alberni**
1 East	35.17	34.19	34.97	77.7	22.3
2 East	28.57	27.68	28.23	61.6	38.4
3 East	19.88	19.93	19.97	53.8	46.2
4 East	34.03	32.60	33.35	50.7	49.3
5 East	27.70	26.93	27.38	58.5	41.5
6 East	19.70	18.85	19.32	46.0	54.0
7 East	23.11	20.08	21.77	53.2	46.8
11 West	35.25	35.98	35.78	36.3	63.7
12 West	27.87	27.81	27.84	52.0	48.0
13 West	18.38	19.54	19.19	47.0	53.0
14 West	23.52	21.42	21.77	10.8	89.2
15 West	12.39	14.30	13.69	26.1	73.9
16 West	30.53	29.38	29.35	4.6	95.4
17 West	20.30	20.92	20.97	11.7	88.3
18 West	13.07	14.11	14.03	6.0	94.0
19 West	19.53	24.27	22.39	40.8	59.2
21 West	N/A	16.42	16.42	0.0	100.0

A.3.7 Green–up assumptions

Green-up criteria for this analysis were based on the time it takes a stand to reach 3 metres in the IRM and unconventional logging zones, and 5 metres in the VQO management zones. The age used for each zone is an area-weighted average by analysis unit. Also, the ages were first calculated using the site index for each forest district (see Table A-24.) and then these ages were combined to result in an area-weighted average green-up age for the entire Arrowsmith TSA.

A.3 Forest Management Assumptions

A.3.8 Minimum harvestable age for each analysis unit

Minimum harvestable ages define the earliest age at which an area may be harvested, not the age at which harvesting must occur. The minimum harvestable ages criteria were defined by forest district staff by geographical location within the Arrowsmith TSA. In the Duncan Forest District the criterion for minimum harvestable age is when stands have an top height of 30 metres. In the Port Alberni Forest District the criteria are that stands must have an average diameter of 25 centimetres and a minimum volume of 300 cubic metres per hectare in the eastern zone, and 400 cubic metres per hectare in the western zones.

Minimum harvestable ages were determined by geographical location, and area-weighted to create one age for each analysis unit within the Arrowsmith TSA. Table A-25. shows the minimum harvestable ages for existing and managed stand yield tables.

Table A-25. Minimum harvestable ages for existing and managed stand yield tables

Analysis unit	Existing volume table number	Managed volume table number	Minimum harvestable age		Regeneration delay
			existing	managed	
1	1	101	48	45	2
2	2	102	59	60	2
3	3	103	112	117	2
4	4	104	48	45	2
5	5	105	64	61	2
6	6	106	111	120	2
7	7	107	73	96	2
11	11	111	47	42	2
12	12	112	67	58	2
13	13	113	149	114	2
14	14	114	73	72	3
15	15	115	168	165	3
16	16	116	55	51	3
17	17	117	87	78	3
18	18	118	188	146	3
19	19	119	84	78	3
21	21	121	215	157	3

A.3 Forest Management Assumptions

A.3.9 Yield assumptions

Yield tables for all existing (greater than 30 years old) stands were developed using the batch version (4.5) of the Variable Density Yield Projection (VDYP) model provided by Ministry of Forests, Inventory Branch. All yield tables assume the utilization levels identified in Section A.3.2, "Utilization levels." The data for the VDYP model are from existing stand information on the 1994 inventory file, provided by Inventory Branch. For all existing stands, aggregated waste and breakage (W2B) factors are developed from the *Inventory Metric Diameter Class Decay, Waste and Breakage Factors Manual* (B.C. Ministry of Forests 1976). A single W2B factor is developed for each of two age ranges for each Public Sustained Yield Unit (PSYU), species and utilization level.

The alder and deciduous volume in all mixed species stands has been excluded from existing yield tables.

Yield tables for all regenerated (i.e. managed) stands were produced using the Table Interpolation Program for Stand Yields (TIPSY) growth and yield model (version 2.1.4) developed by Ministry of Forests, Research Branch. Mean area-weighted site indices of existing stands are assumed to apply to all regenerated stands as well. TIPSY reports potential yields for a specific site, species and management regime. Operationally these yields will be reduced due to irregular stocking, disease, or other factors that reduce productivity. Operational adjustment factors (OAFs) alter the magnitude (OAF1) and shape (OAF2) of the base TIPSY yield curves. OAF1 reflects reduced productivity due to unproductive areas (e.g. swamps, rock outcrops) while OAF2 reflects losses that increase with age (e.g. diseases). For all regenerated stands, waste and breakage factors are assumed to be included in OAF2 used in the TIPSY model inputs. The specific operational adjustment factors used are:

- Operational adjustment factor 1: 15.0%;
- Operational adjustment factor 2 for Douglas-fir stands: 16.9%;
- Operational adjustment factor 2 for all other stands: 5.0%.

A.4 Volume Estimates for Existing Stands

Table A-26. shows the existing stand yield tables for all species and site types in the analysis.

Table A-26. Existing stand yield table estimates

Zone	East	East	East	East	East	East	East
Analysis unit	Fd	Fd	Fd	Fd Mix	Fd Mix	Fd Mix	Other conifer
(site)	good	medium	poor	good	medium	poor	
Table	1	2	3	4	5	6	7
Age	Volume	Volume	Volume	Volume	Volume	Volume	Volume
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	3.27	0.01	0.00	0.85	0.04	0.00	0.88
30	142.48	60.17	1.79	127.76	58.12	2.51	42.87
40	289.72	177.32	45.74	263.37	170.86	47.21	118.03
50	417.82	278.30	111.86	378.77	266.71	113.03	196.13
60	529.70	365.76	170.49	477.57	348.65	172.10	270.44
70	628.34	442.33	221.71	563.19	419.51	223.80	337.45
80	716.16	510.09	266.98	638.28	481.61	269.34	397.21
90	791.95	568.46	306.27	700.54	533.29	308.06	446.88
100	858.81	620.22	341.23	754.32	578.20	342.07	490.00
110	918.43	666.57	372.65	801.27	617.75	372.33	527.74
120	971.51	708.10	400.96	841.39	652.08	398.96	559.26
130	1013.99	740.62	422.53	876.84	681.73	421.67	592.30
140	1049.47	767.15	439.89	906.63	706.22	440.23	622.06
150	1077.25	787.13	452.75	930.28	725.23	454.64	647.89
160	1097.34	800.70	461.12	947.92	738.89	464.97	669.97
170	1109.74	807.92	464.99	959.60	747.31	471.30	688.44
180	1114.68	809.04	464.60	966.21	751.39	474.21	704.96
190	1128.51	817.32	469.01	978.17	760.15	480.06	722.02
200	1142.88	826.07	473.75	990.42	769.19	486.24	738.19
210	1157.22	834.86	478.51	1002.47	778.06	492.24	753.47
220	1171.35	843.50	483.14	1014.17	786.63	497.98	768.63
230	1185.10	851.85	487.57	1025.44	794.85	503.42	782.97
240	1198.43	859.90	491.77	1036.25	802.68	508.54	796.53
250	1211.30	867.62	495.72	1046.59	810.15	513.34	809.34
260	1211.45	867.84	495.94	1047.44	811.14	514.72	813.87
270	1211.59	868.03	496.15	1048.15	812.02	515.99	817.95
280	1211.70	868.21	496.34	1048.74	812.79	517.14	821.64
290	1211.78	868.36	496.52	1049.22	813.47	518.20	824.96
300	1211.85	868.49	496.68	1049.58	814.06	519.17	827.94
310	1211.90	868.60	496.83	1049.85	814.56	520.04	830.61
320	1211.94	868.70	496.97	1050.02	814.99	520.82	832.97
330	1211.97	868.79	497.09	1050.10	815.34	521.53	835.07
340	1211.97	868.85	497.21	1050.11	815.62	522.15	836.89
350	1211.97	868.91	497.31	1050.05	815.83	522.69	838.46

continued

A.4 Volume Estimates for Existing Stands

Table A-26. Existing stand yield table estimates

Zone	West	West	West	West	West	West	West
Analysis unit	Fd Mix	Fd Mix	Fd Mix	H/B	H/B	C/H Mix	C/H Mix
(site)	good	medium	poor	good/med	poor	good	medium
Table	11	12	13	14	15	16	17
Age	Volume	Volume	Volume	Volume	Volume	Volume	Volume
10	0.00	0.00	0.00	0.00	0.00	0.02	0.00
20	4.24	0.05	0.01	0.85	0.00	7.50	0.15
30	150.97	66.62	2.37	47.04	0.03	130.06	24.46
40	297.69	187.25	42.59	147.37	9.54	254.71	107.30
50	423.61	289.16	111.15	240.21	55.78	365.45	188.36
60	532.41	375.99	168.52	321.57	108.13	464.22	261.89
70	627.48	450.97	217.59	391.97	160.65	551.68	327.80
80	711.44	516.64	260.25	453.79	206.96	630.23	387.73
90	783.56	573.55	297.08	506.52	248.06	692.40	436.30
100	846.82	623.86	329.63	552.52	284.92	745.06	478.02
110	902.87	668.79	358.64	592.89	318.11	790.02	514.15
120	952.31	708.83	384.29	627.31	347.26	824.55	542.22
130	992.94	740.64	404.99	662.81	376.07	867.70	576.27
140	1027.30	766.78	422.20	695.33	402.65	907.46	607.73
150	1054.60	786.98	435.72	724.59	426.90	942.24	635.53
160	1074.92	801.31	445.59	750.90	449.00	972.38	659.84
170	1088.30	809.90	451.89	774.53	469.14	998.24	680.81
180	1095.27	813.36	455.17	796.84	488.29	1023.96	701.91
190	1109.55	822.38	461.41	817.59	506.29	1048.63	722.13
200	1124.08	831.62	467.62	836.86	523.17	1071.83	741.18
210	1138.42	840.69	473.59	854.74	539.00	1094.08	759.18
220	1152.40	849.48	479.26	871.38	553.89	1117.74	778.49
230	1165.93	857.90	484.63	886.86	567.87	1140.29	796.95
240	1178.97	865.92	489.67	901.27	581.03	1161.79	814.56
250	1191.49	873.55	494.38	914.70	593.42	1182.30	831.40
260	1192.07	874.45	495.95	923.30	602.07	1186.49	835.96
270	1192.56	875.23	497.42	931.17	610.13	1190.13	840.07
280	1192.96	875.91	498.76	938.35	617.63	1193.24	843.77
290	1193.28	876.50	500.00	944.89	624.62	1195.89	847.09
300	1193.51	876.99	501.16	950.86	631.13	1198.07	850.05
310	1193.69	877.40	502.24	956.28	637.20	1199.85	852.70
320	1193.80	877.73	503.24	961.19	642.84	1201.24	855.04
330	1193.84	877.99	504.16	965.63	648.10	1202.28	857.09
340	1193.83	878.19	505.03	969.65	653.00	1202.99	858.88
350	1193.76	878.30	505.83	973.26	657.56	1203.39	860.43

continued

A.4 Volume Estimates for Existing Stands

Table A-26. Existing stand yield table estimates (concluded)

Zone	West	West	West
Analysis unit	C/H Mix	B/S Mix	Helicopter
(site)	poor	all	all
Table	18	19	21
Age	Volume	Volume	Volume
10	0.00	0.34	0.00
20	0.02	14.77	0.20
30	0.09	101.87	6.62
40	11.20	196.68	44.88
50	50.34	283.23	104.32
60	96.62	367.95	164.50
70	140.56	443.82	219.62
80	181.44	509.16	269.91
90	215.63	564.09	312.16
100	245.61	611.46	349.22
110	272.09	652.67	381.95
120	292.52	687.46	408.12
130	316.59	724.20	437.77
140	338.70	757.94	465.06
150	358.13	788.38	489.28
160	374.96	815.79	510.55
170	389.24	840.52	529.01
180	404.15	864.07	547.63
190	418.50	886.02	565.49
200	432.18	906.53	582.40
210	445.18	925.72	598.42
220	459.61	943.69	615.56
230	473.71	960.63	632.07
240	487.28	976.53	647.87
250	500.37	991.53	663.01
260	503.48	1002.77	668.09
270	506.35	1013.33	672.79
280	508.98	1023.27	677.11
290	511.41	1032.63	681.11
300	513.64	1041.49	684.80
310	515.69	1049.84	688.21
320	517.57	1057.76	691.34
330	519.29	1065.29	694.23
340	520.87	1072.42	696.90
350	522.31	1079.22	699.34

A.5 Volume Estimates for Managed Stands

Table A-27. shows the managed stand yield tables for all species and site types in the analysis. The appropriate regeneration delays, as shown in Table A-25., are applied within the timber supply model and are not accounted for in these yield tables.

Table A-27. Managed stand yield tables January, 1995

Zone	East	East	East	East	East	East	East
Analysis unit	Fd	Fd	Fd	Fd Mix	Fd Mix	Fd Mix	Other conifer
(site)	good	medium	poor	good	medium	poor	
Table	101	102	103	104	105	106	107
Age	Volume	Volume	Volume	Volume	Volume	Volume	Volume
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	30.4	3.4	0.0	17.8	2.4	0.0	0.0
30	189.0	82.9	4.2	162.2	75.0	3.4	12.6
40	357.6	192.1	41.0	318.5	185.9	37.7	81.8
50	425.3	299.3	104.3	486.4	291.7	101.1	170.1
60	681.8	408.2	154.2	633.8	404.1	162.1	253.8
70	811.4	496.8	197.2	766.4	499.2	214.9	333.4
80	918.9	579.3	234.9	877.2	585.1	258.9	406.9
90	1009.4	648.8	272.7	971.2	662.7	303.3	472.9
100	1082.4	709.1	304.0	1052.7	730.7	343.3	532.3
110	1140.9	758.3	334.8	1119.5	785.6	380.4	589.0
120	1192.6	798.9	360.1	1173.5	833.2	413.5	637.4
130	1237.1	834.0	381.6	1221.3	873.6	440.6	680.3
140	1271.7	862.8	398.4	1263.4	909.1	464.4	719.6
150	1299.2	885.7	412.2	1298.1	940.0	485.0	754.7
160	1319.8	903.4	423.2	1326.6	964.4	504.3	785.5
170	1334.8	918.0	432.8	1347.9	983.3	520.9	812.9
180	1348.0	928.6	441.4	1364.4	999.0	536.2	836.2
190	1358.0	936.4	448.4	1378.9	1011.8	548.1	856.4
200	1358.0	941.7	454.0	1389.8	1021.4	558.9	874.5
210	1358.0	945.3	457.7	1401.2	1029.5	567.9	891.6
220	1358.0	947.8	460.6	1401.2	1038.6	576.3	909.8
230	1358.0	948.9	462.3	1401.2	1045.7	583.8	925.8
240	1358.0	948.3	462.4	1401.2	1051.1	590.9	939.5
250	1358.0	945.3	461.5	1401.2	1054.6	595.8	950.3
260	1358.0	942.3	459.4	1401.2	1056.5	599.9	959.3
270	1358.0	938.0	456.3	1401.2	1056.6	603.4	967.3
280	1358.0	932.3	452.9	1401.2	1055.7	605.2	973.5
290	1358.0	925.5	448.6	1401.2	1053.9	606.3	978.9
300	1358.0	925.5	445.4	1401.2	1053.9	607.3	983.6

continued

A.5 Volume Estimates for Managed Stands

Table A-27. Managed stand yield tables January, 1995

Zone	West	West	West	West	West	West	West
Analysis unit	Fd Mix	Fd Mix	Fd Mix	H/B	H/B	C/H Mix	C/H Mix
(site)	good	medium	poor	good/med	poor	good	medium
Table	111	112	113	114	115	116	117
Age	Volume	Volume	Volume	Volume	Volume	Volume	Volume
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	54.6	4.0	0.0	0.0	0.0	7.3	0.0
30	239.8	98.9	3.5	17.3	0.0	141.8	8.5
40	448.6	233.1	50.4	114.6	2.2	301.6	92.0
50	656.4	372.9	127.3	213.6	18.0	476.9	182.3
60	850.9	518.4	202.5	309.5	54.1	648.0	273.4
70	1018.1	650.5	268.4	409.4	102.3	808.6	359.6
80	1161.4	780.7	330.1	503.9	149.2	951.9	451.7
90	1287.2	889.7	391.5	590.8	195.4	1082.9	534.2
100	1392.4	991.4	447.5	675.2	238.8	1201.9	614.9
110	1484.3	1082.6	500.5	750.3	277.7	1305.2	686.1
120	1569.7	1162.9	548.1	820.7	315.6	1394.5	751.9
130	1641.4	1230.8	590.8	880.2	351.4	1478.3	816.1
140	1701.7	1294.2	630.4	932.3	384.8	1551.0	871.9
150	1755.8	1351.2	665.6	983.7	413.9	1614.9	920.6
160	1804.7	1400.4	698.4	1030.7	440.7	1671.3	967.0
170	1843.9	1442.3	727.4	1073.1	465.1	1722.9	1008.9
180	1863.7	1479.5	753.8	1112.0	489.1	1773.8	1047.5
190	1863.7	1512.2	777.5	1146.9	513.7	1819.8	1082.7
200	1863.7	1542.4	799.1	1178.0	533.0	1860.4	1114.4
210	1863.7	1572.4	819.0	1204.0	552.6	1898.6	1144.5
220	1863.7	1605.0	840.8	1229.0	571.2	1937.5	1173.3
230	1863.7	1634.0	860.5	1251.0	589.3	1972.6	1198.3
240	1863.7	1658.5	878.3	1270.6	605.8	2005.1	1220.7
250	1863.7	1680.0	895.0	1290.9	620.7	2037.6	1241.6
260	1863.7	1699.3	909.9	1310.7	634.8	2067.2	1259.9
270	1863.7	1716.3	922.9	1328.7	648.1	2093.2	1279.9
280	1863.7	1732.1	934.7	1345.3	660.0	2118.0	1298.4
290	1863.7	1748.3	945.4	1360.2	670.1	2136.9	1315.6
300	1863.7	1748.3	945.4	1360.2	677.2	2136.9	1315.6

continued

A.5 Volume Estimates for Managed Stands

Table A-27. Managed stand yield tables January, 1995 (concluded)

Zone	West	West	West
Analysis unit	C/H Mix	B/S Mix	Helicopter
(site)	poor	all	all
Table	118	119	121
Age	Volume	Volume	Volume
10	0.0	0.0	0.0
20	0.0	0.0	0.0
30	0.0	35.4	0.0
40	2.1	133.2	7.8
50	14.0	240.1	56.6
60	56.1	347.3	121.7
70	104.9	449.5	189.1
80	153.3	551.5	256.7
90	203.1	644.5	315.2
100	249.9	730.3	369.6
110	290.5	806.5	422.4
120	325.1	876.4	470.9
130	358.0	941.7	513.2
140	388.4	1001.2	553.9
150	419.1	1054.2	593.9
160	445.9	1100.3	629.4
170	470.5	1139.0	661.7
180	491.8	1175.2	690.8
190	513.5	1210.2	717.3
200	533.2	1242.9	741.1
210	551.4	1273.1	761.9
220	571.1	1302.4	782.6
230	589.2	1327.8	804.3
240	606.3	1351.0	823.7
250	622.1	1371.8	841.8
260	636.0	1389.9	859.1
270	648.4	1406.3	875.7
280	660.2	1422.9	891.4
290	670.7	1438.1	905.5
300	677.8	1438.1	915.2

APPENDIX B

Description of Inventory Updates and Supplementary Information

Introduction

The following tables and commentary outline updates to the Forest Inventory Planning (FIP) file that were made before using the methods and inputs to derive the timber harvesting land base outlined in Appendix A, "Description of Data Inputs and Assumptions." This appendix includes supplementary information for tables in Appendix A.

B.1 Inventory Updates

B.1.1 Update of the Provincial forest land base

Since the timber supply analysis in 1988 the land base for the Arrowsmith TSA has changed due to land exchanges and updating of TSA boundaries. This section outlines omissions to the 1994 inventory update for the Provincial Forest ownership codes 62-C and 69-C.

Areas defined on the inventory as Provincial forest code 0999 sub code 0 were reviewed and the areas not part of the Provincial forest are listed in Table B-1.

Table B-1. Provincial Forest code 0999, sub code 0, areas removed from the land base

Forest district	Location[a]	Mapsheet	Ownership	Polygon number
Duncan	East	092B042	62-C	All
		092B053	62-C	All
		092B062	69-C	206
		092B063	62-C	02 03 04
		092B071	69-C	06 07 08 09 11 12 13 14 2850
		092B081	62-C	2852
		092B092	62-C	2864
Duncan	West	092C058	62-C	All
		092C089	62-C	All
		092C090	62-C	All
Port Alberni	East	All	62-C/69-C	All
Port Alberni	West	All	62-C/69-C	All

(a) The data package was compiled by east and west zone designations for each forest district. See Appendix A, Section A.1, "Zone and Analysis Unit Definition."

B.1.2 Update of timber licence reversion areas.

As noted in Appendix A, "Description of Data Inputs and Assumptions" many errors were noted in the coding of Timber Licence areas (ownership code 70-N). To resolve this problem forest district records of the existing Timber Licence land base were used in lieu of the FIP file records. However, this procedure did not account for some Timber Licence areas in the Duncan Forest District that had already reverted to the Arrowsmith TSA, and are not reflected in the current inventory. Areas that were updated are listed below and presented in Table B-2.

- All areas are in the Duncan Forest District and associated with mapsheet 092C059.
- Mapsheet 092C059 polygon numbers 13, 38, 45 and 60 were recorded as stands having ages 300 years or greater. These stands have been harvested and are now recorded as NSR.
- Mapsheet 092C059 polygon numbers 1 through 11 are correct. All other polygons, except those presented in Table B-2., were updated to have their ownership codes recorded as 62-C. Table B-2. shows the correct amount of area by ownership code for those polygons that have both ownership code 62-C and 70-N area.

B.1 Inventory Updates

Table B-2. Update of polygons with mixed ownership code area

Forest district	Mapsheet	Polygon number	% area 70-N	% area 62-C
Duncan	092C059	13	95	5
		15	10	90
		16	5	95
		21	40	60
		22	50	50
		26	15	85
		29	5	95
		38	1	99
		42	2	98
		45	70	30
		47	70	30
		51	2	98
		56	10	90
		60	95	5
		61	20	80
		67	80	20
		68	100	20
		69	90	10
		71	100	0
		117	5	95
		119	40	60

B.1.3 Update of specific polygons for mapsheet 092B071

During the inventory update process polygons 1 through 88 on mapsheet 092B071 were not updated. The Duncan Forest District staff provided the Timber Supply Branch with a digital file with updated information. This information was transferred to the forest inventory planning file. The digital file is on file at the Timber Supply Branch.

B.1.4 Update of recreation inventory

Forest recreation inventory data was available on the Forest Inventory Planning file for the entire Arrowsmith TSA. However, since the last compilation the Port Alberni Forest District staff have reviewed and updated their forest recreation inventory. Using the V–feature code (Field = RECREATE) by recreation polygon number (Field = RECPOLNO) the forest inventory file was updated so that the most accurate information could be used in the analysis to delineate the timber harvesting land base by management zone (see Appendix A, Section A.1.1, "Definition of management zones"). Table B-3. shows the updates to the forest inventory file by mapsheet, management zone (V-feature) and recreation polygon number.

B.1 Inventory Updates

Table B-3. Forest recreation inventory update

Mapsheet	VQO	Recreation polygon number[a]
092E030	Retention	06 21 23
092E039	Retention	06 08
092E040	Retention	02 03 04 06 28
	Partial retention	25 27
092E048	Partial retention	24
092E049	Retention	13 14 15 38 39 40 43
	Partial retention	41 44
	Modification	36
092E050	Partial retention	07
092E058	Modification	06 09 15 16 21
092E059	Modification	28
092E068	Modification	14 26
092F002	Modification	02 03
092F003	Retention	02
	Partial retention	29 31 39
	Modification	09 15 43
092F004	Retention	06(07) 06(09) 74
	Partial retention	05(07) 95 99
	Modification	19(IRM) 24 29 65
092F005	Retention	14 16 21 22 30 31 42 52 55 56 58
	Partial retention	04 05 09 11 32 44 54 57 61
	Modification	17 25 63 65
092F006	Retention	24 26 27 28 29 30 41 45
	Partial retention	19
	Modification	05 17 18 20 46
092F012	Partial retention	03 06 07 13
	Modification	09 11
092F013	Partial retention	29
	Modification	03 24
092F014	Modification	12 19 49
092F015	Partial retention	07
	Modification	04
	IRM	01 08 09 10
092F016	Modification	02
092F021	Partial retention	06 07
	Modification	06
092F022	Retention	09 15
	Partial retention	13
092F026	Modification	07 27
092F028	Retention	10
092F030	Partial retention	01 02

continued

(a) The recreation polygon numbers on the Forest Inventory Planning (FIP) File are only two digits numbers whereas the mapsheets are three digit numbers. Where there is duplication of numbers, the correct polygon is also identified by management code sub-field.

Table B-3. Forest recreation inventory update (concluded)

Mapsheet	VQO	Recreation polygon number[a]
092F036	Modification	07 13
092F037	Modification	17
092F038	Modification	07 23
092F039	Modification	03
092F046	Modification	09 14 15 29
092F047	Modification	02 04 07 09 15 18
092C085	Retention	03 19 20 21 22 30 31 32 33
	Modification	42
092C094	Retention	01 07 08 09 18 27 40 41 43 47 48 50 51 53 59
	Partial retention	06 20 42 44 45 46 49 52 54 55 61
	Modification	55 61
092C095	Retention	03 05 09 12 13 14 15 16 18 19 24 26 27 28 29 30 32 37 40 42 46 48 50 60 65 66 67 71
	Partial retention	33 34 36 68 75
	Modification	52 70
092C096	Retention	01 08 12 13 17 18 19 22 23 24 25 28
	Partial retention	20 27
	Modification	07 26 29
092G001	Retention	13
092G002	Retention	01

(a) The recreation polygon numbers on the Forest Inventory Planning (FIP) File are only two digits numbers whereas the mapsheets are three digit numbers. Where there is duplication of numbers, the correct polygon is also identified by management code sub-field.

B.2 Supplementary Information

B.2.1 Description of Duncan Forest District ESA table notes

Table B-4. Planning cell ESA deduction by ESA code — Duncan Forest District

Mapsheet	Planning cell polygon number	Forest cover polygon number	ESA code
092B081	8542	290	S002
		292	S002
	8575	326	W004
		327	W004
092C059	8512	158	S002
		156	S002
092B062	8524	163	S002
		162	S002
		141	S002
		161	S002
		158	S002
	8525	156	S002
		153	S002
	8527	150	S002
		151	S002

Table B-5. Planning cell ESA deduction by polygon number — Duncan Forest District

Mapsheet	Planning cell polygon number	Forest cover polygon number	Per cent reduction
092G001	8516	24	100
		26	100
		28	70
		406	90
		18	100
		22	100
		16	100
		34	10
		14	80
		02	40
		12	90