Integrated Resource Management Plan

Data Package – Arrowsmith TSA

V 1.4

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Prepared for:

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1 Introduction

The Resource Practices Branch (RPB) of the Ministry of Forests, Lands and Natural Resource Operations (FLNRO) aims to develop a new management unit planning framework; the Integrated Resource Management Plan (IRMP). The IRMP is a sustainable forest management planning framework with the objective to integrate all aspects of landscape-level and operational planning for each Timber Supply Area (TSA).

The IRMP will integrate Type 4 Silviculture Strategies with timber supply review (TSR) to reduce duplication and redundancies where possible by sharing inventories, management zones, analysis units, Timber Harvesting Land Base (THLB) definitions and management assumptions. It is expected that the IRMP process will improve the linkages to landscape level fire management, the Cumulative Effects Framework, the Forest and Range Evaluation Program's (FREP) multiple resource values assessments (MRVA) and other regional, management unit level or landscape level plans and strategies.

The IRMP aims to improve resource planning in British Columbia by addressing specific issues such as:

- Species at risk management and reserve allocation. Are the reserves placed where they provide the conditions most needed by species at risk?
- Ability to investigate options to co-locate reserves to provide required habitat benefits while preserving or increasing harvest opportunities;
- Current and predicted harvest levels – are the assumptions regarding the transition from old growth stands to second growth and managed stands accurate and, if not, what are the possible impacts on timber harvest and habitat values?
- What options are available to address habitat and timber supply using silvicultural treatments?
- Effective use of public funds for new and existing funding initiatives;
- A feedback loop for adaptive management; ability to assess decision outcomes and modify behaviour based on new and better information; and,
- First Nations consultation; better understanding of the expected impacts of planned activities.

Before developing the IRMP framework the FLNRO initiated Type 4 Silviculture Strategies in several TSAs most seriously impacted by the mountain pine beetle and wildfires. A Type 4 silviculture strategy is a rationalized plan to guide public expenditures to improve future timber supply within a management unit. There are currently eight Type 4 Silviculture Strategies underway in the interior of BC that can, over time, be integrated with TSR and evolve into IRMPs.

This project in the Arrowsmith TSA is a pilot project and it will run in conjunction with the on-going TSR. The objective is to build an IRMP for the TSA use the project as a learning tool while expanding IRM planning to other TSAs[1].

1.1 Context

This document is the second of four documents that make up an IRMP. The documents are:

[1] In other TSAs, the IRM process will be referred to as Integrated Silviculture Strategies.

1. Situational Analysis – describes in general terms the current situation for the unit. The Situational Analysis forms the starting point for the initial planning group meeting to identify opportunities.
2. **Data Package - describes the information that is material to the analysis including data inputs and assumptions.**
3. Modeling and Analysis report –provides modeling outputs and rationale for choosing a preferred scenario.
4. Integrated Resource Management Plan – represents the preferred management scenario which is the basis for the first iteration of the IRMP. It includes an investment strategy and provides treatment options, associated targets, timeframes and expected benefits.

When the IRMP is complete, a spatial operations schedule will provide direction for harvesting and a land base investment schedule will guide Forest for Tomorrow Annual Operating Plans.

1.2 Study Area

The Arrowsmith TSA is located on the southern half of Vancouver Island. It includes communities in four regional districts: the Alberni Clayoquot, Cowichan Valley, Nanaimo, and Capital Regional District. Other major population centres include Duncan, Ladysmith, Municipality of North Cowichan, Parksville, Qualicum Beach and Port Alberni; smaller communities include Tofino, Ucluelet, Lake Cowichan, Nanoose, Chemainus, Union Bay and Fanny Bay.

The Arrowsmith TSA is part of the West Coast Natural Resource Region of FLNRO and is administered by the South Island Natural Resource District.

The Crown land within the TSA is scattered with small parcels occurring from the east coast of Vancouver Island to Mooyah Bay in the north. The total area of Crown land is 159,214 ha, of which 4,127 ha is within the Tree Farm License (TFL) 46 takeback area. Figure 1 shows the Crown ownership areas within the TSA.

The TSA is divided into 3 zones: East, West and Clayoquot. The East zone has a long harvest history with extensive areas of managed second growth forests. Forests in the East zone are located near communities and often form community interface areas.

The forests in the West zone are generally older and more isolated; second - growth forests where they exist are young and will not be available for harvest for some time. In the Clayoquot zone, timber harvesting and resource management is strictly governed as discussed below. The management zones are shown in Figure 2.

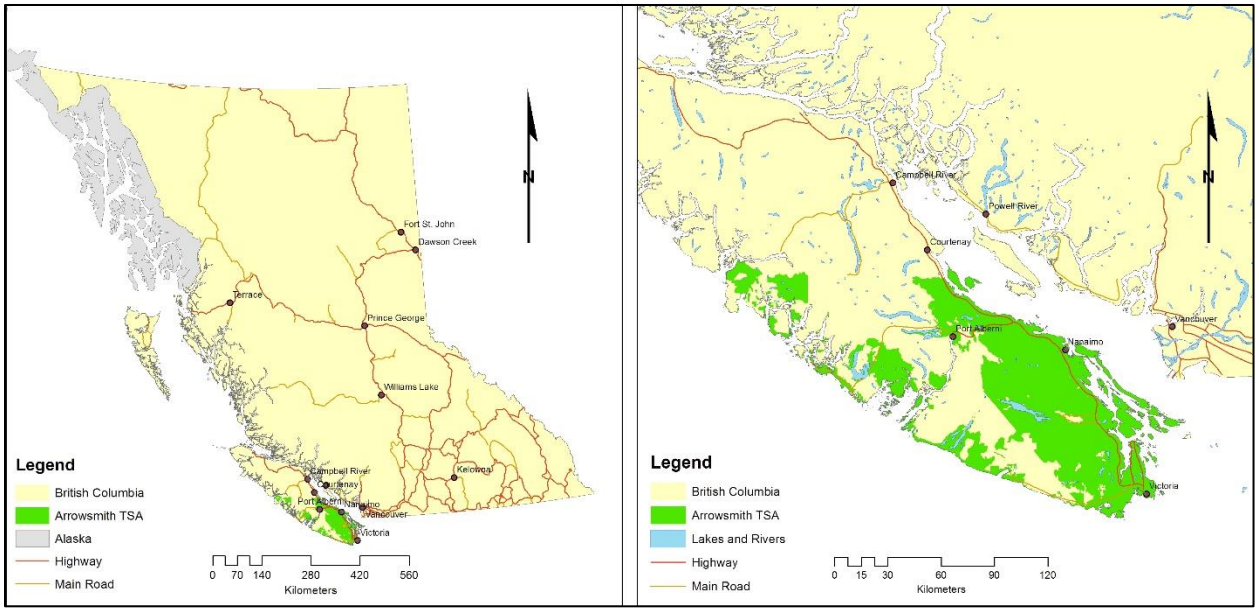

Figure 1: Location of Arrowsmith TSA

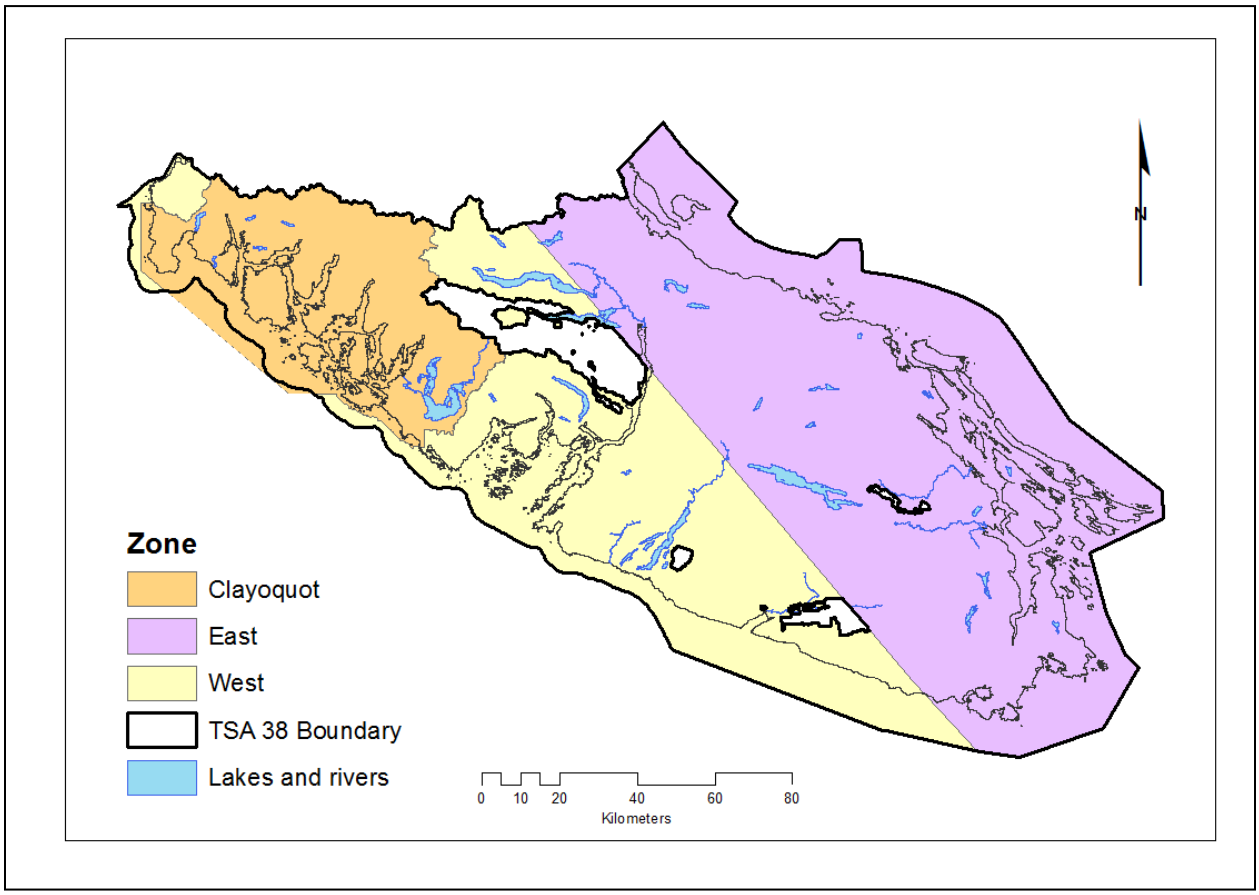

Figure 2: Arrowsmith TSA management zones

The Vancouver Island Land Use Plan (VILUP) and associated Higher Level Plan Order (HLPO) direct resource management on all Crown land within the Arrowsmith TSA outside of the Clayoquot Sound Land Use Decision area and the Gulf Islands. The VILUP and HLPO designate three management zones: Special Management Zones (SMZ); Enhanced Forestry Zones (EFZ) and General Management Zones (GMZ).

The SMZs accounts for approximately 16 448 ha (14%) of the productive forest in the Arrowsmith TSA. The SMZs within the TSA are: Barkley Sound, Alberni Canal, San Juan Ridge, Upper Qualicum and Nahmint. The SMZs require higher level of mature and old seral retention than other zones and apply a three-metre green-up height within each SMZ.

The EFZ with the objective of enhanced timber production allows a shorter, 1.3 meter green-up height. The EFZ accounts for 9 255 ha (8%) of the productive forest in the TSA. The EFZs within the TSA are: Effingham, Maggie, Sarita and Loss.

No special management is designated under the GMZ. Rather, general management under the Forest and Range Practises Act (FRPA) and other legislation apply to these areas.

Almost 90,000 ha or 34% of Clayoquot Sound is preserved. This includes over 70,000 ha of coastal temperate rain forest. An additional 21% of Clayoquot Sound is under special management emphasizing the protection of wildlife, recreation and scenic values. Some logging using retention systems is allowed.

The provincial government adopted the recommendations of the Clayoquot Sound Scientific Panel (CSSP) in 1995. The recommendations include completion of 15 watershed plans. Harvesting is not allowed within the plan areas as they are reserved for ecosystem representation, red- and blue-listed plant and wildlife species, cultural values, recreation, hydro-riparian resources, sensitive soils and unstable terrain and interior forest conditions. Areas outside of the watershed reserves are available for harvesting; however the CSSP recommendations specify the maximum rates of cut, old-seral forest requirements, visual quality objectives and variable retention harvest systems.

The total productive forest area in the Arrowsmith TSA portion of Clayoquot Sound is 23,103 hectares. Since the recommendations of the CSSP, there has been little harvesting in the Clayoquot Sound area within the TSA.

The terrain of the TSA is variable; lowland valleys with nutrient rich, moist sites are common as are mountainous areas, with poorer, drier sites. Most of the productive forest in the TSA is within the Coastal Western Hemlock (CWH) biogeoclimatic zone with cool, wet summers and mild winters. Western hemlock is the dominant tree species in these areas. In the drier Coastal Douglas-fir (CDF) zone on the eastern side of the southern portion of the TSA, the stands are dominated by Douglas-fir. The Mountain Hemlock (MH) zone occurs at higher elevations.

The forests of the TSA are productive and diverse; more than half of the forests on the land base contributing to timber supply are considered to have medium or good site productivity. Major tree species include: Douglas-fir, western redcedar, western hemlock and true firs; other species such as cypress, spruce, red alder, and maple can also be found in the TSA.

Inventory site index estimates are assumed to be the best for natural stands and old plantations. Provincial site productivity layer estimates of site index are assumed to be the best for contemporary plantations and future stands.

2 Timber Supply

2.1.1 Historical and Current AAC

The current AAC in the Arrowsmith TSA is 420,000 m^3 per year of which 6,300 m^3 is attributable to red alder-leading stands with at least 50 % deciduous species by volume, and 13,700 m^3 attributable to the Clayoquot Sound area. This AAC will remain in effect until a new AAC is determined, which is scheduled for early 2017.

Table 1: Historical and current AAC

AAC (m^3)		1986	1989	1992	1996	2002	2004(April1)	2004 (April 22)	Current
		392,000	395,870	498,250	400,000	373,300	391,796	418,796	420,000
Partition	Deciduous		3,870		6,300	6,300	6,300	6,300	6,300
	Clayoquot				13,700	13,700	13,700	13,700	13,700

The harvest performance in the TSA has generally not met the AAC. Over a six-year period from 2008 to 2014 approximately 84% of the available AAC has been harvested.

2.1.2 Age Class Distribution and Species Profile

While older age classes are prevalent in the productive forest, the long harvest history in the TSA is reflected in the relatively large areas of younger forest in the THLB. Almost 70% of the THLB is younger than 101 years old (Figure 4). Age classes 6 and 7 are not well represented; future harvesting in the TSA will depend on the timber currently in age classes 3, 4 and 5, and available timber in age classes 8 and 9 (Figure 3).

Western redcedar and yellow cypress (cedar group) leading stands dominate the older age classes together with hemlock/balsam leading stands, while Fd leading stands are more common in younger age classes (Figure 4).

Younger Fd - leading stands dominate the East zone (Figure 5), while old age class 8 and 9 western redcedar/yellow cypress and hemlock/balsam leading stands are prevalent in the West zone (Figure 6). Note the fairly large area of younger (1 to 3) age classes in the West zone.

Age class 8 and 9 western redcedar/yellow cypress and hemlock/balsam stands dominate the Clayoquot zone; however age classes 1 and 2 are also well represented (Figure 7).

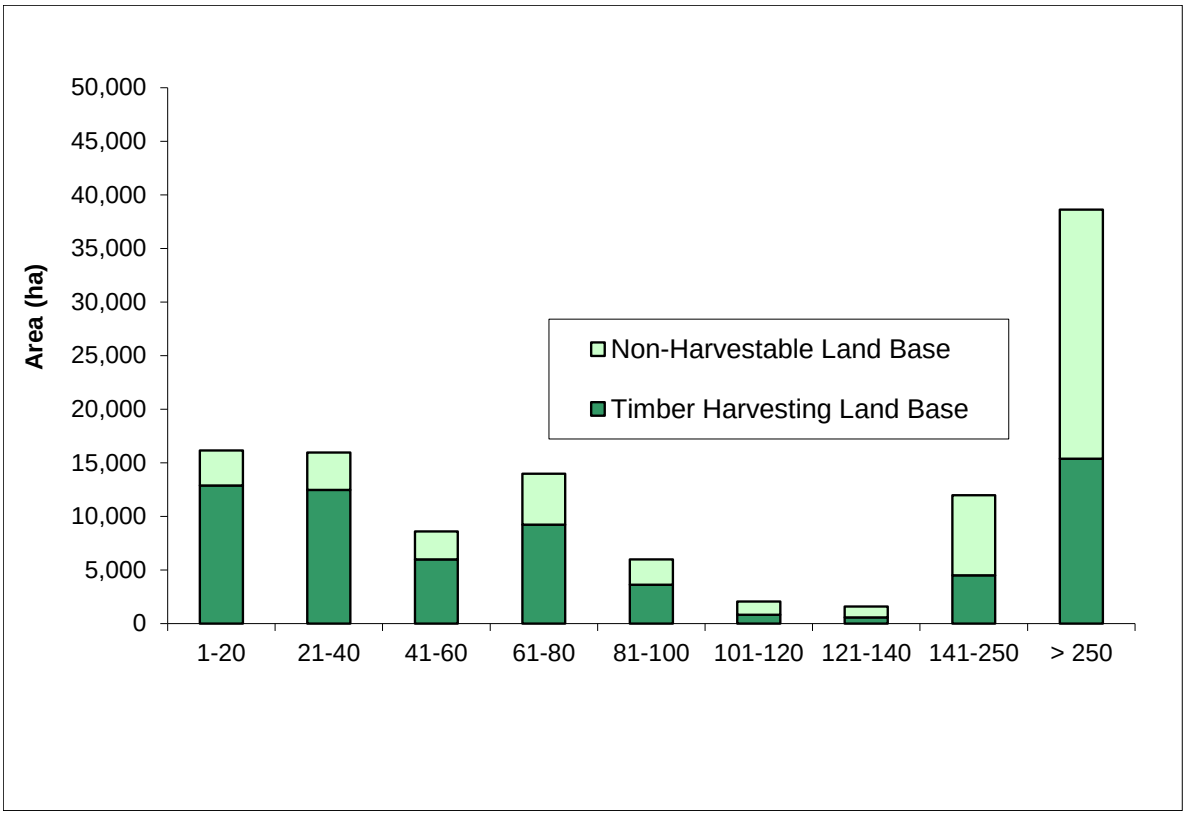

Figure 3: Age class distribution in the Arrowsmith TSA

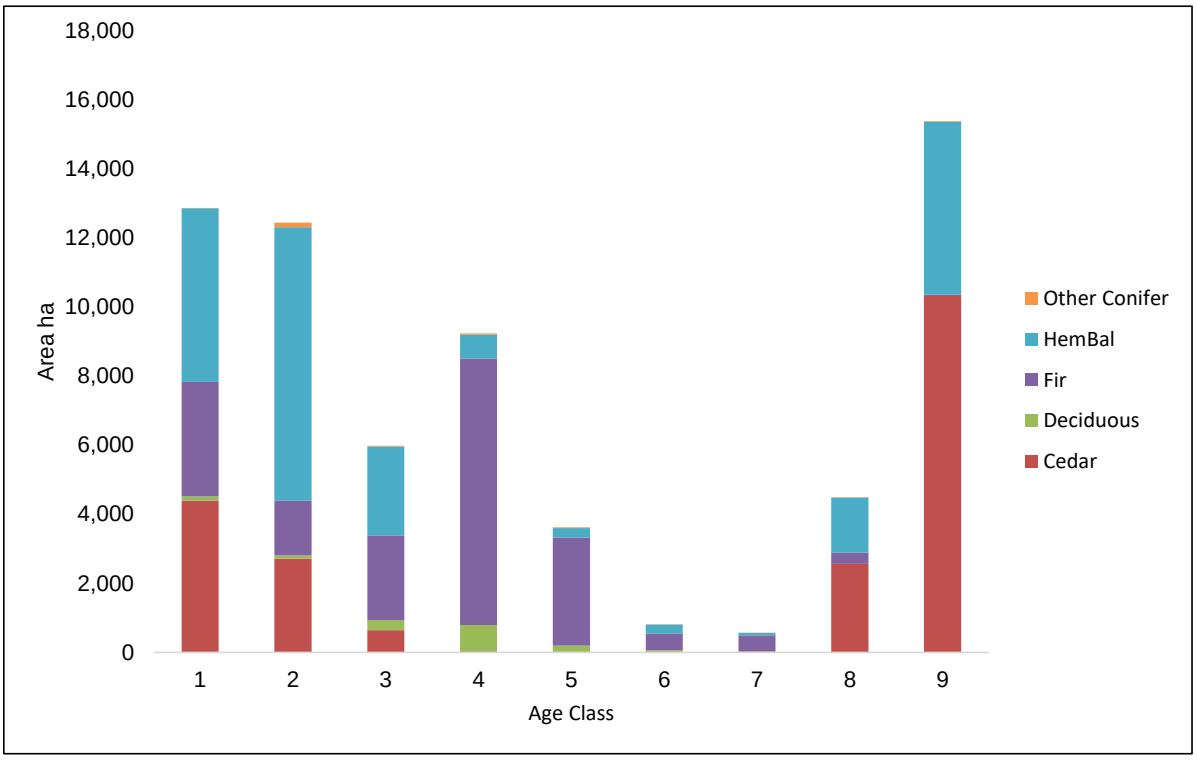

Figure 4: Age class distribution by leading species group on the THLB; Arrowsmith TSA

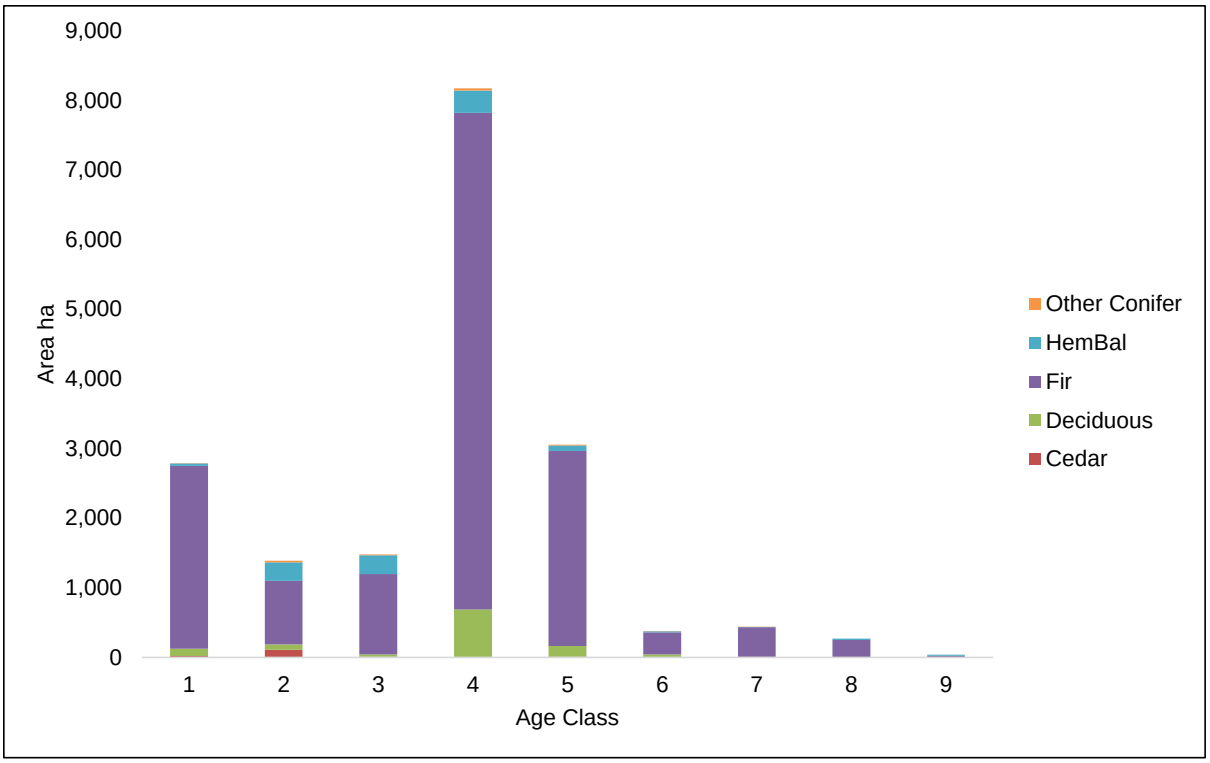

Figure 5: Age class distribution by leading species group on the THLB; East zone

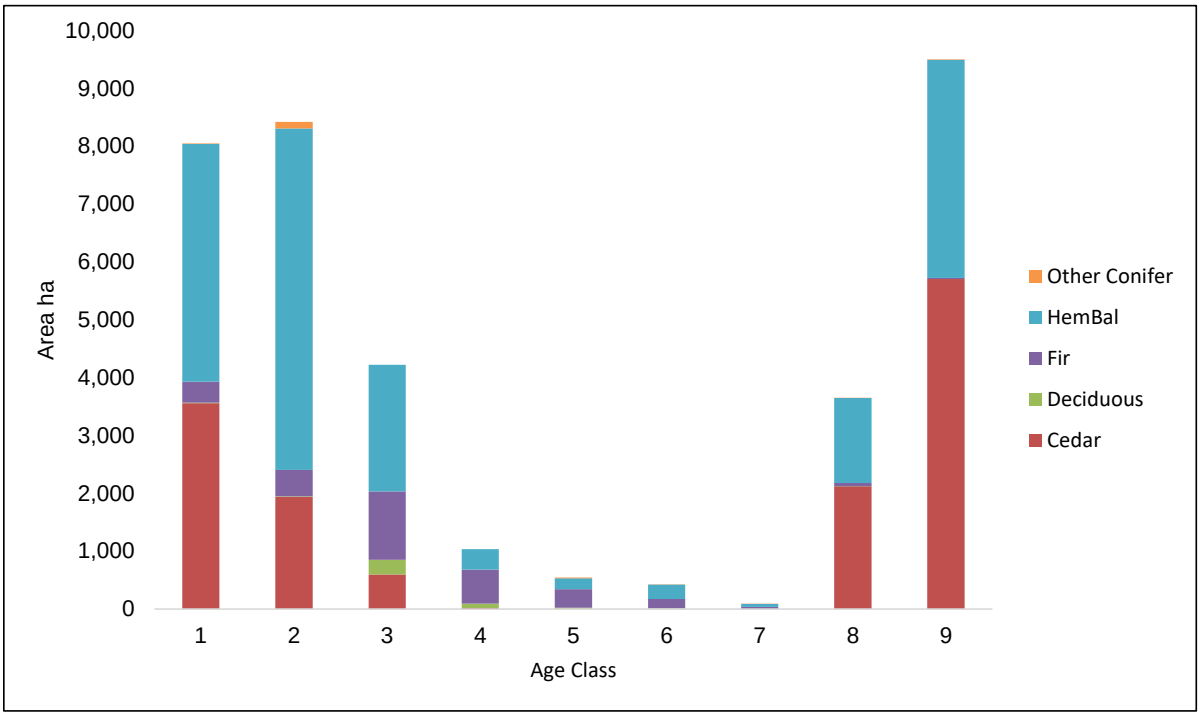

Figure 6: Age class distribution by leading species group on the THLB; West zone

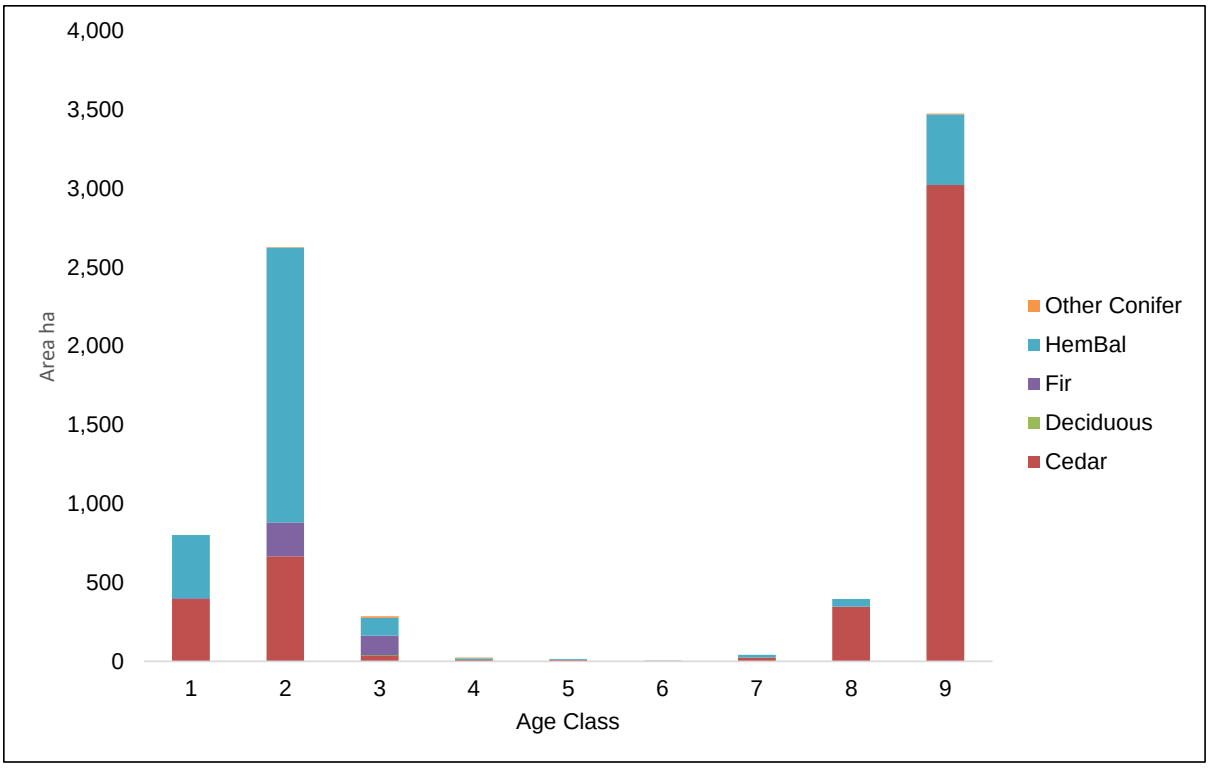

Figure 7: Age class distribution by leading species group on the THLB; Clayoquot zone

2.2 Timber Supply Review Initiated in 2014

By legislation the deadline for the next AAC determination for the Arrowsmith TSA is July 2019; 10 years after the last determination. A new TSR was initiated by the FLNRO in 2014 to address concerns regarding the timber supply in the Arrowsmith TSA. The following factors contributed to the early commencement of the TSR:

- Economic operability: FLNRO staff and the TSA licensees regarded the economically operable land base as modeled in the last TSR to be an overestimation. An economic operability project was completed in the spring of 2014. The project redefined the economically operable land base for the on-going TSR;
- Fragmented and constrained land base with new and proposed area-based licenses: the TSA is heavily fragmented and constrained. New and proposed area-based tenures fragment the land base even more and make it difficult for the TSA licensees and BCTS to find operating area;
- First Nations treaties and interim treaty agreements are withdrawing land from the TSA and are contributing to the difficulty in finding operating areas.

2.3 Retention Strategies

The VILUP sets retention targets for different land - use zones, with the Clayoquot Sound Plan Area having its own targets. Almost 60 % of the harvest in the Arrowsmith TSA includes variable levels of retention with the rest consisting of clear cut with reserves and clear cut (MOFR, 2009).

3 Modelling Approach

3.1 Model

For this analysis Forest Simulation Optimization System (FSOS) is used for modelling. FSOS can operate as both a simulation and a heuristic optimization model using the same database. Simulation allows for sensitivity analysis and utilizes a hard constraint-based approach. Optimization is a target-oriented approach representing a shift in modeling approach from "what can we take from the forest" to "what can we create in the forest." Blocking and scheduling is conducted separately in simulation, and simultaneously in optimization. Scheduling in simulation progresses one period at a time, while optimization planning considers all periods at the same time. Data can be spatial and/or non-spatial. FSOS accommodates overlapping resource values and constraints and can account for multiple values such as timber, silvicultural treatments, carbon allocation, biodiversity, wildlife, and visual quality. Algorithms employed in FSOS include simulated annealing, Tabu search algorithms, and Hill Climbing.

3.2 Data Sources

This analysis first built a dataset similar to the one constructed for the Arrowsmith TSA TSR. The intent was to use this TSR equivalent dataset to benchmark our forest estate model runs with those based on the current Arrowsmith TSA TSR, particularly the Base Case. After benchmarking the data set was modified by incorporating additional THLB netdowns and management objectives that reflect the goals and objectives of the IRMP. Hal MacLean of the Forest Analysis and Inventory Branch (FAIB), FLNRO provided most of the required data in ESRI file geodatabase format. Additional data layers were also provided by the South Island Natural Resource District in Port Alberni and the West Coast Region in Nanaimo.

Table 2 lists all the data layers used in the analysis. For more information on the data coverages pertaining to the Arrowsmith TSA TSR, refer to the Arrowsmith Timber Supply Area Timber Supply Review Data Package (September 2015) published by the Ministry of Forests, Lands, and Natural Resource Operations.

Table 2: Spatial Data Sources

Dataset layer	Source	Factor
WHSE_ADMIN_BOUNDARIES.FADM_TSA	BCGW	TSA administration (outer boundary)
WHSE_ADMIN_BOUNDARIES.FADM_TSA (TSA_NUMBER = '38' AND TSB_NUMBER is not null)	BCGW	Timber Supply Area (inner boundary)
WHSE_FOREST_VEGETATION.F_OWN (SINRD local version)	FAIB/SINRD	Land ownership and schedule codes
WHSE_FOREST_VEGETATION.VEG_COMP_LYR_R1_POLY	BCGW	Vegetation cover
Inventory Disturbance Update (consolidated cutblocks and change detention)	FAIB	Accounting for recent harvests
WHSE_ARCHAEOLOGY.RAAD_AOA_PROVINCIAL	BCGW	Archaeological sites
WHSE_WILDLIFE_MANAGEMENT.WCP_WILDLIFE_HABITAT_AREA_POLY	BCGW	Wildlife habitat areas
WHSE_WILDLIFE_MANAGEMENT.WCP_UNGULATE_WINTER_RANGE_SP	BCGW	Ungulate winter range
WHSE_LAND_USE_PLANNING.RMP_OGMA_LEGAL_CURRENT_SVW	BCGW	OGMAs (legal)
WHSE_LAND_USE_PLANNING.RMP_OGMA_NON_LEGAL_CURRENT_SVW	BCGW	OGMAs (transitional)

Dataset layer	Source	Factor
Consolidated Draft OGMAs	SINRD	OGMAs (draft from licensees)
WHSE_LAND_USE_PLANNING.RMP_PLAN_NON_LEGAL_POLY_SVW	BCGW	Non-legal objectives: VILUP - agriculture, settlement, General; Clayoquot - SMZ, Reserve, Enhanced)
CDF_LUO-signed_selections_all_final	RWC	Coastal Douglas-fir: CDF LUO July 30, 2010
RIPARIAN RESERVE ZONE and Management Zone BUFFERS	SINRD	Riparian management areas
WHSE_FOREST_VEGETATION.RESPROJ_RSRCH_INSTN_GVT_SVW	BCGW	Research installations
WHSE_FOREST_VEGETATION.GRY_PSP_STATUS_ACTIVE	BCGW	Permanent/temporary sample plots
WHSE_FOREST_TENURE.FTEN_RECREATION_POLY_SVW	BCGW	Recreation sites
WHSE_FOREST_TENURE.FTEN_RECREATION_LINES_SVW	BCGW	Recreation trails
WHSE_FOREST_VEGETATION.REC_FEATURES_INVENTORY	BCGW	Recreation features
Economic Operability Assessment (2014) – Forest Ecosystem Solutions Ltd.	SINRD	Economic operability
ESA	RWC	Environmentally sensitive areas
WHSE_BASEMAPPING.DRA_DIGITAL_ROAD_ATLAS_LINE_SP	BCGW	Roads
WHSE_FOREST_TENURE.FTEN_TIMBER_LICENCE_POLY_SVW	BCGW	Timber licence reversions
WHSE_LAND_USE_PLANNING.RMP_LANDSCAPE_UNIT_SVW	BCGW	Landscape units
WHSE_FOREST_VEGETATION.BEC_BIOGEOCLIMATIC_POLY	BCGW	Biogeoclimatic polygons
WHSE_FOREST_VEGETATION.REC_VIMS_VLI_SVW (SINRD local version)	SINRD	Visual landscape inventory
WHSE_LAND_USE_PLANNING.RMP_STRGC_LAND_RSRCE_PLAN_SVW STRGC_LAND_RSRCE_PLAN_NAME <> 'Clayoquot Sound Land Use Plan'	BCGW	Land use/Watershed plan boundaries
WHSE_LAND_USE_PLANNING.RMP_STRGC_LAND_RSRCE_PLAN_SVW STRGC_LAND_RSRCE_PLAN_NAME = 'Clayoquot Sound Land Use Plan'	BCGW	Clayoquot Sound Study Area Boundary
WHSE_LAND_USE_PLANNING.RMP_PLAN_LEGAL_POLY_SVW	BCGW	Resource management zones(VILUP RMZs: Special *vs*. Enhanced)
WHSE_WATER_MANAGEMENT.WLS_COMMUNITY_WS_PUB_SVW	BCGW	Community watersheds
WHSE_WILDLIFE_MANAGEMENT.WCP_FISH_SENSITIVE_WS_POLY	BCGW	Fisheries sensitive watersheds
Community Interface Zone (BCTS_ECA)	SINRD	Community interface zones
CLAY_WS	RWC	Clayoquot Sound basins/subbasins boundaries
RATE_OF_CUT	RWC	Clayoquot Sound basins/subbasins rate of cut
Projected_Layer	SINRD	Sensitivity tests – encumbered areas (currently avoided or log around area within THLB likely to be excluded in future)
EN_Line	SINRD	Sensitivity tests – wood flow between zones
Proposed Goshawk WHA	SINRD	Sensitivity tests – proposed WHA
Woodshed_Boundaries	SINRD	Harvest priority and timing rules
TFL46_res_a	MFLNRO /FAIB	Additional inventory for Rosander woodshed - 1997
MFR_FIRST_NATIONS_AGREEMENT_BOUNDARIES	MARR	Reporting
FIRST_NATIONS_CAD_BOUNDARIES	MARR	Reporting
REG_LEGAL_AND_ADMIN_BOUNDARIES.QSOI_BC_REGIONS	BCGW	Reporting
Ditidaht Red Zone	SINRD	Reporting
WHSE_TERRESTRIAL_ECOLOGY.STE_TEM_ATTRIBUTE_POLYS_SVW	BCGW	TEM

Dataset layer	Source	Factor
HarvestMethod	FESL	Physical Operability
NOGO_Nests_March4_2016_Arrowsmith.shp	MFLNRO	Goshawk nests
MAMU_SuitHab_with_depletions_to_Jan2015	MFLNRO	Marbled murrelet habitat
MAMU_LLAS_Tugwell_20160424_clip	MFLNRO	Marbled murrelet in Tugwell landscape unit
PSTA_Public_Threat_Rating	MFLNRO	Wildfire threat rating
Wildland_Urban_Interface_Buffer_Area	MFLNRO	Urban interface buffer

3.2.1 Forest Inventory

The current forest inventory is old. The Arrowsmith TSA was last inventoried in 1988 – 1989. Since then the inventory information has been updated for disturbance and forest cover attributes have been projected to 2014 for use in the on-going TSR. The forest cover inventory for the TSA has been converted from the forest cover inventory (FC1) to the vegetation resource inventory (VRI) data structure. A new VRI is being developed for the TSA; however, the new inventory is not available for the on-going TSR or the IRMP.

4 TSR Base Case Scenario

4.1 Land Base Assumptions

We have attempted to duplicate all the relevant land base assumptions of the on-going Arrowsmith Timber Supply Area Timber Supply Review (TSR). However, differences exist due to GIS platform differences; the data for the on-going TSR for the Arrowsmith TSA was prepared in a vector environment and then converted to raster environment for modelling, while our analysis is based on a vector dataset only.

Land base assumptions define the crown forested land base (CFLB) and timber harvesting land base (THLB). The THLB is designated to support timber harvesting while the CFLB is identified as the broader land base that contributes toward meeting non-timber objectives such as biodiversity.

A netdown is the process in which areas are removed from the total land base in order to determine the CFLB and the THLB. The removal process is attribute-based (netdown factors), and an area can theoretically be removed from the CFLB or THLB for more than one reason as a result of overlapping resource issues. In practise, however, once an area has been removed, it cannot be deducted again further along in the process.

A netdown is sensitive to the order in which the netdown factors are applied; a different netdown order will return different net areas removed for the various netdown factors, however, the final CFLB and THLB areas will be the same. We have duplicated the netdown order of the on-going Arrowsmith TSA TSR when possible to make netdown comparisons meaningful.

The Arrowsmith TSA land base classification is as follows:

Excluded Land Base (EXLB): this category includes non-crown owned or managed lands, as well as non-forested areas.

Crown Forested Land Base (CFLB): this category represents the total forested areas under crown management.

Non-Harvestable Land Base (NHLB): this category represents the portion of the CFLB where, following current forest practises, harvesting will not or cannot occur. The NHLB includes areas that are currently not harvestable due to economic considerations, meaning that the possibility exists that at least some of NHLB might become harvestable under different economic conditions.

Timber Harvesting Land Base (THLB): this category represents the productive forested land where harvesting is possible based on current legislation and current forest practices.

The results of the netdown are shown in Table 3; these reductions are described below in further detail (areas listed are gross areas and not additive to Table 3).

Table 3: Arrowsmith TSA Netdown Summary

Description	Gross Area (ha)	Net Area (ha)
Total Area	1,891,977	
Water	656,972	656,972
Non FOWN	1,019,937	394,765
Private, Treaty	587,127	583,040

Description	Gross Area (ha)	Net Area (ha)
Area Based Tenure	17,791	17,716
Park and Protected Areas	95,968	92,625
Non-forest	1,681,924	31,991
Crown Forested Land Base		**114,866**
Miscellaneous Crown	6,644	4,170
AOA	10,199	1,466
WHA No Harvest	2,819	2,397
UWR No Harvest	2,202	1,622
Legal OGMA	1,351	355
Non Legal OGMA	6,751	4,094
Draft OGMA	3,649	1,472
Clayoquot Reserve Network	21,273	7,606
CDF Order	1,555	1,330
RRZ Buffer	17,901	1,590
UREP <100ha	285	103
Recreation Trail Buffer	356	35
RFI (SI = V, SENS = H)	344	29
Recreation Site <100ha	988	39
Gulf Island	57,361	797
Not Economic	73,920	12,546
ESA1 Soils	4,356	944
ESA1 Regen	871	142
Low Stocking	23,931	1,617
Non Comercial Type	373	30
Low Site Cedar	7,840	10
Low Site Fir	561	15
Low Site Hemlock	5,232	109
Low Site Spruce	93	
Low Site Pine	1,522	
Sub-Total		**72,350**
Partial Reduction to the THLB		
Riparian Management Zone		1,237
Recreation Features Inventory 50%		24
Recreation Features Inventory 10%		150
Partially Economic		1,724
Unclassified roads and landings		1,550
Wildlife Tree Retention		2,233
Timber Harvesting Land Base		**65,433**
Future Roads		931
Future Timber Harvesting Land		**64,502**

4.1.1 Non-FOWN

Areas outside of the updated ownership layer (Table 4) were excluded from the analysis.

Table 4: Area outside ownership data layer

Description	Area (ha)
FOWN = 0	1,019,937

4.1.2 Private and Treaty

Several categories of non-crown land were excluded from the CFLB. These areas were excluded based on their ownership codes and include privately owned lands, federal and Indian reserves and miscellaneous leases. These areas are shown in Table 5.

Table 5: Lands not managed by the Crown

Ownership Class	Ownership Code	Area (ha)
Private Crown Grant	40	572,747
Treaty Land, Status Transfer Land	41	2,517
Federal Reserve	50	259
Indian Reserve	52	11,190
Military Reserve	53	413
Total		**587,127**

4.1.3 Area Based Tenure

Allowable annual cuts (AACs) are determined individually for tree farm licences, woodlots, community forest agreements and First Nation woodland licences; these lands are excluded from the CFLB. Table 6 shows the areas removed for area-based tenures.

Table 6: Lands under area based tenures

Ownership Class	Ownership Code	Area (ha)
Timber Licence	70	71
Crown and Private Schedule “A” and “B” Lands in a TFL	72	2,757
Crown and Private Woodlot Licence	77	11,035
First Nation Woodland Licence	78	2,560
Community Forest	79	1,368
Total		**17,791**

4.1.4 Park and Protected Areas

National, provincial and regional parks and protected area within the TSA are not considered part of the CFLB. The analysis will take account for any contribution forested area within parks and protected areas have in meeting biodiversity and wildlife values. The removed areas are shown in Table 7.

Table 7: Ownership codes for defining parks and protected areas

Ownership Class	Ownership Code	Area (ha)
National Park	51	31,897

Ownership Class	Ownership Code	Area (ha)
Crown Provincial Park Class A	63	63,234
Crown Provincial Park Class C, park board	65	690
Crown Provincial Park equivalent or reserve, regional parks, etc.	67	147
Total		**95,968**

4.1.5 Non-Crown Forest Management Land Base, non-Forest

Non-forest areas such as alpine, lakes, rocks, salt water etc. are removed from the land base. For this analysis, any areas that are not classified as forest management land base (FMLB) in the VRI will be excluded as non-forest. FMLB considers site index and harvest history to confirm that recently harvested areas are not incorrectly classified as non-forest.

Table 8: Non-forest areas

Not FMLB - likely non-forest	Area (ha)
FMLB <> 'Y'	1,681,924

4.1.6 Miscellaneous Crown Lands not contributing to AAC

Table 9 describes areas that do not contribute to the AAC.

Table 9: Ownership codes defining miscellaneous Crown lands

Ownership Class	Ownership Code	Area (ha)
Crown Ecological Reserve	60-N	696
Crown BMTA (Biodiversity, Mining and Tourism area)	68-N	224
Crown Miscellaneous Reserves	69-N	4,298
Crown and Private timber alienated in watershed	74-N	1,191
Crown Christmas tree permit	75-N	119
Crown Misc. lease	99-N	115
Total		**6,644**

4.1.7 Archaeological sites

Archaeological sites, including culturally modified trees (CMT) are protected under the Heritage Conservation Act. Archaeological overview assessments (AOA) provide information on potential archaeological resources and guide field-level archaeological impact assessments (AIA).

A 50-metre buffer will be applied to each known archaeological site in the analysis.

Table 10: Archaeological overview assessment area

Archaeological Sites	Area (ha)
Buffer	10,199

4.1.8 Wildlife Habitat Areas

Wildlife habitat areas (WHAs) are mapped areas that are required to meet the habitat requirements of an Identified Wildlife species. WHAs designate critical habitats in which industrial activities are managed to limit their impact on the Identified Wildlife.

Table 11 lists the no harvest area of the wildlife habitat area by species.

Table 11: No harvest Wildlife Habitat Areas

Common Species	Area (ha)
Data sensitive	20
Douglas-fir/Garry oak-oniongrass	21
Marbled Murrelet	2,747
Red-legged frog	30
Total	**2,819**

4.1.9 Ungulate Winter Range

Winter ranges for mule deer and Roosevelt elk were established by government actions regulation (GAR) Order U-1-017 in the Arrowsmith TSA in 2003. Boundary changes to winter range units 14, 15 and 16 led to an amendment of the order in 2010. This order contains general wildlife measures (GWM) that prohibit or limit industrial forest operations within in each UWR unit. The GWM is modelled in the analysis by applying THLB exclusion factors. The UWR areas by species are shown in Table 12.

Table 12: Established Ungulate Winter Ranges

UWR Number	Species	Area (ha)
u-1-002	Mule Deer	37
u-1-017	Roosevelt Elk	595
u-1-017	Mule Deer	1,571
Total		**2,203**

4.1.10 Old Growth Management Areas

In the Arrowsmith TSA, OGMAs have been delineated for the landscape units listed in Table 13. There are legal, non-legal, and draft OGMAs in the TSA. Legal OGMAs are spatially defined and legally established spatial areas. Non-legal OGMAs are not legally established; however they meet the requirements of Section 8 of the Old Growth Order.

Draft OGMAs have been set aside to meet the non-spatial Old Growth Order requirements. As the current practice in the TSA accounts for all OGMA types all OGMAs will be removed from the THLB for the analysis.

Table 13: Old Growth Management Areas by Landscape Unit

Old Growth Management Area	LU Provincial ID	Area (ha)
Legal OGMA	479	616
Legal OGMA	953	385
Legal OGMA	1102	302
Legal OGMA	1394	47
Non Legal OGMA	209	665
Non Legal OGMA	267	201
Non Legal OGMA	363	2,044
Non Legal OGMA	374	18
Non Legal OGMA	431	13
Non Legal OGMA	700	79
Non Legal OGMA	752	192
Non Legal OGMA	815	198
Non Legal OGMA	869	12
Non Legal OGMA	915	338
Non Legal OGMA	917	48
Non Legal OGMA	1089	891
Non Legal OGMA	1122	140
Non Legal OGMA	1293	1,914
Draft OGMA	61	430
Draft OGMA	544	1,157
Draft OGMA	681	259
Draft OGMA	762	358
Draft OGMA	1106	1,321
Draft OGMA	1182	124
Total		**11,752**

4.1.11 Clayoquot Reserve Network

Forest management in Clayoquot Sound is governed by the findings of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound. As per the Scientific Panel recommendations areas have been mapped and designated as reserves to protect a range of values. These areas shown in Table 14 will be excluded from the THLB.

These reserves replace OGMAs, wildlife habitat areas, reserves for environmentally sensitive areas and Forest Practices Code riparian buffers. The THLB in Clayoquot Sound is harvestable using variable retention harvesting subject to watershed rate-of-cut constraints, old-seral requirements and visual quality objectives.

Table 14: Clayoquot Reserve Network area

Clayoquot Reserve	Area (ha)
Reserve Network	21,273

4.1.12 Coastal Douglas Fir Order

The 1,555 hectares (Table 15) identified in the Ministerial Order to protect the Coastal Douglas-fir maritime (CDF mm) Biogeoclimatic subzone will be excluded from the THLB.

Table 15: Coastal Douglas fir LUO

Coastal Douglas Fir Land Use Order	Area (ha)
CDF mm	1,555

4.1.13 Riparian Reserve and Management Buffer

The impact of riparian management on the TSA timber supply was modelled by buffering the TSA streams. Buffers were created for riparian reserve zones (RRZ) and riparian management zones (RMZ). Buffer widths were based on stream riparian classifications (S1-S6).

For single-line streams, classifications and RRZ buffers are from the Forest Planning and Practices Regulation and are as follows:

Table 16: Riparian reserve zone buffer for stream classifications

Potential fish habitat	Stream order	Stream classification	RRZ buffer (m)	RMZ buffer (m)
Yes	4	S1-B	50	20
Yes	3	S2	30	20
Yes	2	S3	20	20
Yes	1	S4	0	30
No	2	S5	0	30
No	1	S6	0	20

All double-line streams were classified as S1-A with a 100m RMZ buffer. The RRZ buffers were 100% removed from the THLB. Within the RMZ buffer, the FPPR retention requirements are applied as an amount of forested area retained (Table 17).

Table 17: Area retained in riparian management zones buffers

Riparian class	Basal area to be retained within riparian management zone (%)	Forest area retained (%)
S1-A or S1-B stream	>20	20
S2 stream	>20	20
S3 stream	>20	20
S4 stream	>10	10
S5 stream	>10	10
S6 stream	n/a	0

Areas within the riparian reserve and management zones are shown in Table 18 below.

Table 18: Riparian buffer area

Riparian Buffer	Area (ha)
RRZ	17,901
RMZ	15,348

4.1.14 Permanent sample plots and research installations

Each active permanent sample plot was given a 100-metre buffer (area of 3.14 hectares). Each active sample plot and complete research installation is unavailable for harvesting for 25 years in the timber supply model. The areas of each are shown in Table 19.

Table 19: Research installation and permanent sample plot areas

Research Installation	Permanent sample plots	Area (ha)
	Y	670
Y		1,391
Y	Y	2
Total		**2,063**

4.1.15 Recreation features

Recreation features are spatially defined areas that are important for public and commercial recreation activities. These features, such as wildlife viewing areas and camp sites often constrain or prevent timber harvesting.

Recreation sites and trails identified in the forest tenure recreation map layers in the BCGW are excluded from the THLB. Crown Use, Recreation and Enjoyment of the Public (UREP) Reserves less than 100 hectares in size are also excluded from the THLB.

The recreation feature inventory was also used to exclude areas from harvest activities. Table 20 summarizes the total area under recreation features.

Table 20: Recreation features area

Recreation feature	Area (ha)
UREP <100ha	285
Recreation Trail Buffer	356
RFI (SI = V, SENS = H)	344
Recreation Site <100ha	988
Recreation Sites >100ha 50%	532
Recreation Features Inventory 50%	1,606
Recreation Features Inventory 10%	596
Total	**4,707**

4.1.16 Gulf Islands

It is assumed that Crown forest land (Table 21) on the Gulf Islands is not available for timber harvesting. No harvesting occurs in these areas due to the public desire to manage the Gulf Islands for non-timber values. In the previous AAC determination (July 2009) the chief forester assumed that these areas do not contribute to timber harvest and factored this in his determination.

Table 21: Area removed from Gulf Islands

Description	Area (ha)
Gulf Islands	57,361

4.1.17 Uneconomic areas

An economic operability assessment for the Arrowsmith TSA was completed by Forest Ecosystems Solutions Ltd. in April 2014. The assessment determined areas of the land base where the value of merchantable timber is considered greater than the cost to access and harvest it. Two meetings with current licensees took place to review the minimum economic volumes (February 27, 2014) and the preliminary economic classification (March 11, 2014). The feedback from licensees was used to set the final minimum volumes and to refine the economic operable land base classification.

Table 22: Economically inoperable areas

Description	Area (ha)
Not Economic	73,920

The economically operable land base was further classified into helicopter, cable and ground based harvest areas. All existing and planned roads were buffered by 300 m. Roads and coastlines were also buffered by 1,750 m to define helicopter harvest areas. These buffers were classified as follows:

1. Areas within 300 m of a road are conventional harvest areas;
2. Areas between 300 m and 1,750 m from a road are helicopter to land harvest areas;
3. Areas within 1,750 m of the helicopter water drop are helicopter to water harvest areas;

The conventional harvest areas (as defined above) were further split into cable or ground harvest, based on slope, as follows:

- If the slope was less than or equal to 40% and any part of the polygon was 20 m or less from the nearest road, the harvest method was classified as ground;
- If the slope was greater than 40% or the entire polygon was further than 20 m from the nearest road, the harvest method was classified as cable;
- Small patches of ground (up to 5 ha in size) that are surrounded by cable, were be changed to cable;
- Small patches of cable under 0.25 ha in size will be changed to ground;

4.1.18 Environmentally sensitive areas

Terrain stability mapping is not available for the Arrowsmith TSA and environmentally sensitive area (ESA) mapping is used as a substitute. Two categories of ESAs are considered in this analysis: sensitive soils and sites with expected regeneration problems (Table 23). Both categories are 100% removed from the THLB.

Table 23: Description of environmentally sensitive areas

Description	Logging History	Area (ha)
ESA1 Soils	No	4,356
ESA1 Regen	No	871
Total		**5227**

4.1.19 Low stocking and non-commercial types

Stands older than 250 years with a volume per hectare of less than 300 m^3/ha are not harvested under current logging practices due to low stocking (Table 24). These stands are removed from the THLB.

Non-commercial types are stands that are not currently utilized in spite of being physically operable and meeting merchantability criteria. Cottonwood and maple stands fall into this category. Table 25 shows stand types that are be excluded from the THLB.

Table 24: Area removed for low stocking stands

Description	Area (ha)
Low Stocking	23,931

Table 25: Non-commercial species

Leading species	Logging History	Reduction %	Area (ha)
Poplar	No	100	26
Black Cottonwood	No	100	16
Bigleaf Maple	No	100	325
Willow	No	100	7
Total			**373**

4.1.20 Low site productivity

Existing natural stands (>= 65 years) that are unlikely to attain a merchantable volume over a reasonable time frame are excluded from the THLB. These stands may be unproductive or not fully occupied with commercial tree species. Coniferous stands with less than 300 m^3/ha at age 150 years are removed from the THLB.

Table 26: Stands with low timber growing potential

Description	Area (ha)
Low Site Cedar	7,840
Low Site Fir	561
Low Site Hemlock	5,232
Low Site Spruce	93
Low Site Pine	1,522
Total	**15,248**

4.1.21 Deferred Timber Licences

Timber Licences (TLs) are a historic tenure that gave the timber licensee an exclusive right to harvest merchantable timber within the licence area. After completion of harvest and successful reforestation, the timber licence area reverts back to the underlying TSA. The TLs within the TSA are included in the THLB after the first harvest.

As shown in Table 27, TLs with closed files are included in the THLB while those with open files are assumed to revert back to the TSA in 10 years.

TLs not listed in Table 27 are excluded from the THLB and the timber supply.

Table 27: Timber Licences

Status of file	TL forest file ID	Comment	Total Area
Active but closed	T0057, T0174, T0277, T0553, T0775, T0811, T0825, T0828, T0843	Included in THLB as TLs will revert to crown soon	5,758
Active but open	T0295, T0738, T0831, T0834, T0837, T0840, T0846, T0910	Not part of timber supply until after 2025	9,096

4.1.22 Existing Roads, Trails and Landings

Existing roads, trails and landings are removed from the THLB. Large roads, such as a highways, are classified in the forest cover inventory as non-forest polygons. Smaller roads, trails and landings not shown in the inventory due to their small size and linear shape are also considered unproductive and netted out of the land base considered available for timber harvesting.

Buffers will be applied to either side of all single line roads and the buffered area removed from the THLB. Widths of buffers vary depending on the category of road and its location (Table 28).

Table 28 shows the existing road classes with their buffer widths and road widths. The buffered road area (Table 29) is the assumed loss of growing area due to roads, trails and landings.

Table 28: Reductions for existing roads and trails

Zone	Road Category	Buffer Width (m)	Road Width (m)
East	Mainline	6.5 each side	13
	Branch	4 each side	8
	Spur	3.5 each side	7
West (including Clayoquot)	Mainline	6.5 each side	13
	Branch	5 each side	10
	Spur	4 each side	8

Table 29: Area of buffered existing roads

Description	Area (ha)
Current Roads	4,339

4.1.23 Stand level biodiversity

An aspatial reduction for wildlife tree retention (WTR) is applied at the end of the netdown to the THLB. The retention targets consider areas within riparian buffers and the land base that does not contribute to timber harvesting. A minimum of 7% retention is required across harvest areas and it is assumed that a half of this retention is achieved from areas outside of the THLB; a 3.5% netdown is applied to the THLB. Gross area for stand level biodiversity is shown in Table 30.

Table 30: Stand level retention

Description	Area (ha)
Wildlife Tree Retention	67,315

The Renfrew Sustainable Resource Management Plan (SRMP) sets additional objectives for wildlife tree retention in the landscape units listed in Table 31 below.

Table 31: Wildlife Tree Retention by LU and BEC subzone in the Renfrew SRMP

Landscape Unit	Biogeoclimatic Subzone	% WTR Requirement
Caycuse	CWHmm	14
	CWHvm	11
	CWHxm	14
	MHmm	4
Gordon	CWHmm	14
	CWHvh	10
	CWHvm	10
	CWHxm	13
	MHmm	5

Landscape Unit	Biogeoclimatic Subzone	% WTR Requirement
Nitinat	CMAunp	0
	CWHmm	14
	CWHvh	2
	CWHvm	12
	CWHxm	15
	MHmm	4
San Juan	CWHmm	11
	CWHvh	12
	CWHvm	12
	CWHxm	7
	MHmm	5
Walbran	CWHvh	6
	CWHvm	6
	MHmm	0

4.1.24 Fire Threat Rating

A Provincial Strategic Threat Analysis (PSTA) of wildfire risk was created at the strategic level to inform the government's landscape fire management planning and fuel treatment programs. It was created by combining the weighted results of three important components of wildfire threat:

- Head Fire Intensity (90th percentile) - 60%
- Fire Density - 30%
- Spotting impact - 10%

Head Fire Intensity (HFI) represents the intensity of the flaming front, which is related to suppression effort and impacts to values. Fire density represents the ignition and fire spread potential based on historic fire occurrence patterns. Spotting impact represents the ability of embers from a burning biomass fuel (such as a group of trees) to be sent aloft for some distance over the landscape and start new fires.

These weighted values were added together to produce a final fire threat analysis value ranging theoretically between 0 and 100, then grouped into 10 classes (Table 32). The 10 Fire Threat Classes are presented below; class limits represent the weighted average of three input layers described above:

Table 32: Fire Threat Classes

Fire Threat Class	Fire Threat Value	Description
Class 1	0.1 - 5 (lowest threat)	Low
Class 2	5.1 - 10	Low
Class 3	10.1 - 15	Low
Class 4	15.1 – 20	Moderate
Class 5	20.1 – 27	Moderate
Class 6	27.1 – 33	Moderate
Class 7	33.1 – 40	High
Class 8	40.1 – 47	High

Fire Threat Class	Fire Threat Value	Description
Class 9	47.1 – 55	Extreme
Class 10	55.1 – 81 (highest threat)	Extreme

This coarse level Provincial dataset was clipped to the Arrowsmith TSA (Table 33) area and added to the resultant.

Table 33: Fire threat areas in Arrowsmith TSA

Fire Threat Description	Forest Area (ha)	THLB Area (ha)
Extreme	315	258
High	3,610	2,164
Moderate	67,926	38,775
Low	42,662	22,265
Total	**114,513**	**63,462**

The Wildland Urban Interface is any area where combustible wildland fuels (e.g. vegetation) are found adjacent to homes, farm structures or other buildings. The Wildland Urban Interface Buffer consists of areas within two kilometres of a community with a density of between six and 250 structures per square kilometre. The data was updated to 2015 for built structures, and provided by FLNRO for the analysis. It helps identify built up areas that may be at risk due to wildfires and can help guide planning processes for modifying or reducing the amount of forest or range fuels in order to mitigate the risk of fire in the built environment. The buffered area and threat descriptions within the Arrowsmith TSA is shown in Table 34.

Table 34: Fire threat areas within wildland urban Interface buffer area in Arrowsmith TSA

Fire Threat Description	Forest Area (ha)	THLB Area (ha)
Extreme	51	24
High	2,333	1,301
Moderate	14,798	8,264
Low	4,567	2,831
Total	**21,750**	**12,419**

4.2 Management Assumptions

This section provides details on how non-timber resource values are integrated with timber objectives in modeling and what assumptions are used for forest management.

4.2.1 Age 2015 Calculation Assumptions

The VRI dataset was provided in geodatabase format with inventory attributes projected to January 1, 2014. A modeling age attribute was created and populated from the projected_age field, then updated for recent depletions that were not accounted for in the VRI spatial file. By using the year of harvest we were able to calculate the current stand age.

In TFL 46 take back areas where VRI inventory data was lacking, the old TFL 46 inventory (1997) was used to update the species and age information. For the Rosander take back area, the original spatial files were used to update the age and analysis unit information in that area. Recent cutblock data was added to the Rosander inventory to account for depletions, and the ages in Rosander were updated as per the process described above.

4.2.2 Harvesting

4.2.2.1 Utilization Assumptions

The utilization level defines the minimum top diameter (inside bark) and minimum diameter (dbh) of stems that must be removed from harvested areas. It also specifies the maximum height of stumps that may be left. These factors are used to determine the merchantable stand volume in the analysis.

The utilization levels used in this analysis are shown in Table 35.

Table 35: Utilization levels used in the analysis

Leading species	Utilization		
	Minimum dbh (cm)	Maximum stump height (cm)	Minimum top dib (cm)
Natural conifer >120 years of age	17.5	30	15
Natural conifer between 64 and 120 years of age	12.5	30	10
Managed conifer	12.5	30	10
Alder >45 years of age	17.5	30	15

4.2.2.2 Minimum Harvest Criteria

Minimum harvest criteria is the earliest age, volume per ha or other criterion such as DBH at which stands become eligible for harvest within the timber supply model. Minimum harvest criteria can have a profound effect on modeled harvest levels by creating acute timber supply shortages, or “pinch points”, that constrain the rest of the planning horizon.

For this analysis, the minimum harvestable criteria for stands in each analysis unit - located within the conventional harvest areas - is the age at which the stand is predicted to reach a volume of 350 m^3/ha. In helicopter harvest areas a volume of 450 m^3/ha is required. In practice, most forest stands are harvested beyond the minimum harvest age due to economic considerations and constraints on harvesting which arise from managing for other forest values.

4.2.2.3 Harvest Scheduling

Simulation models are rule-driven, and require harvest scheduling rules to control the order in which stands are harvested. It is important that these rules are able to organize the harvest in a way that realizes the productive potential of the land base in a reasonable manner to understand the impacts of the timber supply assumptions and constraints.

The relative oldest first rule is a commonly used harvest rule that will be used in the base case. In this rule, the age of a stand is related to its minimum harvestable age. Stands that have the greatest

proportional difference between their actual age and their minimum harvest age are given priority for harvest, subject to forest cover requirements.

4.2.2.4 Harvest Priority

Harvest priority can be used to override the harvest rule. It can be used in modelling to reflect situations when it is known that some areas will be targeted for harvesting. Such targeting may be required to address forest health issues as an example.

4.2.2.5 Silviculture and Harvesting Systems

Clear cut with reserves is the most common silvicultural system in the Arrowsmith TSA. Retention levels vary throughout the TSA and are highest in SMZs and Clayoquot Sound. Trees are retained to meet riparian or wildlife habitat objectives or higher level plan objectives.

4.2.2.6 Non-Recoverable Losses

Non-recoverable losses provide an estimate of the average annual volume of timber damaged or killed within the THLB and not salvaged or accounted for by other factors. These losses result from natural events such as insects, diseases, wind, wildfires, etc. The values shown in Table 36 indicate the estimated annual volume that will not be salvaged. Non-recoverable losses are removed from the harvest volume for each timber supply forecast.

Table 36: Non-recoverable losses, Arrowsmith TSA

Cause of Loss	Annual Loss in THLB (m^3/yr)	Salvage Rate (%)	Annual Non-Recoverable Loss in THLB (m^3/yr)
Wind	n/a	n/a	n/a
Fire	1,067	0	1,067
Root Diseases	5,545	25	4,159
Douglas fir Bark Beetle	7,691	50	3,845
Spruce Beetle	2	0	2
Western Balsam Bark Beetle	32	0	32
Total	**13,270**		**8,038**

4.3 Growth and Yield

Growth and yield assumptions define the net volumes that are realized when natural and managed stands are harvested. They also describe various tree and stand attributes over time (i.e., volume, height, diameter, presence of dead trees, etc.).

4.4 Analysis Units

An analysis unit is a grouping of similar forest area with the objective of simplifying the analysis and the interpretation of analysis results.

4.4.1 Natural Stands

Natural stands in this analysis were defined as coniferous and >= 65 years (2015) or alder stands >= 30 years (2015). Their growth and yield were modeled using Variable Density Yield Prediction (VDYP7). Inventory site index estimates are considered to be the most appropriate in modelling these stands.

The Rosander area lacked a VRI inventory and relied on the previous TSR yield curves (TFL 46) instead.

The large number of natural stand yield curves (9350 VRI stands in the CFLB) were aggregated into 642 analysis unit yield curves. The grouping was completed based on TSA land base (THLB or NHLB), species composition, inventory site index and the inventory VDYP volume at ages 70 and 140.

The VRI stands were grouped into 49 species composition groups based on their leading species percent and their leading and secondary tree species. The objective was to maintain a uniform species composition for the final analysis units. Stands were split into three broad leading species percent groups: >=70, >=50 and <70, and <50. Within these three groups stands were broken into 17 more groups based on the leading and secondary species. There were nine leading species: Ba, Cw, Cy, Fd, Hw, pine, Dr, Ss and other.

The Ba, Cw, and Cy groups were split into Hw and non-Hw groups based on the secondary species. The Fd and Hw groups were split into three sub-groups based on the secondary species while the alder group was split into Fd and non-Fd groups based on the secondary species. The pine and other leading stands with >=50 percent leading species were combined into one group. The groups are presented in Table 37.

Table 37: CFLB Area (ha) of species groupings

Species Composition	Percent of Leading Species		
	<50	>=50, <70	>=70
Ba/Hw	218	853	184
Ba/Non-Hw	20	57	124
Cw/Hw	1,965	10,646	8,160
Cw/Non-Hw	584	2,244	853
Cy	160	999	189
Cy/Hw	404	2,673	1,167
Dr/Fd	70	475	975
Dr/Non-Fd	51	242	331
Fd	131	567	7,854
Fd/Cw	65	415	1,613
Fd/Hw	229	1,922	5,432
Hw/Ba	929	4,263	1,025
Hw/Cw	2,277	7,096	1,230
Hw/Non-BaCw	170	907	481
Oth	70	53	
Pl	76	306	
Ss	15	82	107

The analysis units were further subdivided into three site index groups by land base and the nine leading species. The other, pine and spruce leading species were too small to split by land base and SI breaks were chosen for the combined CFLB.

A K-Means clustering method, weighted by CFLB area, was used to choose the break points for the SI groups. The clustering minimised the within group variance for each SI group. Table 38 presents the site index ranges and CFLB area weighted average for each site index group.

Table 38: SI ranges for each SI Group (CFLB area weighted averages)

Leading Species	SI Group	THLB		NHLB		Combined	
		Range	Ave	Range	Ave	Range	Ave
Balsam	L	10.1 to 14.9	11.9	8.1 to 11.6	9.9		
	M	15.5 to 21.7	18.6	12 to 15.8	13.4		
	H	22.3 to 27.6	25.7	15.9 to 27.6	18.3		
Cedar	L	8.1 to 14.1	12.5	5.5 to 11.7	9.8		
	M	14.2 to 17.6	15.6	11.8 to 15.9	13.7		
	H	17.8 to 30.5	19.7	16 to 40.7	18.2		
Cypress	L	9.9 to 12.1	11.4	5 to 8.8	7.8		
	M	12.3 to 14	13.1	8.9 to 11.5	10.0		
	H	14.4 to 17.2	15.3	11.6 to 17.2	13.2		
Fir	L	13.1 to 23	19.5	10.2 to 20.9	16.7		
	M	23.1 to 30	26.7	21 to 28.8	25.1		
	H	30.1 to 44.2	33.5	28.9 to 44.2	32.4		
Hemlock	L	9.2 to 15.3	12.3	0 to 11.2	8.4		
	M	15.4 to 22.9	18.3	11.3 to 17.9	14.1		
	H	23.1 to 35.8	27.8	18.2 to 35.7	22.0		
Red alder	L	16.1 to 23.6	21.4	5.1 to 20.6	17.2		
	M	23.7 to 28.2	25.9	20.9 to 26.3	24.0		
	H	28.3 to 38.7	30.6	26.7 to 38.8	28.9		
Other	L					18 to 19.6	18.6
	M					25.1 to 33.2	29.1
	H					38 to 47.6	44.6
Pine	L					5.3 to 11.5	8.8
	M					11.7 to 17.1	14.3
	H					17.3 to 25.8	20.1
Spruce	L					5.3 to 18.2	12.6
	M					19.5 to 29.9	25.7
	H					32.7 to 39	36.7

The final analysis unit subdivision was based on yield curve volumes to minimize the variance of the final analysis unit average yield curves. K-Means clustering of the yield curve volume at ages 70 and 140, weighted by CFLB area, was used to choose up to five volume groups within each land base (2), species group (49) and SI group (3). The other, pine and spruce species groups were not separated by THLB and NHLB land bases and combined into a single CFLB land base for volume groups.

The modelling analysis unit yield curves were generated from an area weighted average of the inventory VYDP curves within each analysis unit. The yield curves were averaged separately for the THLB and NHLB. In the THLB this resulted in 503 analysis unit curves, broken down by species composition, site index group and volume group. In the NHLB the analysis unit yield curves were only separated by species composition and site index, which resulted in 139 average yield curves.

4.4.2 Managed Stands

Stands established after 1950 are considered managed stands in this analysis. Their growth and yield will be modeled using Table Interpolation Program for Stand Yields (TIPSY) and the Tree and Stand Simulator (TASS). Provincial site productivity layer estimates of site index are considered to be the best estimates of site productivity for modelling managed stands.

Analysis units for managed stands are based on leading species, growth rating, management status and zone. Table 39 presents the analysis units used in TSR 3. The same analysis units were used in this analysis as well.

Table 39: Analysis units and definition of growth rating for each leading species group

Leading species	Rating	SI	Management Status	Zone
Cedar/Cypress	1 – Good	>= 22.0	All analysis units were further grouped by management status: 1. Existing, old plantation 2. Existing, contemporary plantation 3. Future managed	All analysis units were further grouped by zone: 1. East 2. West 3. Clayoquot Sound
	2 – Medium	>= 15.0 and < 22		
	3 – Poor	< 15.0		
Douglas-fir	1 – Good	>= 33.0		
	2 – Medium	>= 30.5 and < 33.0		
	3 – Poor	< 30.5		
Hemlock/Balsam	1 – Good	>= 27.5		
	2 – Medium	>= 24.0 and < 27.5		
	3 – Poor	< 24.0		
Spruce	1 – Good	>= 29.5		
	2 – Medium	< 29.5		
Red Alder	2 – Average	n/a		
Other	2 – Average	n/a		

A good productivity rating indicates that a stand falls approximately within the top 25% of its reference species group when ranked by site index; medium stands fall within the middle 50% while the poor stands fall within the bottom 25%. The rating applies to the forest management land base of the Arrowsmith TSA.

4.4.3 Operational Adjustment Factors in Managed Stand Yields

The yield tables generated by TIPSY (TSR benchmark runs) and TASS (IRMP runs) are based on the data observed and collected in research plots established by FLNRO and industry. Historically, this research has been carried out in fully stocked, even aged stands with no significant incidences of pests and diseases.

Operational adjustment factors (OAF) are usually applied to yields to reflect average operational growing conditions.

OAF 1 allows for yield reductions associated with non-productive areas in the stand, uneven spacing of crop trees (clumping), and endemic and random loss. The standard OAF1 of 15% is considered a province-wide approximation of the difference between research plots and actual yields, and is composed of the following estimates:

- Espacement 4%
- Non-productive 4%
- Random risk 3%
- Endemic losses 4%

The standard OAF 1 of 15% will be applied to all yield curves generated by TIPSY and TASS.

OAF 2 allows for increasing volume losses towards maturity, attributable to decay, waste and breakage, disease and pest factors. The standard OAF2 of 5% is also a province-wide approximation of the difference between research plot yields and actual yields. As this difference increases with age, the impact of OAF 2 also accelerates with age.

Existing and future managed Douglas fir stands are susceptible to root disease and resulting volume losses. As laminated and armillaria root diseases are common in the TSA, the stand volume losses due to these diseases are accounted for in managed stands through revised OAF 2 values. OAF 2 has been increased from 5% to 12.5% for Douglas-fir stands less than 65 years old in 2015, and to 10% for future Douglas-fir stands located in the east zone of the TSA. These stands are predominately in the CDF and CWHxm1 and 2 biogeoclimatic ecosystem classification (BEC) subzones.

4.4.4 Volume adjustments for retention within harvested areas

The retention target for different land use zones with the Clayoquot Sound Land Use Decision Area is 40% as per the VILUP. A volume reduction of 40% will be applied to all future stands in Clayoquot Sound to account for the impact of reduced stand-growth due variable retention harvesting.

In the rest of the TSA an 18% volume reduction will be applied to the existing and future managed stands in constrained areas to account for shading effects as follows:

- Future managed stands; SMZs, and VQOs with visual quality objectives of P and R;
- Existing managed stands; SMZs established since VILUP came into effect (after year 2001);

4.5 Silviculture

4.5.1 Immature Plantation History

The classification of managed stands is consistent with the on-going TSR. Existing managed stands are classified as old plantations or contemporary plantations. It is assumed that older managed stands will not grow as rapidly as more recently regenerated stands. The TSR chose a transition year of 1985 between old plantations and contemporary plantations. The transition year is based on the approximate time that the bare-root seedling stock was significantly improved on the coast, while at the same time the transition to containerized seedling stock had also begun.

4.5.2 Regeneration Activities in Managed Stands

Regeneration assumptions for managed stands presented here are based on the on-going TSR. Managed stands were classified in three categories: old plantations, contemporary plantations and future stands. The modelling of their growth and yield was done using FLNR table interpolation program for stand yields (TIPSY v4.3) model.

Table 40, Table 41 and Table 42 show the basic regeneration assumptions used in this analysis to benchmark the TSR Base Case. Existing managed stands (Table 40 and Table 41) were modeled based on the species compositions from VRI summaries for stands that fall within each analysis unit. The future managed stand (Table 42) species composition is based on RESULTS summaries for recent openings (i.e., last 12 years) within each analysis unit.

Genetic gain is incorporated into yield estimates for contemporary and future plantations (Section 4.5.5).

Table 40: Regeneration assumptions for existing old plantations

Zone	Leading Species	Site Rating	Species Composition	Regen Delay	OAF1	OAF2	Regen Method	Initial Density (sph)
East	Cedar	G	Cw54Hw28Fd10Dr8	2	15	5	Plant	1000
East	Cedar	M	Cw48Hw28Ba16FD8	2	15	5	Plant	1000
East	Cedar	P	Cw48Hw28Ba16FD8	2	15	5	Plant	1200
East	Douglas-fir	G	Fd80Hw14Cw6	2	15	12.5	Plant	1200
East	Douglas-fir	M	Fd76Hw16Cw8	2	15	12.5	Plant	1200
East	Douglas-fir	P	Fd75Hw11Pl7Cw7	2	15	12.5	Plant	1000
East	Hemlock/Balsam	G	Ba39Hw29Fd17YC8Cw7	2	15	5	Plant	1000
East	Hemlock/Balsam	M	Hw48Ba25Fd15Cw12	2	15	5	Plant	1000
East	Hemlock/Balsam	P	Ba44Hw34Fd10Cw8YC4	2	15	5	Plant	1400
East	Spruce	G	Ss44Hw38Cw18	2	15	5	Plant	1000
East	Red Alder	M	Dr71Fd16Hw8Pl5	2	15	5	Plant	1000
East	Pine/Other	M	Pl70Fd20Dr10	2	15	5	Plant	1000
West	Cedar	G	Cw64Hw28Fd8	2	15	5	Plant	1000
West	Cedar	M	Cw68Hw26Dr6	2	15	5	Plant	1000
West	Cedar	P	Cw64Hw29Dr7	2	15	5	Plant	1200
West	Fir	G	Fd64Hw20Cw16	2	15	5	Plant	1200
West	Fir	M	Fd62Hw22Cw16	2	15	5	Plant	1200
West	Fir	P	Fd61Hw14Cw19Dr6	2	15	5	Plant	1000
West	Hemlock/Balsam	G	Hw62Ba16Cw16Fd6	2	15	5	Plant	1000
West	Hemlock/Balsam	M	Hw65Cw18Ba11Fd6	2	15	5	Plant	1000
West	Hemlock/Balsam	P	Hw58Cw36Ba6	2	15	5	Plant	1400
West	Spruce	G	Ss40Hw40Ba20	2	15	5	Plant	1000
West	Spruce	M	Ss58Hw23Cw19	2	15	5	Plant	1000
West	Red Alder	M	Dr77Hw15Cw8	2	15	5	Plant	1000
West	Pine/Other	M	Dr48Pw25Cw18Hw9	2	15	5	Plant	1000
Clayoquot	Cedar	G	Cw60Hw30Fd5Dr5	2	15	5	Plant	1000
Clayoquot	Cedar	M	Cw60Hw40	2	15	5	Plant	1000
Clayoquot	Cedar	P	Cw60Hw40	2	15	5	Plant	1200
Clayoquot	Douglas-fir	G	Fd90Hw10	2	15	5	Plant	1200
Clayoquot	Douglas-fir	M	Fd64Hw22Cw14	2	15	5	Plant	1200
Clayoquot	Douglas-fir	P	Fd55Hw21Cw17Dr7	2	15	5	Plant	1000

Zone	Leading Species	Site Rating	Species Composition	Regen Delay	OAF1	OAF2	Regen Method	Initial Density (sph)
Clayoquot	Hemlock/Balsam	G	Hw58Cw17Ba11Fd6Dr8	2	15	5	Plant	1000
Clayoquot	Hemlock/Balsam	M	Hw55Cw17Fd10Ba5Dr13	2	15	5	Plant	1000
Clayoquot	Hemlock/Balsam	P	Hw55Cw17Fd10Ba5Dr13	2	15	5	Plant	1400
Clayoquot	Spruce	G	Ss58Hw23Cw10Fd4Dr5	2	15	5	Plant	1000
Clayoquot	Spruce	M	Ss67Hw15Cw13Dr5	2	15	5	Plant	1000
Clayoquot	Pine/Other	M	Pl70Cw18Dr12	2	15	5	Plant	1000

Table 41: Regeneration assumptions for existing contemporary plantations

Zone	Leading Species	Site Rating	Species Composition	Regen Delay	OAF1	OAF2	Regen Method	Initial Density (sph)
East	Cedar	G	Cw60Fd18Hw7Ba5Dr10	2	15	5	Plant	1000
East	Cedar	M	Cw64Fd14Hw7Ba7Dr8	2	15	5	Plant	1000
East	Douglas-fir	G	Fd75Cw10Hw5Ba5Pl5	2	15	12.5	Plant	1200
East	Douglas-fir	M	Fd75Cw10Hw5Ba5Pl5	2	15	12.5	Plant	1200
East	Douglas-fir	P	Fd70Cw10Pl10Hw5Ba5	2	15	12.5	Plant	1000
East	Hemlock/Balsam	G	BA35Hw23Fd22Cw8Dr12	2	15	5	Plant	1000
East	Hemlock/Balsam	M	Hw62Fd28Cw10	2	15	5	Plant	1000
East	Hemlock/Balsam	P	Hw37Ba30Fd20Cw13	2	15	5	Plant	1400
East	Red Alder	M	Dr76Fd14Cw10	2	15	5	Plant	1000
East	Pine/Other	M	Pl50Cw12Fd12Hw8Dr18	2	15	5	Plant	1000
West	Cedar	G	Cw67Hw24Ba9	2	15	5	Plant	1000
West	Cedar	M	Cw70Hw23Ba7	2	15	5	Plant	1000
West	Cedar	P	Cw75Hw17Yc8	2	15	5	Plant	1200
West	Fir	G	Fd76Cw14Hw10	2	15	5	Plant	1200
West	Fir	M	Fd65Hw15Cw13Ba7	2	15	5	Plant	1200
West	Fir	P	Fd75Hw15Cw10	2	15	5	Plant	1000
West	Hemlock/Balsam	G	Hw52Ba27Cw21	2	15	5	Plant	1000
West	Hemlock/Balsam	M	Hw56Ba22Cw22	2	15	5	Plant	1000
West	Hemlock/Balsam	P	Hw50Ba28Cw22	2	15	5	Plant	1400
West	Spruce	G	Ss47Hw30Cw23	2	15	5	Plant	1000
West	Spruce	M	Ss40Hw30Cw30	2	15	5	Plant	1000
West	Red Alder	M	Dr100	2	15	5	Plant	1000
West	Pine/Other	M	Fd40Pl35Cw25	2	15	5	Plant	1000
Clayoquot	Cedar	G	Cw58Hw30Ba12	2	15	5	Plant	1000
Clayoquot	Cedar	M	Cw78Hw22	2	15	5	Plant	1000
Clayoquot	Cedar	P	Cw78Hw22	2	15	5	Plant	1200
Clayoquot	Douglas-fir	G	Fd55Hw25Cw20	2	15	5	Plant	1200
Clayoquot	Hemlock/Balsam	G	Hw66Cw18Ba16	2	15	5	Plant	1000
Clayoquot	Hemlock/Balsam	M	Hw60Ba25Cw15	2	15	5	Plant	1000
Clayoquot	Hemlock/Balsam	P	Hw53Ba18Cw24Yc5	2	15	5	Plant	1400
Clayoquot	Spruce	M	Ss40Dr30Hw20Cw10	2	15	5	Plant	1000
Clayoquot	Red Alder	M	Dr85Hw10Cw5	2	15	5	Plant	1000
Clayoquot	Pine/Other	M	Pl55Cw22Hw10Ss5Dr8	2	15	5	Plant	1000

Table 42: Regeneration assumptions for future plantations

Zone	Leading Species	Site Rating	Species Composition	Regen Delay	OAF1	OAF2	Regen Method	Initial Density (sph)
East	Cedar	G	Cw60Fd20Hw10Pw3.5Ss3.5Ba3	2	15	5	Plant	1000
East	Cedar	M	Cw60Fd20Hw10Pw3.5Ss3.5Ba3	2	15	5	Plant	1000
East	Cedar	P	Cw70Hw20Hw10	2	15	5	Plant	1000
East	Douglas-fir	G	Fd80Hw10Cw8Pw1Ss1	2	15	10	Plant	1000
East	Douglas-fir	M	Fdc80Hw15Cw3Pw2	2	15	10	Plant	1000
East	Douglas-fir	P	Fdc75Hw20Cw3Pw1Pl1	2	15	10	Plant	1000
East	Hemlock/Balsam	G	Hw75Cw15Fdc5Ba5	2	15	5	Plant	1000
East	Hemlock/Balsam	M	Hw75Cw15Fdc5Ba5	2	15	5	Plant	1000
East	Hemlock/Balsam	P	Hw60Cw25Ba10Fdc5	2	15	5	Plant	1000
East	Spruce	G	Hw60Cw30Fdc5Ss5	2	15	5	Plant	1000
East	Red Alder	M	Dr75Cw10Hw10Fdc4Ss1	2	15	5	Plant	1600
East	Pine/Other	M	Fdc50Pl40Hw5Cw5	2	15	5	Plant	1000
West	Cedar	G	Cw60Hw30Ba5Cy4Ss1	2	15	5	Plant	1000
West	Cedar	M	Cw65Hw25B5Cy4Ss1	2	15	5	Plant	1000
West	Cedar	P	Cw70Hw20Ba5Cy5	2	15	5	Plant	1000
West	Douglas-fir	G	Fd65Hw25Cw10	2	15	5	Plant	1000
West	Douglas-fir	M	Fdc60Hw25Cw15	2	15	5	Plant	1000
West	Douglas-fir	P	Fdc55Hw25Cw20	2	15	5	Plant	1000
West	Hemlock/Balsam	G	Hw65Cw18Ba15Fdc2	2	15	5	Plant	1000
West	Hemlock/Balsam	M	Hw70Cw18Ba10Cy2	2	15	5	Plant	1000
West	Hemlock/Balsam	P	Hw70Cw20Ba10	2	15	5	Plant	1000
West	Spruce	G	Hw70cw20Ba8Ss2	2	15	5	Plant	1000
West	Spruce	M	Hw70cw20Ba8Ss2	2	15	5	Plant	1000
West	Red Alder	M	Dr70Hw20Cw10	2	15	5	Plant	1000
West	Pine/Other	M	Cw50Hw30Cy15Pl5	2	15	5	Plant	1000
Clayoquot	Cedar	G	Cw60Hw30Cy5Ss5	2	15	5	Plant	1000
Clayoquot	Cedar	M	Cw50Hw30Cy15Ss5	2	15	5	Plant	1000
Clayoquot	Cedar	P	Cy30Cw30Hw25Ss5	2	15	5	Plant	1000
Clayoquot	Douglas-fir	G	Fdc50Hw30Cw20	2	15	5	Plant	1000
Clayoquot	Douglas-fir	M	Fdc40Hw30Cw30	2	15	5	Plant	1000
Clayoquot	Douglas-fir	P	Fdc40Hw30Cw30	2	15	5	Plant	1000
Clayoquot	Hemlock/Balsam	G	Hw50Cw30Cy10Ba8Ss2	2	15	5	Plant	1000
Clayoquot	Hemlock/Balsam	M	Hw50Cw30Cy10Ba8Ss2	2	15	5	Plant	1000
Clayoquot	Hemlock/Balsam	P	Hw55Cy20Ba15Cw10	2	15	5	Plant	1000
Clayoquot	Spruce	G	Hw70Cw28Ss2	2	15	5	Plant	1000
Clayoquot	Spruce	M	Hw70Cw28Ss2	2	15	5	Plant	1000
Clayoquot	Red Alder	M	Hw70Cw28Ss2	2	15	5	Plant	1600
Clayoquot	Pine/Other	M	Cw50Pl40Cy5Hw5	2	15	5	Plant	1000

4.5.3 Not satisfactorily restocked (NSR) areas

In this analysis all NSR is considered current. It is assumed to regenerate within the regeneration delay detailed under Section 4.5.2.

4.5.4 Fertilization

Between 2007 and 2013 approximately 6,800 hectares of Douglas fir stands were fertilized. This is modeled in the analysis by applying an average gain of 30 m^3 per ha in volume at rotation to the Douglas-fir component of selected stands.

4.5.5 Genetic Gain

Where available, class A seed from seed orchards is used for regeneration due to its advanced volume production. Genetic gain was applied to the yield curves of contemporary and future plantations as per Table 43.

Table 43: Genetic gain

Species	Contemporary Plantations			Future Plantations	
	Applicability	Availability of Seed	Genetic Worth	Availability of Seed	Genetic Worth
Douglas-fir	50%	99%	7.9%	100%	11%
Western redcedar	35%	89%	6.3%	95%	10%
Western hemlock	8%	99%	6.7%	100%	14%
Sitka spruce	0%	90%	0%	100%	0%
Amabilis fir	0%	2%	0%	0%	0%
Yellow-cedar	0%	30%	21%	48%	21%

4.6 Forest Cover Requirements

Modern natural resources management requires that multiple forest characteristics are retained across the landscape. These multiple characteristics are often referred to as forest cover objectives or requirements. It is important to identify how the THLB, and the productive forest which does not contribute to the THLB, are accounted for in the forest cover requirements. The most common way to express forest cover requirements is through maximum allowable disturbance or minimum area retention.

4.6.1 Landscape Green-up

As a surrogate for spatial cutblock adjacency constraint, a landscape green-up constraint will be applied in the base case, specifying that no more than 25% of the THLB area in each landscape unit outside of VILUP may be below the green-up height of 3 m at any given time. The same constraint applies to the VILUP SMZ and GMZ; in the EFZ a shorter green-up height of 1.3 m is required.

4.6.2 Visual Resources outside of Clayoquot Sound

Visual quality objectives are managed on the CFLB. Forest cover requirements for visual quality objectives are composed of two values:

- Visually Effective Greenup (VEG)—the stand height at which regeneration is perceived as a newly established forest, above which the stand is considered to have no visual impact; and
- Percent Planimetric Denudation—the maximum proportion of the productive area of a visual polygon that can be below the VEG height.

4.6.3 Percent Planimetric Denudation

The visual landscape inventory dataset field EVQO was used to determine the planimetric denudation limits. The limits are shown in Table 44. The targets are applied to the CFLB portion of each visual polygon separately. The allowable disturbance varies depending on the visual class and the visual absorption capability (VAC). The higher the VAC, the more disturbance is permitted.

Table 44: Maximum allowable disturbance for different visual classes

Zone	Visual Class	Visual Absorption Capability (VAC)	Maximum Allowable Disturbance	Green-up Height
West	Preservation (P)	M	0.5 %	5 m
East	Retention (R)	L	3.0 %	5 m
West		M	5.0 %	5 m
East	Partial Retention (PR)	L	10.0 %	5 m
West		M	15.0 %	5 m
East	Modification (M)	L	20.0 %	5 m
West		M	25.0 %	5 m

4.6.1 Scenic Areas (Clayoquot)

The inventory of scenic resources Clayoquot Sound is different from visual inventories completed for the rest of British Columbia. Instead of VQOs, scenic class objectives (SCOs) are assessed in the inventory. These are unique to Clayoquot Sound. SCOs have been translated into provincial VQO classes for this analysis.

Table 45: Visual classes and maximum allowable disturbance in Clayoquot Sound

Class Name	VQO class	Maximum Allowable Disturbance	Green-up height
Small-scale Alteration	PR	40%	6 m
Minimal Alteration	PR	30%	7 m
Natural Appearing	R	20%	8 m

4.6.2 Community Watersheds

There are 40 designated community watersheds that overlap the Arrowsmith TSA. None of these watersheds have a completed Coastal Watershed Assessment Procedure (CWAP). Most of them are located on private land; only six have more than 100 hectares of productive forest transecting the THLB.

Forest cover constraints will be applied to these watersheds to reflect current management practices; the rate of harvesting within each watershed will be limited to 1% of the CFLB each year.

4.6.3 Fisheries Sensitive and CWAP Watersheds

Fisheries-sensitive and CWAP watersheds are managed to a 20% equivalent clearcut area (ECA). This will be modeled by limiting the harvest to 1% of the CFMLB each-year.

4.6.4 Community Interface Areas

Community interface areas are contentious area near urban areas. These areas are currently managed similarly to designated community watersheds. Harvesting is limited to 1% of the CFMLB each year.

4.6.5 Landscape Level Biodiversity Outside of Clayoquot Sound

Old forests are retained in every landscape unit (LU) and natural disturbance type to protect landscape level biodiversity. In 24 of the 39 LUs within the Arrowsmith TSA and outside of the Clayoquot Sound, old-forest is retained through OGMAs. In the remaining 15 LUs old-forest retention is managed as per the O*rder Establishing Provincial Non-Spatial Old Growth Objectives*. Targets are shown in Table 46.

Stands older than 250 are considered old growth in natural disturbance types (NDT) 1, 2 and 4. In NDT 3 stands are required to reach an age of 141 to be regarded as old. The targets are established for each LU based on NDT and BEO.

Table 46: Non-spatial old growth objectives

Natural Disturbance Type (NDT)	Biodiversity Emphasis Option (BEO)	Old Growth Requirement (%)
NDT 1	Low & Intermediate	13
NDT 1	High	19
NDT 2	Low & Intermediate	9
NDT 2	High	13
NDT 3	Low & Intermediate	14
NDT 3	High	21
NDT 4	Low & Intermediate	13
NDT 4	High	19

4.6.6 VILUP SMZ Mature and Old Seral Requirements

VILUP HLPO Section 2 (1) (a) specifies mature plus old forest cover objectives for all special management zones. The VILUP sets the mature and old targets between 25 and 33% and defines the age of mature seral stage as 81 to 121 years depending on the stand type. If the targets are not currently met, a recruitment strategy must be implemented to achieve them in 50 years. The targets and mature seral age cut-offs are further defined in landscape units plans. Mature and old seral stage cover requirements in the productive forest are shown in Table 47.

Table 47: Mature+Old seral forest cover targets in SMZs

SMZ	SMZ Number	BEC Zone	Age of Mature	Target (%)
Barkley Sound	14	CWH	81	25
		MH	121	25

SMZ	SMZ Number	BEC Zone	Age of Mature	Target (%)
Alberni Canal	18	CWH	81	25
		MH	121	25
Nahmint	13	CWH	81	25
		MH	121	25
Upper Qualicum	20	CWH	81	25
		MH	121	25
San Juan Ridge	22	CWH	81	25
		MH	121	25

4.6.7 Landscape Level Biodiversity (Clayoquot)

In the Clayoquot zone, landscape level biodiversity will be modelled by setting a 40% old seral target at the watershed level. Age of old is defined as 251 or older.

4.6.8 Rate of Cut Restrictions (Clayoquot)

Each watershed in Clayoquot Sound consists of a number of sub-basins. For each sub-basin over 500 ha in size, the 5 year rate of harvest is limited to a maximum of 5% of the sub-basin area. This constraint will be modelled by limiting the area that can be less than 5 years old to 5% in each sub-basin.

5 Objectives for the Arrowsmith TSA

Coarse objectives were developed for the Arrowsmith TSA through several stakeholder meetings. The objectives were developed for broad values considered important to the stakeholder group: economic values, environmental values and social values.

The objectives are expressed as statements of what ideally is desired on the land base; however, not all objectives might be realized as stated when attempting to achieve them simultaneously. The objectives are not ranked or constrained by targets; this provides maximum flexibility and learnings from scenario analysis.

Each objective contains a performance measure or indicator to facilitate meaningful quantitative and qualitative comparisons between different scenarios and ultimately management options. Note that the objectives and performance measures are focused on addressing critical issues that have been raised by stakeholders; however, there are other non-listed objectives that will be captured as current management as driven by legislation and policies. These will be fixed in the IRMP Base Case and across all scenarios. Strategies to achieve objectives are collated into logical scenarios for comparison against the IRMP Base Case.

The following matrix illustrates agreed upon management objectives.

Table 48: Management objectives for the Arrowsmith TSA

Value category	Objective	Performance measure/indicator	What is better?	Notes
Economic	Maximize volume harvested	Cubic meters harvested per year	More	This could be an aggregate over many years to allow year-to-year variation; this objective will be constrained by the even flow objective
	Maintain an even flow of harvested volume	Variance in annual volume harvested, by decade	Less	
	Maximize revenue of harvest	Yield times average revenue, by product and grades, summed by year	More	
	Maximize carbon storage	Tonnes of carbon	More	A clear trade-off with harvesting but still an off-setting economic opportunity.
Environmental	Maintain Northern Goshawk nesting and foraging habitat	60% of known and modelled breeding territories	More	Does not directly address breeding areas, but locations are difficult and not as constraining as foraging requirements
		Forage habitat: 1) report only; 2) maintain 40% within the foraging territory.	More	
	Maintain CDF representation	Netdown potential CDF reserves	More	
	Visuals	Map and report overlaps with other values	More	

Value category	Objective	Performance measure/indicator	What is better?	Notes
	Maintain Marbled Murrelet Habitat	Meet Recovery Strategy Targets	More	
	Maintain integrity of hydro-riparian network for habitat, water quality and flow	Use existing models, report only for now	More	
Social	Maximize availability of western redcedar for traditional use	Proportion of area of stands with >30% Cw in age class 9+	More	
	Minimize risk of catastrophic fire in interface areas	Proportion of interface area classified as moderate-high threat	Less	

6 IRMP Base Case

The TSR Base Case analysis assumptions were revised through stakeholder meetings to reflect current management in the Arrowsmith TSA. Table 49 shows the core IRMP Base Case assumptions in a nutshell.

Table 49: IRMP Base Case assumptions

Objectives and overall assumptions	Characterize current management to the extent practicable
Land base assumptions	➢ Incorporate projected tenures in the analysis; ➢ Remove Ditidaht red zone from the THLB; ➢ Exclude Clayoquot Sound from the analysis; ➢ Incorporate proposed NOGO WHAs and nests currently outside of WHAs in the analysis; ➢ Use most TSR assumptions as they are; ➢ Incorporate woodshed volume targets, woodshed based NOGO restrictions and woodshed based harvest deferrals in the analysis.
Harvest assumptions	➢ Attempt to harvest 100,000 m^3/year on average off the east zone; ➢ Use oldest first harvest rule in the west zone.
Silviculture assumptions	➢ Use revised managed stand yield curves (TASS); include impacts of past spacing and impacts of past fertilization; ➢ Incorporate shading effect as in TSR.
Habitat assumptions	➢ Report on NOGO forage habitat; ➢ Report on MAMU habitat.

6.1 Land Base Reductions

The total reduction to the THLB after Clayoquot Sound (8,599 ha of THLB), the projected tenures (11,676 ha of THLB), the proposed NOGO WHAs and nest buffers outside WHA (374 ha of THLB), and woodshed based reductions (Ditidaht red zone, 867 ha of THLB) are removed is 21,607 ha (Table 50). The remaining land base is the THLB for the IRMP Base Case.

Table 50: IRMP Base Case THLB

Land Base	THLB (ha)
TSR Base Case	65,433
Clayoquot Sound	-8,599
Projected tenures	-11,767
Proposed NOGO WHA and nests outside WHA	-374
Ditidaht red zone	-867
IRMP Base Case	**43,853**

6.1.1 Projected Tenures

The IRMP Base Case excludes all projected tenures from the analysis. The projected tenures are shown in Table 51. The total projected tenure reduction amounts to 11,767 ha of THLB.

Table 51: Projected tenure THLB reductions

Projected Tenure	THLB Removed
AVCFA K2D expansion	83
BCTS Rosewall Chart FNWL	6,225
Cataract CFA (Tseshaht FNWL)	887
CDF AOI PARCEL	187
Qayalit CFA- Browns Ridge	445
Qayalit CFA- Loup Creek	1,798
Qayalit CFA- Mt Bolduc	1,729
Snuneymuxw Phase1 AOI	169
Te'mexw AIP	103
Tseshaht Areas of Interest	104
W1902 expansion	35
Total	**11,767**

6.1.2 Northern Goshawk (NOGO)

Two different netdown approaches were applied to remove NOGO nests from the THLB: if the nest was located within a proposed WHA, the WHA was removed from the THLB. Nests that are not within proposed WHAs were buffered as per the current operational practice leaving a 12 ha area around nest sites. Table *52* shows the total NOGO THLB reduction (374 ha).

Table 52: NOGO reductions; IRMP Base Case

NOGO WHA or Nest Buffer	THLB Removed
1-573	0[1]
1-575	169
1-574	178
Nest Buffers	27
Total	**374**

[1] Net reduction = 0 due to overlap with other reductions

6.1.3 Ditidaht Red Zone

The Ditidaht red zone is located in the Rosander woodshed. As harvest in the red zone is unlikely, it is removed from the THLB.

Table 53: Woodshed based reductions

Reduction Area	THLB Removed
Ditidaht red zone	867

6.2 Minimum Volume Requirements and Harvest Deferrals

Minimum volume requirements can be set for an area, when it is known that the financial viability of the harvest from that area requires a minimum harvestable volume. Due to the scattered and isolated

nature of the TSA, many areas may require a minimum harvest volume to reflect the operational reality associated with mobilization and demobilization.

Harvest deferrals can be used to override the harvest rule as well. They are used in cases where access to an area must be deferred for a period of time for various reasons.

The SINRD has divided the TSA into woodsheds; subunits of the TSA serviced by common road systems and timber gathering points. This analysis includes harvest priority rules and/or harvest timing rules to account for deferrals and costs associated with mobilization and demobilization. In some cases the deferrals are applied to woodsheds due to unresolved land use issues. The following table shows all the woodsheds that are subject to minimum volume requirements or harvest deferrals. The minimum volume requirements are applied to 5 year periods.

Table 54: Woodsheds; minimum harvest volumes and deferrals

Woodshed	THLB Area (TSR)	THLB Area (IRMP)	Minimum Harvest Volume m^3 or Deferral	Comments
Browns Ridge	451	6	No min volume or deferral.	
Clayoquot	7,989	0	Partition in TSR (13,700 m^3 per year).	Excluded from THLB in IRMP Analysis
Effingham	2,103	2,103	No min volume or deferral.	
Effingham BCTS	1,036	1,036	Defer old growth harvest for 10 years.	
Escalante	8,240	8,240	No min volume or deferral.	
Handy	4,284	4,284	No min volume or deferral.	
Holland	2,303	2,303	Min harvest volume of 5,000 m^3 per 5 years.	
Koksilah	888	888	Min harvest volume of 5,000 m^3 per 5 years.	
Mayo/Hillcrest	1,991	1,991	Min harvest volume of 5,000 m^3 per 5 years.	
McKay Lake	1,508	1,339	Min harvest volume of 5,000 m^3 per 5 years.	
Mt Benson	679	679	Defer harvest for 10 years.	Uncertainty regarding land use.
Mt Brenton	2,747	2,747	Min harvest volume of 5,000 m^3 per 5 years.	
Mt Wesley	627	627	No min volume or deferral.	
No Name	633	633	No min volume or deferral.	
Rosander	1,901	1,901	Min harvest volume of 10,000 m^3 per 5 years. Defer for 10 years.	
Rosewall	6,338	113	Min harvest volume of 5,000 m^3 per 5 years.	
San Juan	2,141		Min harvest volume of 10,000 m^3 per 5 years.	
Sarita	186	186	Defer harvest for 10 years.	Uncertainty regarding land use.
Sechart/Cataract/Pipestem	4,005	3,019	No min volume or deferral.	
Toquart/Lucky	5,218	5,218	No min volume or deferral.	
Tzartus	1,216	1,216	Min harvest volume of 5,000 m^3 per 5 years.	
Vernon Bay	861	856	No min volume or deferral.	

6.3 Silviculture Assumptions

The TSR base case regeneration assumptions were refined for the IRMP Base Case. The regeneration assumptions were refined for two main reasons:

1. To take advantage of the ability of TASS II to model stands with mixed species, and stands that are composed of planted and natural components.
2. To include the impacts of past juvenile spacing on older Fd-leading analysis units. The Silviculture Working Group, composed of several government and licensee foresters with extensive knowledge of the Arrowsmith TSA used RESULTS data summarized for TSR with additional RESULTS queries, and summaries of Interfor's silviculture survey data to formulate the IRMP base case assumptions. A summary of the results of this work is presented in Table 55.

Table 55: Modified silviculture assumptions for the IRMP Base Case

Attribute	Zone	Old Plantations	Contemporary Plantations	Future Plantations
Regeneration Method	East	Assume planting of leading species only. Other species are regenerated through natural regeneration.	Assume planting of Fd and Cw. Other species are regenerated through natural regeneration.	100% planted; assume natural ingress.
	West	Cw leading stands are assumed to be 80% naturally regenerated and 20% planted. Ss leading stands are assumed to be planted Other species leading stands are assumed to be naturally regenerated.	Fd, Cw and Ss leading stands are assumed to be planted. Other species leading stands are assumed to be naturally regenerated.	100% planted; assume natural ingress.
Initial Densities	East	Planted stands are assumed to have 900 sph of planted seedlings (net of mortality). Other species are assumed to occupy the site through ingress. HemBal leading stands are assumed to start at 1,500 sph; other species 1,000 sph.	Planted stands are assumed to have 900 sph of planted seedlings (net of mortality). Other species are assumed to occupy the site through ingress. HemBal leading stands are assumed to start at 1,500 sph; Pine and Dr at 400 sph.	Planted stands are assumed to have 1,100 sph of planted seedlings, except 900 sph for planted Cw. Ingress: 1,500 sph of HemBal and 400 sph of other species
	West	Planted stands are assumed to have 900 sph of planted seedlings (net of mortality). Other species are assumed to occupy the site through ingress. Natural regenerated stands are assumed to have 2,500 sph for all species, except 1,200 for pine leading stands	Planted stands are assumed to have 900 sph of planted seedlings (net of mortality). Other species are assumed to occupy the site through ingress. Natural regenerated stands are assumed to have 2,500 sph for all species	Planted stands are assumed to have 900 sph of planted seedlings (net of mortality). Other species are assumed to occupy the site through ingress at 1,500 sph
Regen delay	All	Planted: 2 years Natural regeneration and ingress: Start at year 2, most trees in by year 7	Planted: 2 years Natural regeneration and ingress: Start at year 2, most trees in by year 7	Planted: 2 years Natural regeneration and ingress: Start at year 2, most trees in by year 7
OAFs	All	As per TSR	As per TSR	As per TSR

Attribute	Zone	Old Plantations	Contemporary Plantations	Future Plantations
Genetics	All	As per TSR; none	As per TSR; only for planted species in planted stands	As per TSR; only for planted species in planted stands
Juvenile Spacing	All	Assume that Fd-leading stands with SI>20m were spaced Assume that 1,770 ha of Hw stands with SI 28 m or greater were spaced to 700 sph in the west at year 20.	None	None
Fertilization	All	Existing Fd leading good and medium stands in the east and west are assumed to be treated		
Site Indices	All	As per TSR; SI's for secondary species are converted from Au leading species SI using TIPSY SI conversion equations	As per TSR; SI's for secondary species are converted from Au leading species SI using TIPSY SI conversion equations	As per TSR; SI's for secondary species are converted from Au leading species SI using TIPSY SI conversion equations
Species Composition	All	As per TSR AU's	As per TSR AU's	As per TSR AU's

6.3.1 Stand Level Modelling Using TASS

The ongoing TSR used TIPSY for stand-level modeling. TASS II was used instead for the IRMP Base Case and all further scenarios for the following reasons:

1. TIPSY does not have an option for modeling stands that are composed of both planted and ingress trees. TIPSY requires that different weightings of planted and natural curves are used to approximate yields from stands with both planted and ingress trees. Stands with both planted and ingress trees can be modeled in TASS II.
2. The TIPSY database does not include simulations for mixed-species stands. Yield curves for mixtures are simply a combination of the yields for component species weighted by the initial species proportions. Mixed species stands can be simulated in TASS II with the caveat that calibration of the model for mixtures is ongoing with the development of the latest version of TASS (TASS III).
3. TASS has a custom bucking routine which allowed us to use generic industrial log sorts and pricing for second growth timber.

6.3.2 Regeneration Method

Future managed stands were assumed to be 100% planted as in the TSR. Existing managed stands were assumed to be both planted and naturally regenerated (Table 55). Ingress was assumed for all existing and future managed stands. Due to uncertainties with the results from the modeling of mixed stands which contain significant components of Douglas fir (which by merchantability results in almost pure Douglas fir stands), the assumed natural ingress in these stands was modeled as planted.

According to silviculture survey data and field knowledge, Hw often forms a significant minority component through ingress in Fd planted stands. However, TASS model runs in these stands tend to produce pure Fd stands without the Hw component. For this reason, the assumed natural ingress of Hw was modeled as planted seedlings in this project to ensure that the resulting stands in modelling resembled those found in the field.

6.3.3 Initial Densities

Initial densities vary depending on the regeneration method. Ingress was assumed to occur.

6.3.4 Regeneration Delay

Regeneration delay for planted stock was assumed to be the same as in TSR (2 years). Natural regeneration and ingress were assumed to start at year 2 and be complete in 7 years.

6.3.5 Juvenile Spacing

According to RESULTS significant areas in the TSA have been spaced. Some of the spacing was so called twilight spacing occurring around age 40, while the rest was regular spacing at around age 20. Fd-leading analysis units with a site index greater than 20 m account for approximately 1,400 ha of spacing in the east zone and 1,600 ha in the west zone. It was assumed that 70% of these stands (east and west) were spaced with twilight spacing and 30% with regular spacing.

According to RESULTS, approximately 1,770 ha of Hw stands in the West were spaced. This spacing was also included in the analysis.

According to RESULTS and the knowledge of local foresters, significant areas of Fd-leading old plantations in the TSA have been spaced. Some of the spacing, which occurred in the 1970's and 1980's, was so called twilight spacing occurring around age 40 to a residual density of 500 stems per hectare (sph). The rest, more recently completed spacing, was regular spacing at around age 20 to 600 sph. It was assumed that these treatments occurred on good and medium analysis units.

According to RESULTS, approximately 1,770 ha of Hw stands in the West were spaced. This spacing was also included in the analysis.

6.3.6 Fertilization

According to RESULTS data compiled for TSR approximately 6,800 ha Fd-leading stands were fertilized between 1978 and 2013. This was modeled in the TSR base case. It was assumed that some stands were treated more than once.

As these treatments are linked to stand age, they were applied to the IRMP base case as three different regimes (Table 56). Based on the unharvested stands in each age category, the IRMP Base Case assumes about 1,956 hectares of spacing and about 3,500 hectares of fertilization in these stand types.

Table 56: Spacing and fertilization, Fd-leading old plantations

Age Range (Current)	Spacing Regime	Fertilization 1 Age	Fertilization 2 Age
28 to 40 years	Regular	25	
41 to 50 years	Regular	25	35
51 to 63 years	Twilight	45	50

6.3.7 Industrial Recoverable Volume

Industrial recoverable volume estimates are based on the logs that are expected to be marketed maximizing the financial benefit to the licensee (when operating on crown land in BC). Industrial preferred log lengths for sawlog and gang are 13 m, 11 m and 8 m. Chip & Saw and pulp sorts also include log lengths of 6.3 and 5 m. Industrial sorts use a top diameter inside bark (DIB) of 12.5cm.

Government's net volume estimates are based on calculating appraisal stumpage rates and determining Annual Allowable Cuts (AAC), and use different top DIB, minimum log length and log length. Table 57 compares the key differences between these compilation methods.

Table 57: Government and industry compilation methods

Compilation Attribute	Government	Industry
Top DIB	10.0 cm.	12.5 cm.
Min. Log length	2.6 m	5 m
Log Lengths	10 m	13, 11, 8 m
Recoverable Volume	no	yes

Industrial recoverable volumes were used for this project to compare the impacts of different silvicultural regimes on timber yield and value.

6.3.8 Industrial Sorts and Values;

The majority of the coastal industry uses generic log sorts (sawlog, gang, chip & saw) for coniferous logs. Based on advice from a coastal log quality expert[2], the generic sort matrix for Douglas fir gang was customized to split the gang sort into a small and large gang sort. This was done to better reflect the influence of top diameter on price within the gang sort (the predominant sort when harvesting managed stands at less than 100 years of age).

The average industrial selling prices used for this project are based on data from the Forest Industry Trader, an industrial newsletter, for 2014 and 2015. Sorts and values for intensively managed red alder are from Coast Mountain Hardwoods[3] Sets of "Low" and "High" prices were used in an attempt to differentiate values based on quality. High prices are surrogates for logs with better quality which are suitable to export to Japan (using delivered net prices to Japan). Low prices are surrogates for "fast grown" trees with poor taper, low ROG and big branches (using prices for a "utility" sort[4]). For this project average values will be used for the base case and all the analysis scenarios.

The government system assigns alpha log grades (e.g., for immature timber; H, I, J, U, X, Y) based on an algorithm. The government selling price is based on recent transactions using the alpha log grades as summarized in the Coast Marketing Pricing System Log Values for Second Growth Timber Reports (published with monthly and quarterly averages).

Industrial sorts and values were used for this project to compare the impacts of different silvicultural regimes on timber yield and value.

[2] Orr-Ewing, A., March 2012

[3] Brian Kyle, November, 2016

[4] Orr-Ewing, A., January 2016

6.3.9 Bucking Simulation;

Sort specifications and values used for this project for Douglas fir (Fd), Hemlock/Balsam/Spruce/Pine (HB), Western red cedar/yellow cedar (Cw) and intensively managed Red Alder[5] (Dr) are summarized in Table 58, Table 59, Table 60 and Table 61.

Table 58: Fd industrial log sorts and values

Sort	Min Top (cm)	Length (m)	Base Value	Low Value	High Value
Sawlog/ Peeler	38	13	$120.00	$60.00	$150.00
Sawlog/ Peeler	38	11	$120.00	$60.00	$150.00
Sawlog/ Peeler	38	8	$120.00	$60.00	$130.00
Large Gang	30	13	$90.00	$80.00	$130.00
Large Gang	30	11	$90.00	$80.00	$130.00
Large Gang	30	8	$90.00	$80.00	$100.00
Small Gang	20	13	$70.00	$60.00	$110.00
Small Gang	20	11	$70.00	$60.00	$110.00
Small Gang	20	8	$70.00	$60.00	$80.00
Chip'n'Saw	12.5	13	$55.00	$55.00	$80.00
Chip'n'Saw	12.5	11	$55.00	$55.00	$80.00
Chip'n'Saw	12.5	8	$55.00	$55.00	$80.00
Chip'n'Saw	12.5	6.3	$55.00	$55.00	$80.00
Chip'n'Saw	12.5	5.1	$55.00	$55.00	$80.00
Pulp	12.5	5	$35.00	$35.00	$35.00

Table 59: HB industrial log sorts and values

Sort	Min Top (cm)	Length (m)	Base Value	Low Value	High Value
Sawlog	38	13	$70.00	$60.00	$110.00
Sawlog	38	11	$70.00	$60.00	$110.00
Sawlog	38	8	$70.00	$60.00	$80.00
Gang	20	13	$60.00	$50.00	$90.00
Gang	20	11	$60.00	$50.00	$90.00
Gang	20	8	$60.00	$50.00	$70.00
Chip'n'Saw	12.5	13	$50.00	$50.00	$75.00
Chip'n'Saw	12.5	11	$50.00	$50.00	$75.00
Chip'n'Saw	12.5	8	$50.00	$50.00	$75.00
Chip'n'Saw	12.5	6.3	$50.00	$50.00	$75.00
Chip'n'Saw	12.5	5.1	$50.00	$50.00	$75.00
Pulp	12.5	5	$40.00	$40.00	$40.00

Table 60: Cw industrial log sorts and values

Sort	Min Top (cm)	Length (m)	Base Value	Low Value	High Value
Sawlog	38	13	$200.00	$190.00	$210.00
Sawlog	38	11	$200.00	$190.00	$210.00

[5] Dr from the base case runs used the HB sorts and values.

Sort	Min Top (cm)	Length (m)	Base Value	Low Value	High Value
Sawlog	38	8	$200.00	$190.00	$210.00
Gang	20	13	$185.00	$175.00	$195.00
Gang	20	11	$185.00	$175.00	$195.00
Gang	20	8	$185.00	$175.00	$195.00
Chip'n'Saw	12.5	13	$100.00	$100.00	$110.00
Chip'n'Saw	12.5	11	$100.00	$100.00	$110.00
Chip'n'Saw	12.5	8	$100.00	$100.00	$110.00
Chip'n'Saw	12.5	6.3	$100.00	$100.00	$110.00
Chip'n'Saw	12.5	5.1	$100.00	$100.00	$110.00
Pulp	12.5	5	$20.00	$20.00	$20.00

Table 61: Intensively managed Dr industrial log sorts and values

Sort	Min Top (cm)	Length (m)	Base Value	Flat Value
Sawlog1	30.5	8.3, 7.6, 6.3, 5.7, 5.1	$125.00	$85.00
Sawlog2	25.4	8.3, 7.6, 6.3, 5.7, 5.1	$70.00	$75.00
Sawlog3	20.3	8.3, 7.6, 6.3, 5.7, 5.1	$70.00	$70.00
Sawlog4	17.8	8.3, 7.6, 6.3, 5.7, 5.1	$70.00	$65.00
Pulp	15.2	8.3, 7.6, 6.3, 5.7, 5.1	$40.00	$35.00

6.4 Northern Goshawk Forage

As discussed earlier, the existing and proposed WHAs are removed from the THLB in the IRMP Base Case. The IRMP Base Case is also set up to report on NOGO forage habitat; 2,500 m buffers (1962.5 ha) were placed around the centroid of NOGO nest clusters. The buffers were incorporated whether the nests were within WHAs or not. The amount of forage habitat is reported for each forage area.

There are six forage areas within the Arrowsmith TSA shown in table Table 62. In most cases only little area falls within the TSA boundaries.

Table 62: NOGO forage areas in the Arrowsmith TSA

Area Name	Forest Area (ha)
McNaughton	175.9
Beaver Creek	0.3
Cous Creek	51.7
Holland Creek	1225.1
Forage Kelvin Creek	590.8
Forage Edinburgh	2.3

6.4.1 Foraging Model

For this analysis it is assumed that all forested areas within the TSA are capable of becoming suitable NOGO foraging habitat. The NOGO foraging model allows for capable stands to become suitable as a function of age, height, BEC and leading species as per the following formula:

HSIf = mean(Ager, Heightr) * ITGr * BECvar

HSIf values greater than 0.5 indicate suitable goshawk habitat. The habitat index (HSIf) value was assigned to each yield curve in 5-year intervals in the analysis data set. Rather than using the ITG, a simpler rating scheme employing leading species was used with some exceptions. In using the leading species the following adjustments were made:

- ITG group value was used for hemlock and balsam stands only (0.95).
- Some of the analysis units are 50/50 cedar and hemlock. In these cases it was assumed that the predominant management of these stands would favor cedar and the forage rating was set accordingly at 0.7.

6.5 Marbled Murrelet (MAMU)

The Marbled Murrelet (MAMU) is an important species in the TSA requiring old growth forest stands for its nesting habitat. A Habitat Suitability layer was created for the TSA and was provided for the analysis by the FLNRO, West Coast Region. Spatial polygons have a suitable habitat class (1, 2 or 3) and suitable habitat attribute. In this analysis the suitable habitat classes were not used. Rather, the polygons in the data were simply classified as suitable or not. Harvesting a suitable area is assumed to convert it into unsuitable habitat with no recruitment of habitat within the planning horizon of the analysis.

The East Zone of the TSA contains little MAMU habitat (Table 63). Most of it is located in the West Zone; 55% of the MAMU habitat in the west is in the NHLB. The IRMP Base Case was set up to report on the amount of MAMU habitat throughout the planning horizon.

Table 63: Mamu habitat in the Arrowsmith TSA

Description	Forest Area (ha)	THLB Area (ha)	NHLB Area (ha)
East Zone	97.7	19.4	78.3
West Zone	6,017.1	2,708.0	3,309.1

7 Strategies for Exploration

The strategies that could be employed to meet some of the IRMP management objectives were discussed at the stakeholder meetings. The following strategies will be explored in this analysis:

7.1 Volume Scenarios

These scenarios are based on developing feasible treatment regimes for existing and future stands that would maximize harvest volumes. Stand-level analysis was used to assess the different opportunities and choose the preferred regimes which were used for the volume scenario. The treatment regimes assessed in forest level analyses were:

1. Existing managed stands. Fertilize existing managed Fd stands at ages 30, 40, 50, 60 and 70 on good and medium sites.

2. Future stands. Where ecologically suitable, plant hi-gain genetically improved Hw (GW=20%) instead of Cw or Fd.

   On potential root rot sites in the east region complete stumping (and reduce OAF2 to 5%) and plant a higher density of a mix of Fd and Pw.

   Fertilize future Fd stands on good and medium sites at ages 30, 40, 50, 60 and 70.

   Two forest-level runs will be completed, one where the minimum harvest criteria are kept the same as in the IRMP Base Case, i.e. minimum volume of 350 m^3 per ha for conventional harvest areas and 450 m^3 per ha for helicopter harvest areas, and another where the minimum harvest criteria are set at age where 95% of the mean annual increment (MAI) culmination is achieved for each managed stand yield curve.

3. As a surrogate to model partial cutting, retention and partial retention VQOs will be relaxed by one class. The intent is not to actually relax VQOs but to gauge what the maximum impact of partial harvesting might be. The scenario would then assume that only a part of the benefit would be realized due to partial harvesting. This approach was chosen due to the difficulty in modelling partial harvesting.

7.2 Value Scenarios

These scenarios are based on investigating the impact of harvest age on timber value, and developing feasible treatment regimes for existing and future stands that would maximize value from managed stands. Stand-level analysis was used to assess the different opportunities and choose the preferred regimes which were used for the value scenario. The following scenarios were constructed:

1. Increase the MHA to MAI culmination and observe the impact on timber supply and value.

2. Existing stands. Space available Cw stands in the west region on good and medium sites to favour Cw and fertilize at ages 30, 40, 50, 60 and 70.

   Future stands. Where ecologically suitable, plant Cw instead of Hw or Fd and space to favour Cw and fertilize at ages 30, 40, 50, 60 and 70.

On Dr sites in the east region plant Dr (as per the IRMP Base Case) and juvenile space and schedule harvesting for between age 25 and 35 years.

Two forest-level runs will be completed, one where the minimum harvest criteria are kept the same as in the IRMP Base Case, i.e. minimum volume of 350 m^3 per ha for conventional harvest areas and 450 m^3 per ha for helicopter harvest areas, and another where the minimum harvest criteria are set at age where 95% of the MAI culmination is achieved for each managed stand yield curve.

As the volume regimes involving Fd (stumping and fertilization) and Dr stands (spacing and early harvest) also provide increases in value, these regimes are also included in the value scenarios runs.

7.3 Habitat and Biodiversity Scenarios

1. Follow the NOGO federal recovery strategy management direction (more or less). The forage area target is set at 40% and 60% (two separate analysis runs) for each forage area.
2. Test the impact of setting just one TSA-wide forage habitat target. The TSA-wide target is set at 40%.
3. Follow the recovery strategy for MAMU with the conservation area targets. Percent of 2002 habitat; east and west separated. MAMU habitat target for the west is are set at 68% and 90% for the east.
4. Test the impact of higher retention levels for riparian management zones (RMZ); remove RMZ from the THLB.

7.4 Zoning

The THLB in the Arrowsmith TSA was zoned based on suitability for investment in silviculture treatments. Three zones were developed: green, yellow and red. Green depicts areas where management actions and investments are generally recommended due to higher site productivity, lower harvest costs and reduced anticipated risks from constraints and other risks to future harvest. In the yellow zone caution is recommended, while the red zones denotes areas where management actions and investments in forest management should be avoided due to costs and risks. Table 64 details the zoning criteria while the THLB areas for green and yellow zones are presented in Table 65. The silviculture zones are illustrated in Figure 8.

Table 64: THLB zoning, Arrowsmith TSA

Category	Data Source	Green (good)	Yellow (caution)	Red (stop)
Site Productivity, East	Lead Species, Site Class for Future Managed Stands	Fd good HB good	Cw good Fd med FdPr HB med Ss good Dr med	Other
Site Productivity, West	Lead Species, Site Class for Future Managed Stands	Fd god Fd med HB god Ss good Ss med Dr med	Cw good FdPr HB med Pine med	Other
Costs	Operability	Ground	Cable	Heli
	By woodshed, based on stakeholder information	Truck	Boom or Barge	N/A
Constraints to Harvest	FN interest areas, based on comments in woodshed analysis		yes	
	VQO	Other	PR	P, R
	Community Watersheds	No	Yes	N/A
	UWR	No	Partial harvest zone	No harvest zone
	NOGO	No	Forage areas	Nesting areas
	Draft OGMA (from licensees)	No	N/A	Yes
	CDF BEC zone	No	N/A	Yes
Other Constraints/Values	Elk hazard for reforestation; by woodsheds based on analysis of current and target populations	Low	Mod	High
	Fire Hazard	Low	Mod	High

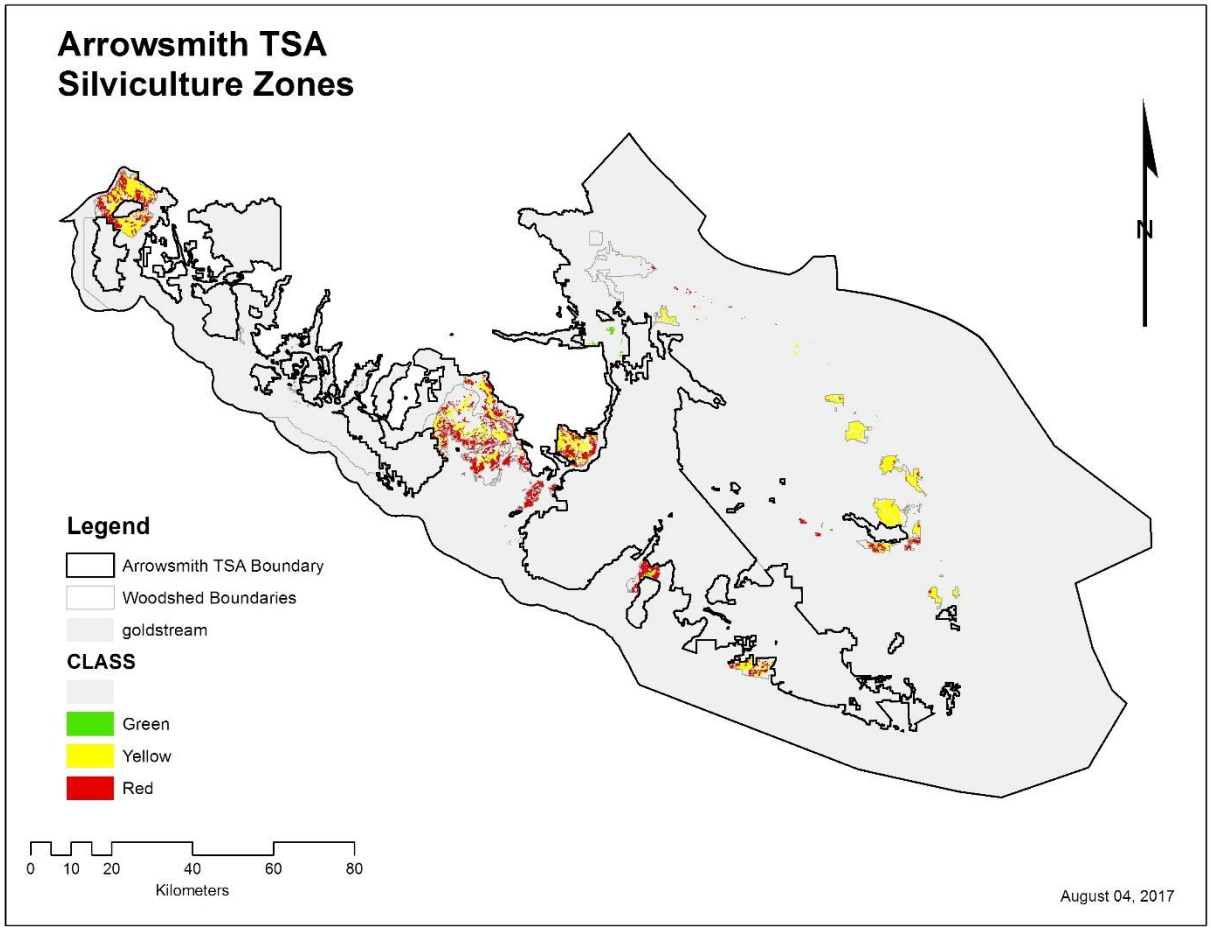

Figure 8: Arrowsmith TSA silviculture zones

Table 65: Silviculture zone areas

Silvicuture Zone	Description	THLB
Green	EM contemporary	114
Green	EM Old	260
Green	Natural	369
Yellow	EM contemporary	7,113
Yellow	EM Old	5,616
Yellow	Natural	10,019
Total		**23,491**

7.5 Preferred Scenario

The analysis results were presented to the Arrowsmith IRMP implementation group on March 10, 2017. The group agreed that the value scenario with some control over the harvest age of the managed stands

should be the basis for the preferred scenario and the ensuing tactical silviculture treatment schedule. The following changes are incorporated into the preferred scenario:

- Extreme and high fire threat areas within the urban interface buffers were classified as red, i.e. not candidates for incremental silviculture investments as described in the value scenarios above. However, stand-level treatment regimes will be introduced in these zones to reduce fire risk.
- Suitable future Cw stands were included in the fertilization program.
- Minimum harvest criteria outside of green and yellow zones is the same as used in the latest TSR (350 m^3 per ha conventional and 450 m^3 per ha helicopter). Within the green and yellow zones the harvest criteria was set at the age where 95% of the MAI culmination is achieved.
- NOGO forage areas targets are to be applied.

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