

Arrowsmith TSA

Economic Operability Assessment

Final Report

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1. Introduction

The Ministry of Forest, Lands and Natural Resource Operations (MoFLNRO), South Island Natural Resource District contracted Forest Ecosystem Solutions Ltd. to complete an Economic Operability Assessment for the Arrowsmith Timber Supply Area (TSA) using an empirical approach method. This economic operability assessment will form part of the land base classification of the next timber supply review (TSR 4).

The economic operability assessment determines areas of the land base where the value of the merchantable timber is greater than the cost to access and harvest it. Gathering detailed value and cost data for the entire Arrowsmith TSA is beyond the scope of this project. Instead, surrogate variables of stand value and harvest costs were used. Surrogates for value are species composition and stand volume, while surrogates for cost are slope, hauling distance and geographic zone. It is assumed that the value of a stand will vary with its species composition and volume, while the harvest cost will vary by the slope class, hauling distance and zone. This approach assumes that past harvesting was economic and therefore, these areas represent those where the value was greater than the cost.

Two stakeholder meetings were conducted to review the minimum economic volumes (February 27, 2014) and preliminary economic classifications (March 11, 2014). The feedback from stakeholders was used to set the final minimum volumes and to refine the economic classification.

2. Data Sources

The data sources used for this analysis are listed in Table 1.

Table 1: Data Sources

Title	Description	Data Source	Vintage
Ownership	Crown Ownership	Port Alberni Forest District	January 2014, updates March 2014
Zones	Clayoquot, East and West Zones	Port Alberni Forest District	January 2014
Combined Roads	All current existing roads	Port Alberni Forest District	January 2014, Updates February 2014
Proposed Roads	Projected roads from TSR3 Total Chance Plan	Port Alberni Forest District	2006, updates March 2014 based on licensee feedback
Arrowsmith TSR3 Roads	TSR 3 road dataset	Port Alberni Forest District	2005, updates Jan 2014
2013 consolidated cut blocks data layer	All cutblocks in British Columbia	MoFLNRO FAIB	2013
2002 VRI	Archived 2002 VRI for Arrowsmith	MoFLNRO FAIB	2002
2013 VRI	Current Vegetation Resources Inventory	BCGW	2013

Title	Description	Data Source	Vintage
TFL46 Resultant	Analysis resultant for TFL 46. Contains forest cover data.	MoFLNRO FAIB	1997
TRIM	Terrain elevation points		2002
Provincial site productivity layer	Site Indices for second growth stands, using approved PEM/TEM	MoFLNRO (via FTP)	2013

2.1. Road Data

Existing and proposed roads for the Arrowsmith TSA were provided by MoFLNRO in three separate datasets. The first, called Combined Roads, contained all currently existing roads. A second dataset, called Proposed Roads, included projected roads from the TSR3 Total Chance Plan. A third layer, Arrowsmith TSR3 Roads, consisted of both existing and proposed roads. It mostly overlapped with the other two datasets, but some roads were only in the Arrowsmith TSR3 Roads layer and were treated as proposed roads for the model.

The road data was updated after consultation with the licensees. Missing roads were added to the data and unrealistic proposed roads were removed.

2.1. Ownership

Much of the forest area within the boundaries of the Arrowsmith TSA is TFL or private land. A consolidated ownership dataset was provided by MoFLNRO, which was used as the source for the classification of Crown managed land. This dataset was updated by adding BCTS operating areas that had been omitted in the original layer.

2.2. TFL 46

Part of the Crown ownership area is the former TFL 46, which reverted back to the Crown. Most of the former TFL 46 area has no VRI data; instead the 1997 projected forest cover data from TSR 3 was used. The TFL 46 forest cover data was a non-standard dataset that only provided timber type, age and site index for each polygon. Timber type is similar to the inventory type group from the old FC1 data. The TFL 46 forest cover data was used only in those areas with no VRI coverage.

2.3. Age Updates

Although the VRI is updated for depletions annually, there are always some discrepancies between the VRI stand age and harvest dates. For this analysis, age in 2013 for forested areas was determined as follows:

- TFL 46, calculate age in 2013 = age in 1997 + 16
- VRI with no depletions, use VRI projected age
- Where VRI age is null and there is a harvest date, age 2013 = 2013 – harvest date – 2
- Where VRI age is not null and there is a harvest date, if VRI age is > harvest date + 10, update age 2013 as above
- Where VRI age is null and there is no harvest date, assume NSR. Age 2013 = -2

A 2 year regeneration delay after harvesting was assumed. Two sources of depletion information were used, the consolidated cutblocks layer, and the harvest date in the VRI. If these two datasets had a different date for the same depletion, the VRI harvest date was used.

3. Study Area

The study area for this project was all Crown managed forested lands within the Arrowsmith Timber Supply Area, on the southern part of Vancouver Island. The study area includes Lasqueti Island, which was recently added to the TSA. The total area of Crown land is 159,214 ha, of which 4,127 ha is within the TFL 46 takeback area. Figure 1 shows the Crown ownership areas within the TSA.

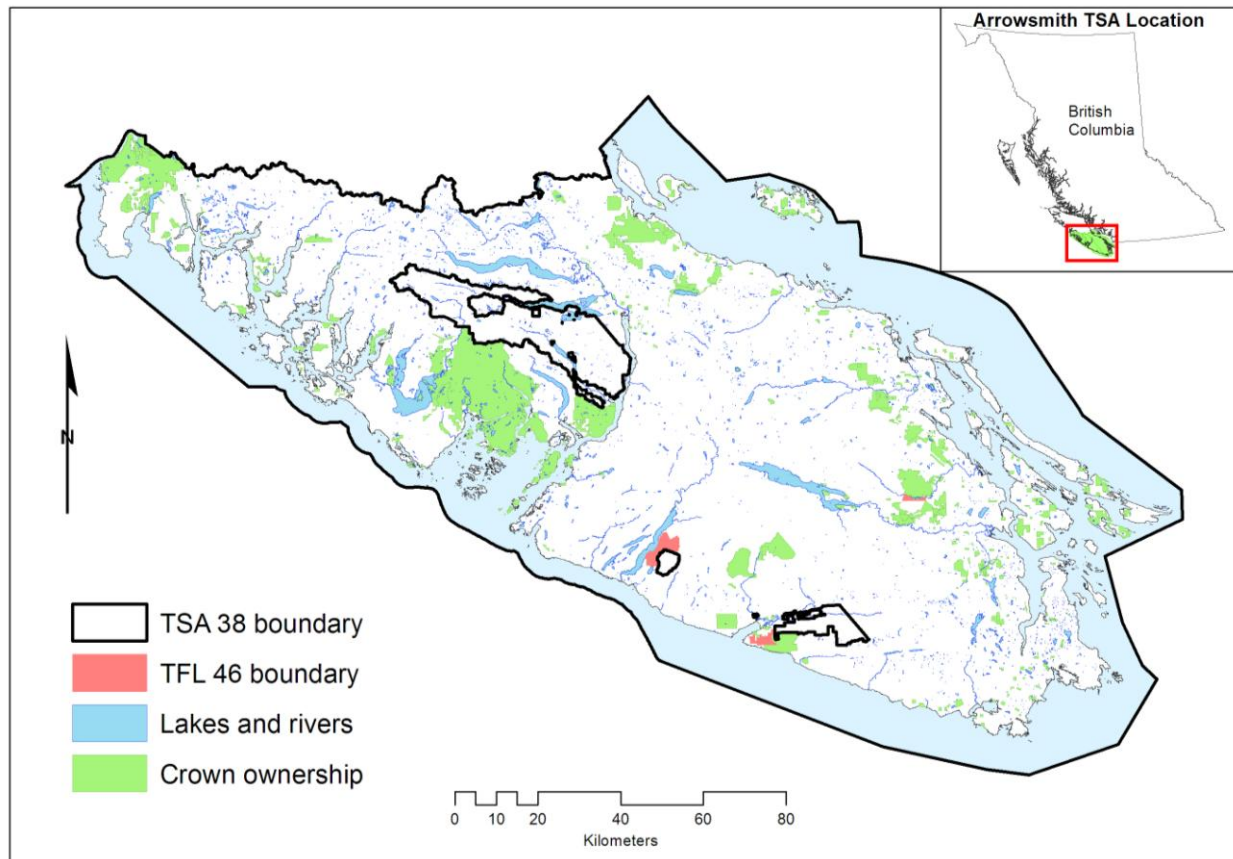


Figure 1: Arrowsmith TSA Study Area and Crown ownership

The TSA is divided into 3 zones: Clayoquot, East, and West. These zones are shown in Figure 2.

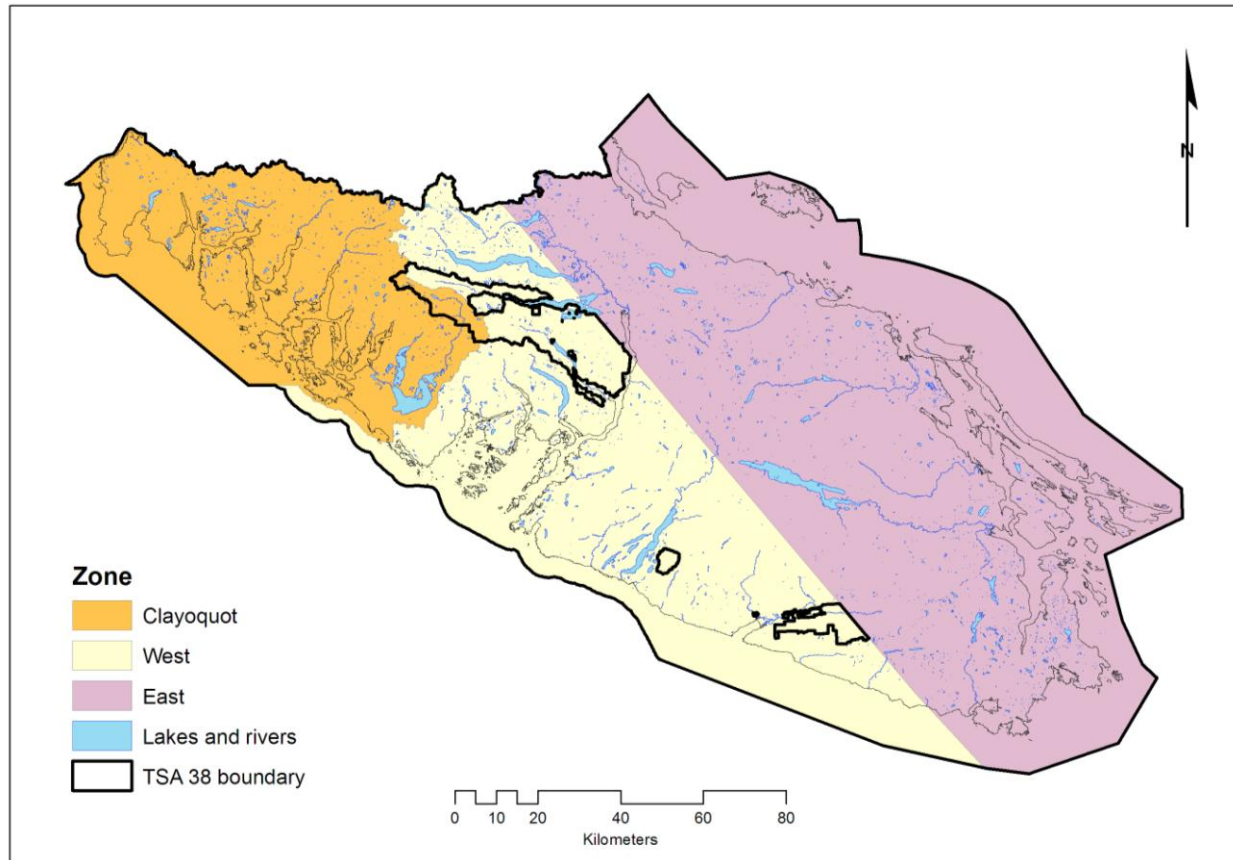


Figure 2: Arrowsmith TSA zones

There are 117,334 ha of forested land in the study area (Table 2). For the purposes of this analysis, forested land was defined as follows:

- In the TFL46 area: all stands with timber type are forested
- In the VRI area: Stand is vegetated (BCLCS level 1 = V) **and** at least one of the following:
 - Stand has been harvested (Opening_Ind = Y) **or**
 - VRI Site Index exists **or**
 - Tree species information is present

Table 2: Arrowsmith Crown Ownership Area

Zone	Forest Area (ha)	Non-Forest Area (ha)	Total Area (ha)
Clayoquot	30,172	7,032	37,204
East	31,609	22,027	53,636
West	55,553	12,821	68,374
Total	117,334	41,879	159,214

4. Methodology

The empirical approach chosen for this analysis used stand volume and species composition as surrogates for value. For each different slope and distance to road class, a minimum volume was determined that stands were required to meet to be classified as economic. Minimum economic volumes were determined separately for each of the three zones in the TSA: Clayoquot, West and East.

The economic operability model was calibrated with 2002 to 2012 harvest data and volumes from the 2002 VRI. A minimum harvest volume was determined for each zone, species group, distance to existing road class, and slope class.

The economic operability model was applied to the 2013 VRI, and TFL 46 forest cover to determine the area of the land base that was considered economic. The inventory stand volumes were projected, as described below, and those with a volume above the minimums determined in the model calibration were deemed to be economic.

4.1. Species groupings

Forest stands were grouped into analysis units in a two step process. First, similar inventory species were grouped together into species groups as described in Table 3. This was done for both the leading and secondary species in the 2002 and 2013 VRIs. In the second step, the simplified leading and secondary species groups were further grouped into analysis units (AU), as described in Table 4, Table 5, and Table 6.

The choice of how to group species together was dependent on amount of area in the inventories. Stand types with low areas were lumped with similar stand types to guarantee that there was enough harvest data to calibrate the model for each category.

Due to the lack of harvest data in Cottonwood and Willow leading stands during the last decade, they were considered uneconomic. Similarly, there was only 1 ha of harvest of an Alder leading stand in the Clayoquot zone, so the Alder stand type was considered to be uneconomic in this zone.

Table 3: Species Groupings

Species Group	Inventory Species
Not Economic	Act, At, Ep, Mv, Ra, W, Vb, X
Cedar (C)	Cw, Yc, Pl
Hemlock/Balsam (H/B)	Ba, Bg, Bl, Hw, Hm, Ss, Sx
Fir (F)	Fd
Alder (D)	Dr, Mb

Table 4 describes how species groups were aggregated into analysis units in the Clayoquot Zone. Cedar leading stands were grouped together into a single analysis unit. Hemlock and Balsam leading stands, without a cedar component, were grouped together. Due to the limited amount of Fir leading stands in the Clayoquot Zone, they were grouped with Hemlock leading stands. Hemlock leading stands with a cedar component formed a large enough group that they could be split into their own analysis unit. Alder leading stands were grouped together with other alder leading stands in the East and West zone; as noted above Alder was considered uneconomic in the Clayoquot zone.

Table 4: Analysis Unit groupings in the Clayoquot Zone

Leading Species Group	Second Species Group	AU Number	AU Name	VRI 2013 Area (ha)	Harvest Data Area (ha)
C	-	1	Cedar	222	0
C	C	1	Cedar	2,743	42
C	D	1	Cedar	42	0
C	F	1	Cedar	169	0
C	H/B	1	Cedar	13,118	1,119
F	-	2	Hemlock	20	0
F	C	2	Hemlock	311	2
F	D	2	Hemlock	29	0
F	H/B	2	Hemlock	651	26
H/B	-	2	Hemlock	494	0
H/B	D	2	Hemlock	333	8
H/B	F	2	Hemlock	711	17
H/B	H/B	2	Hemlock	3,875	339
H/B	C	3	Hemlock/Cedar	6,592	217
D	-	12	Alder	58	0
D	C	12	Alder	102	0
D	D	12	Alder	40	0
D	F	12	Alder	39	0
D	H/B	12	Alder	286	1

Species analysis units in the West zone (Table 5) were similar to the Clayoquot zone. All cedar leading stands were grouped together. There were enough hemlock leading stands with a fir component to separate them into their own analysis unit and combine the Fir leading stands with them. Hemlock stands with a cedar component also formed a large enough group to create an analysis unit. Alder leading stands were grouped together with other alder leading stands in the East and Clayoquot zones.

Table 5: Analysis Unit groupings in the West Zone

Leading Species Group	Second Species Group	AU Number	AU Name	VRI 2013 Area (ha)	Harvest Data Area (ha)
C	-	8	Cedar	258	2
C	C	8	Cedar	3,126	148
C	D	8	Cedar	50	0
C	F	8	Cedar	88	0
C	H/B	8	Cedar	19,239	2,032
F	-	9	Fir/Hemlock	135	47
F	C	9	Fir/Hemlock	196	19
F	D	9	Fir/Hemlock	50	0
F	H/B	9	Fir/Hemlock	2,681	248
H/B	F	9	Fir/Hemlock	1,771	115

Leading Species Group	Second Species Group	AU Number	AU Name	VRI 2013 Area (ha)	Harvest Data Area (ha)
H/B	-	10	Hemlock	326	6
H/B	D	10	Hemlock	236	4
H/B	H/B	10	Hemlock	9,198	566
H/B	C	11	Hemlock/Cedar	13,220	566
D	-	12	Alder	126	3
D	C	12	Alder	117	0
D	D	12	Alder	36	0
D	F	12	Alder	32	11
D	H/B	12	Alder	198	0

Table 6 shows the analysis unit groupings for the East zone. The high area of Fir in this zone allows for more Fir analysis units, while the low amount of Hemlock requires that it is lumped with other analysis units. Cedar leading stands were grouped together along with Fir leading stands that had a Cedar component. Pure Fir stands were grouped, as were Fir stands with a Deciduous component. Fir stands with a Hemlock component or Hemlock leading stands were also grouped. East zone Alder leading stands were grouped with Alder stands from the West and Clayoquot zones.

Table 6: Analysis Unit groupings in the East Zone

Leading Species Group	Second Species Group	AU Number	AU Name	VRI 2013 Area (ha)	Harvest Data Area (ha)
C	-	4	Fir/Cedar	41	0
C	C	4	Fir/Cedar	33	0
C	D	4	Fir/Cedar	67	0
C	F	4	Fir/Cedar	370	57
C	H/B	4	Fir/Cedar	197	13
F	C	4	Fir/Cedar	6,634	294
F	-	5	Fir	7,520	807
F	D	6	Fir/Decid	2,207	237
F	H/B	7	Fir/Hemlock	9,740	904
H/B	-	7	Fir/Hemlock	14	0
H/B	C	7	Fir/Hemlock	264	14
H/B	D	7	Fir/Hemlock	112	4
H/B	F	7	Fir/Hemlock	877	41
H/B	H/B	7	Fir/Hemlock	283	0
D	-	12	Alder	108	11
D	C	12	Alder	247	26
D	D	12	Alder	266	97
D	F	12	Alder	1,898	245
D	H/B	12	Alder	181	14

4.2. Slope and Road Distance

Two of the categories used to separate minimum harvest volumes were slopes and distance to roads or helicopter water drop areas.

A digital elevation model (DEM) raster was created at 50 m resolution, using TRIM elevation points. This elevation raster was used to generate a slope raster, which was used to classify the land base into four slope classes (Figure 3). The classes were:

- $\leq 40\%$
- 40-80%
- 80-120%
- $>120\%$

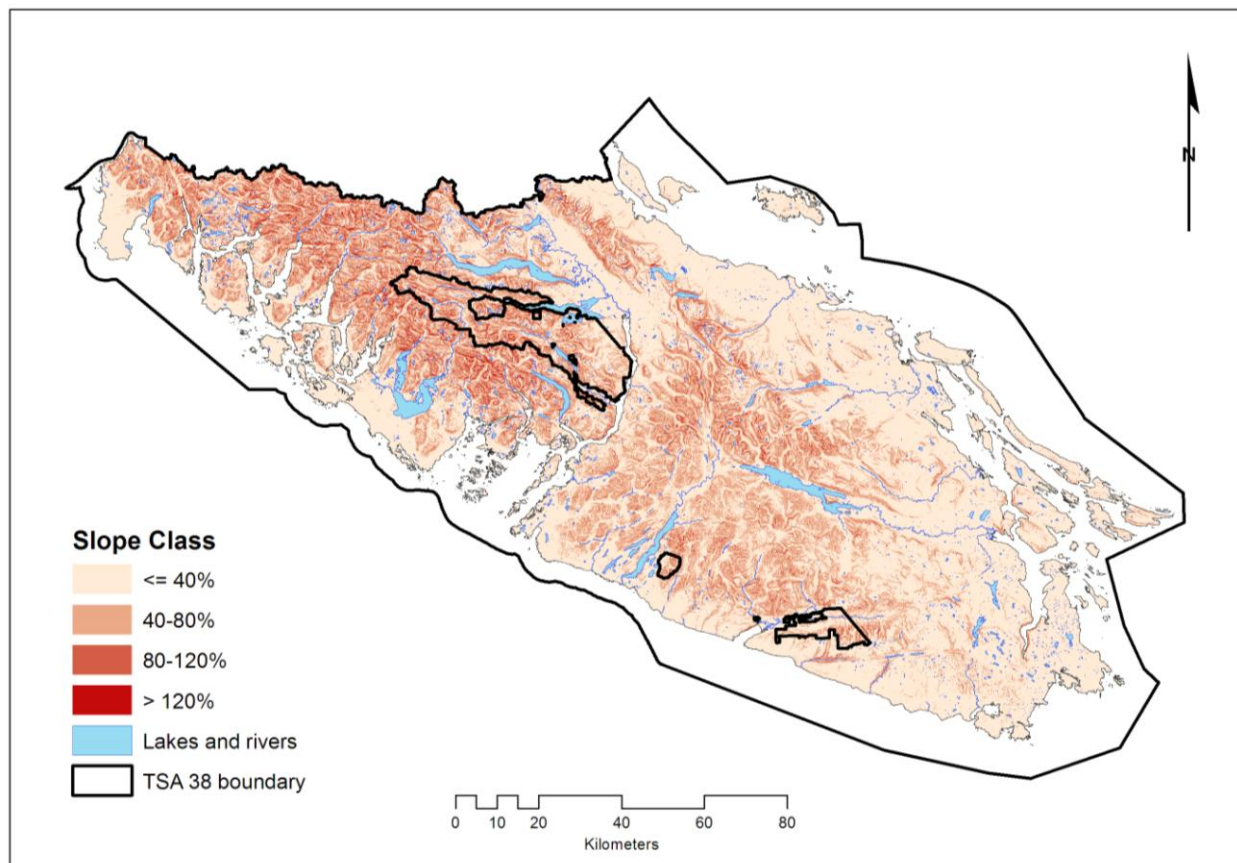


Figure 3: Slope class

Distance from roads, or helicopter water drop areas, was another category that minimum harvest volumes were expected to vary within. The distance to road classes were created by buffering all existing and proposed roads to create the following distance classes:

- 0-100 m (100m label)
- 101-200 m (200m label)
- 201-300 m (300m label)
- 301-500 m (500m label)
- 501-700 m (700m label)
- 700-1750m (1750m label)

The maximum distance timber would be hauled by a helicopter to a road was determined to be 1750 m. Any area beyond this distance was considered to be non-economic.

Some unroaded portions of the TSA were classified as helicopter water drop (Figure 4). Heli-water areas less than 300 m from the ocean were grouped into one 0-300 m distance class and the farther areas used the same distance classes as the roads. Figure 5 shows the distance to roads dataset.

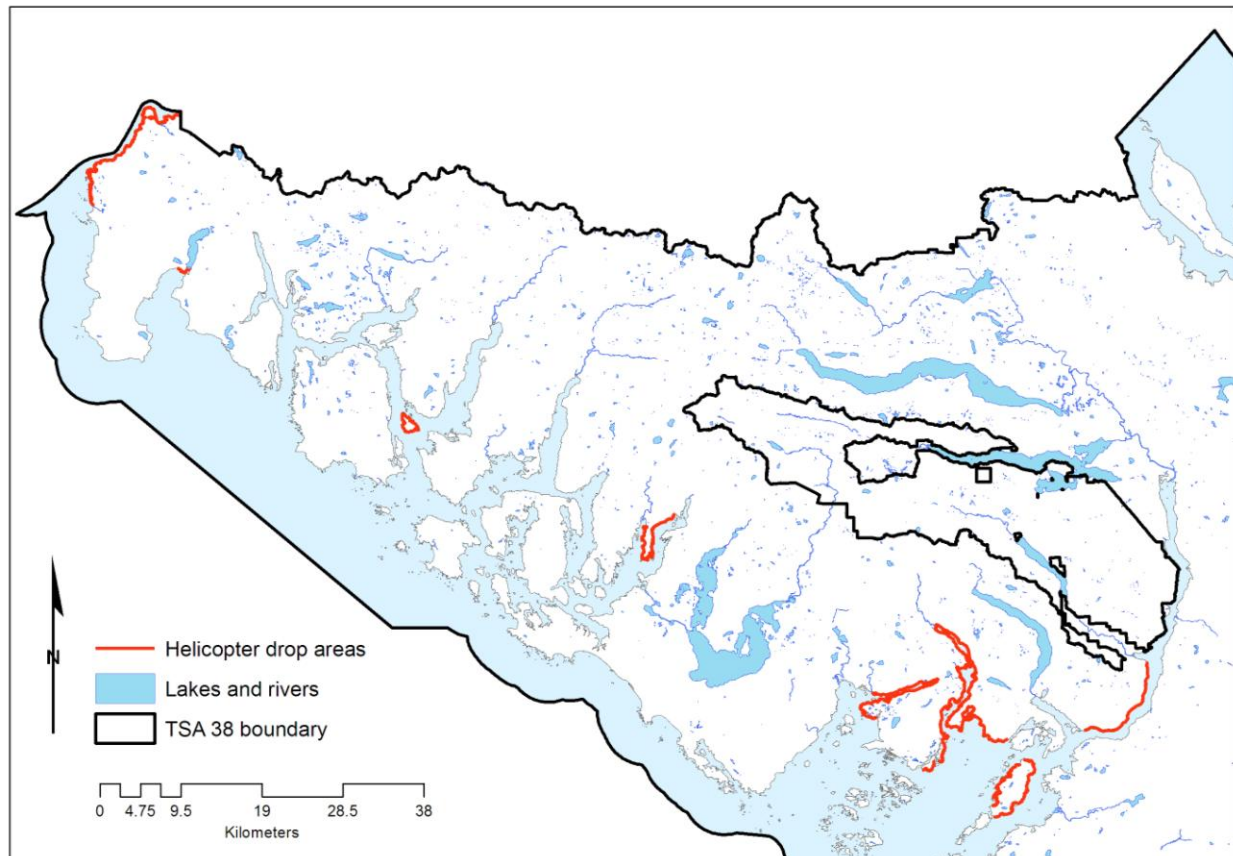


Figure 4: Heli-water access areas

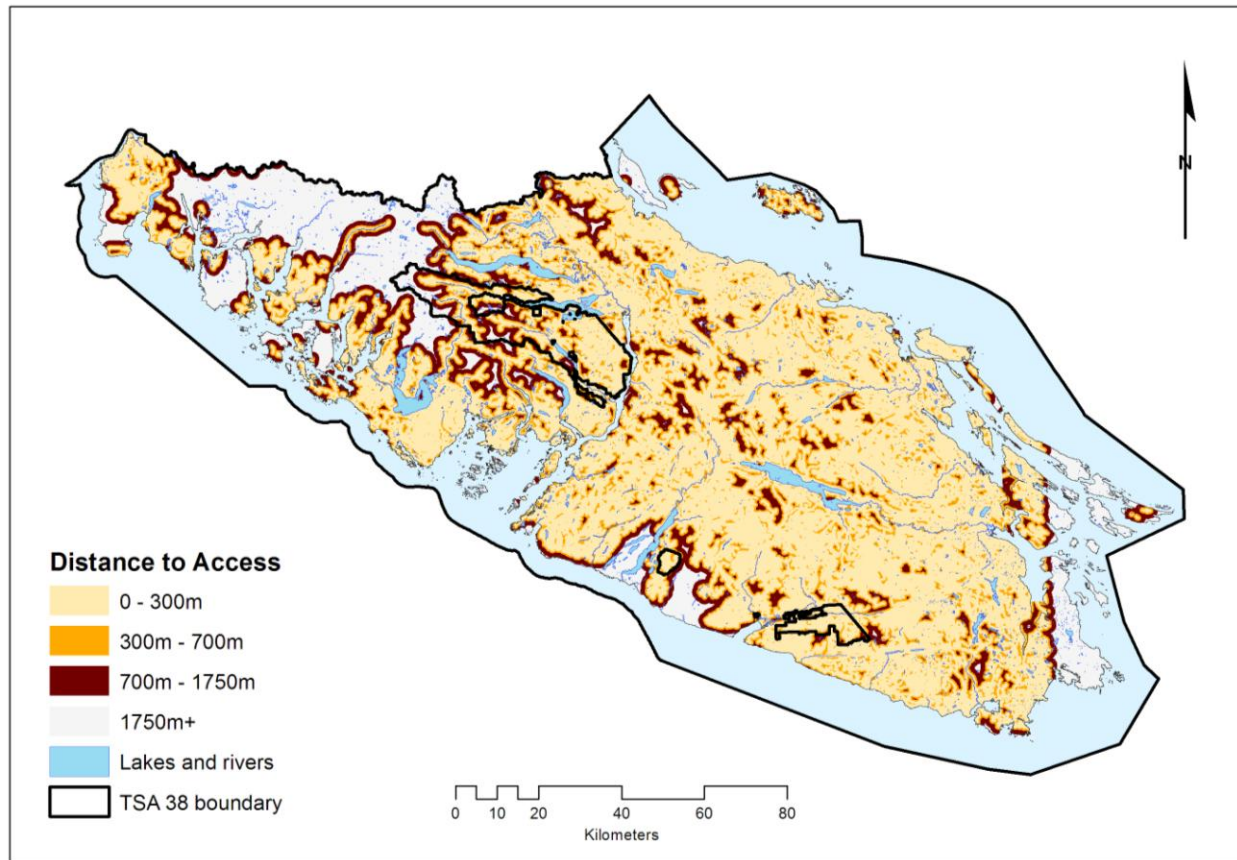


Figure 5: Distance to roads

4.3. Growth and Yield for Model Application

All the forested stands in the study area were classified into analysis units as per TSR 3. The analysis units were assigned based on the stand's leading species and inventory SI.

Inventory volumes in the 2013 VRI were projected forward using TIPSYP 4.3 for young managed stands (≤ 63 years) and VDYP 7 for older natural stands (> 63 years). The age cutoff between managed and natural stands matches the one used in the TSR 3 analysis.

Young 2013 VRI stands projected with TIPSYP 4.3 used TSR 3 regeneration assumptions and the provincial site productivity layer for site indices. The yield curve volume used to determine if the stand was economic was the volume at 95% of the maximum mean annual increment (MAI).

Older stands were projected using VDYP 7. The volume used to determine if the stand was economic was the maximum VDYP 7 volume. In cases of old stands, where the stand had passed its maximum yield volume and its volume was declining, the current VRI volume was used.

The TFL 46 inventory did not provide inputs needed to run VDYP 7. For the older stands in this area, TSR 3 natural stand yield curves were used to determine the maximum volume and were assigned based on the stand's TSR 3 analysis unit.

5. Model Calibration

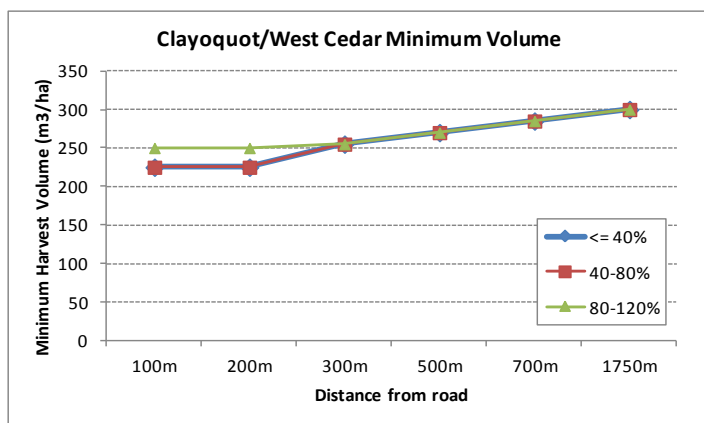
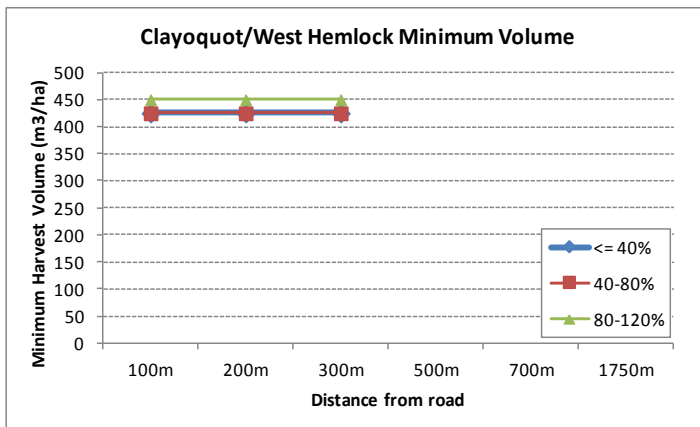
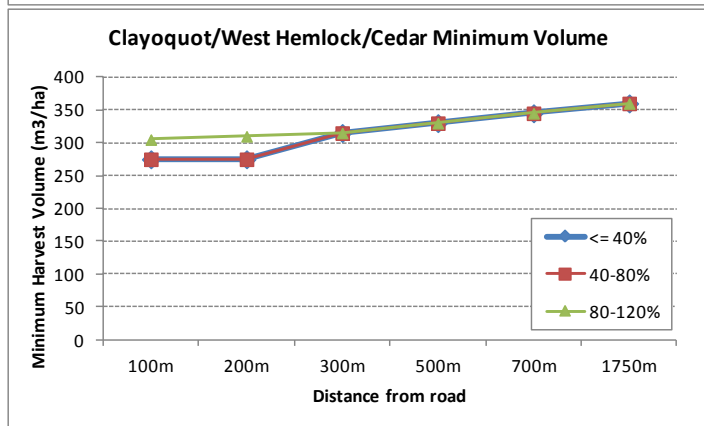
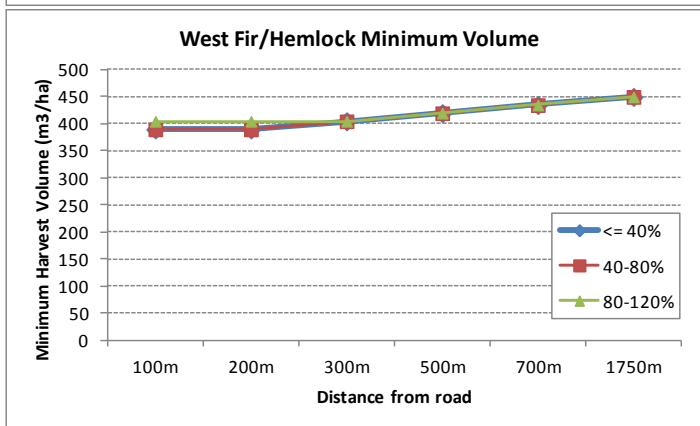
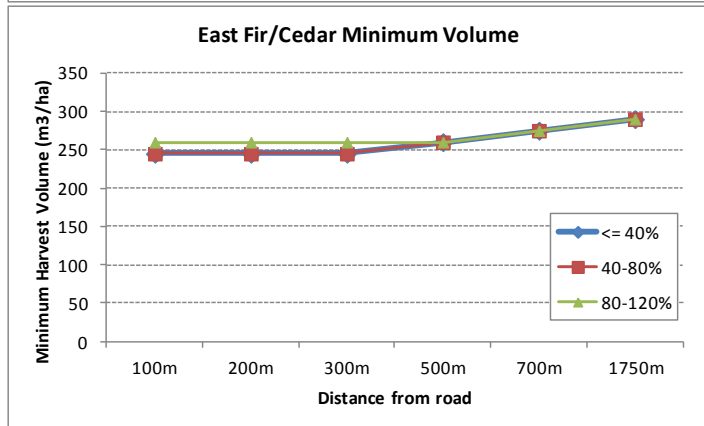
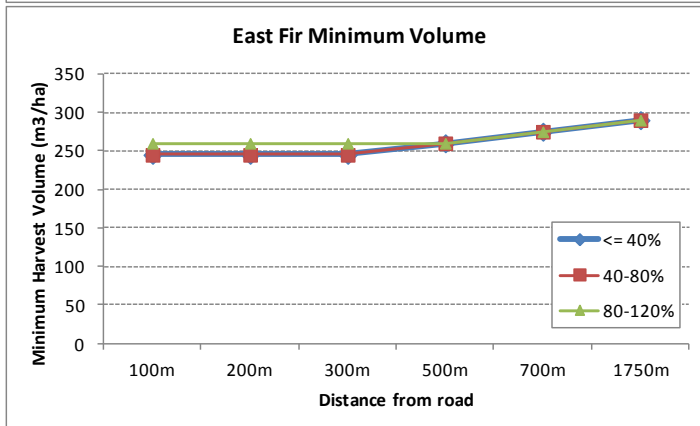
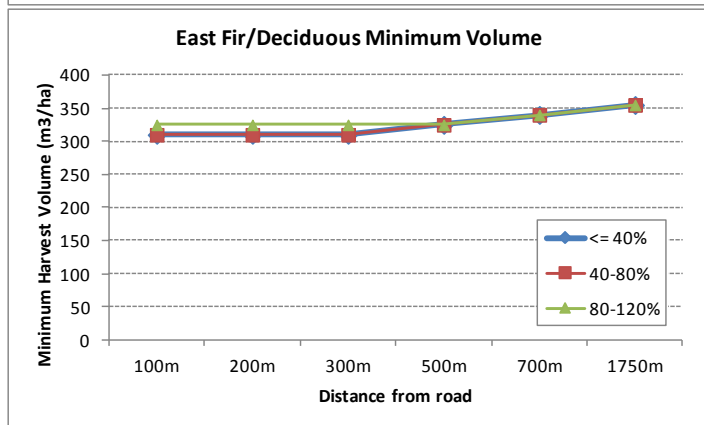
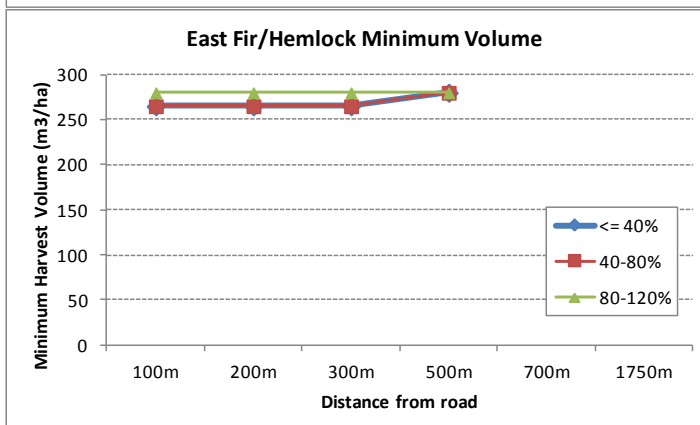
Model calibration guided the determination of the minimum economic harvest volumes for each analysis unit, slope class, and distance to existing road class within each zone. Areas harvested in the TSA between 2002 and 2012 that had a 2002 VRI provided the source data for the calibration (Table 7). There were 41,580 ha of 2002 to 2012 harvest data in the TSA boundary, but most of this harvest occurred on tree farm licenses (TFLs) or on private land. 8,310 ha of past 2002-2012 harvesting occurred on areas covered by the 2002 VRI and 8,301 ha of this area contained tree species information required for the model calibration.

Table 7: Harvest Area by zone and analysis unit

Zone	AU Name	Area (ha)	Area (%)
Clayoquot	Cedar	1,161	15%
	Hemlock	391	5%
	Hemlock/Cedar	217	3%
East	Fir/Cedar	364	5%
	Fir	807	10%
	Fir/Decid	237	3%
	Fir/Hemlock	963	12%
West	Cedar	2,182	28%
	Fir/Hemlock	430	5%
	Hemlock	576	7%
	Hemlock/Cedar	566	7%
All	Alder	410	5%
Total		8,301	

The 2002 VRI stand volumes, projected to the date of harvest, were summarized within each zone, analysis unit, existing distance and slope category. For each category, the area weighted 5th percentile (95th minimum percentile) volume was calculated. These are shown in Appendix 1. As expected there was a general trend of higher slope classes and higher distance classes having higher minimum harvest volumes, though this trend was not shown in all cases.

The raw plots of minimum harvest volume by species, analysis unit, slope class and distance class (Appendix 1) were reviewed by stakeholders. These plots, along with plots of the areas of harvest data and 2013 VRI in each category were used to determine the final minimum harvest volumes. Categories with less harvest data were given less weight. Licensee expertise was necessary to distinguish between cases where a stand type was not harvested due to rarity instead of it being uneconomic. After stakeholder consultation it was decided that the final minimum volume cutoffs in the West zone would also be applied to the Clayoquot zone. The final volume cutoffs for each class are shown in Figure 6 and Table 8.



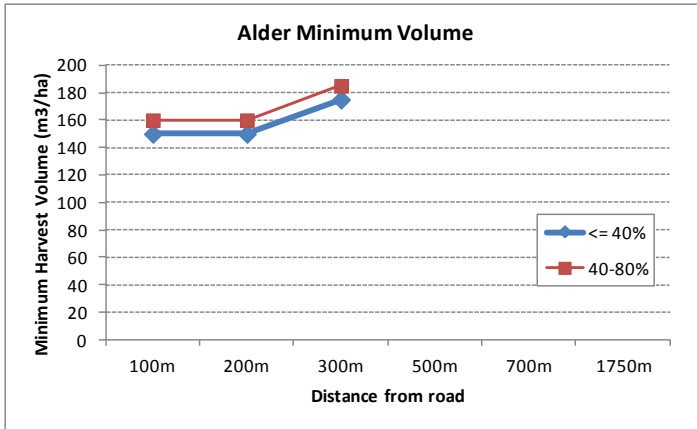


Figure 6: Minimum harvest volumes used in the model

Table 8: Final minimum harvest volumes

Zone	AU Name	Slope	Distance from Road					
			100m	200m	300m	500m	700m	1750m
All	Alder	<= 40%	150	150	175			
		40-80%	160	160	185			
		80-120%						
Clayoquot/ West	Cedar	<= 40%	225	225	255	270	285	300
		40-80%	225	225	255	270	285	300
		80-120%	250	250	255	270	285	300
	Hemlock	<= 40%	425	425	425			
		40-80%	425	425	425			
		80-120%	450	450	450			
	Hemlock/ Cedar	<= 40%	275	275	315	330	345	360
		40-80%	275	275	315	330	345	360
		80-120%	305	310	315	330	345	360
West	Fir/ Hemlock	<= 40%	390	390	405	420	435	450
		40-80%	390	390	405	420	435	450
		80-120%	405	405	405	420	435	450
East	Fir	<= 40%	245	245	245	260	275	290
		40-80%	245	245	245	260	275	290
		80-120%	260	260	260	260	275	290
	Fir/ Cedar	<= 40%	245	245	245	260	275	290
		40-80%	245	245	245	260	275	290
		80-120%	260	260	260	260	275	290
	Fir/ Deciduous	<= 40%	310	310	310	325	340	355
		40-80%	310	310	310	325	340	355
		80-120%	325	325	325	325	340	355

Zone	AU Name	Slope	Distance from Road					
			100m	200m	300m	500m	700m	1750m
	Fir/ Hemlock	<= 40%	265	265	265	280		
		40-80%	265	265	265	280		
		80-120%	280	280	280	280		

Some stand types were deemed to be uneconomic due to a lack of harvest history or expert opinion. The following types of stands were all not considered economic:

- Any Cottonwood or Willow leading stands
- Any Alder leading stand in the Clayoquot zone
- Alder > 300 m from a road or with a slope class > 80%
- Any stand with a slope class > 120%
- Any West or Clayoquot Hemlock stand > 300 m from a road
- Any East Fir/Hemlock stand > 500 m from a road

6. Model Application and Results

The minimum volumes determined in the model calibration were applied to the 2013 VRI to determine the economically operable areas in the Arrowsmith TSA. Any 2013 VRI stand with a projected volume greater than or equal to the minimum volume for its analysis unit, slope and distance to road class was considered to be economic.

The forested study area contained 1,538 ha lacking tree species information. For these areas the species analysis unit was assigned based on the BEC zone and subzone. Most of these areas (90 percent) were under 20 years old and were past cut blocks (96 percent).

The distance to roads class included both existing and projected roads and heli-water access areas. The final distance used for model application was the minimum of the three distance sources. For heli-water access areas that were located between 0 and 300 m from the ocean (0-300 m class), the minimum volumes for the 200-300 m road distance were used to account for higher harvest costs.

Small islands with no roads present were classified as uneconomic. In some cases these islands were covered by less than 1750 m road buffers from the mainland roads or heli-water areas.

After the initial review of the economic classification with stakeholders, some areas that are only partially economic were identified based on local knowledge. Three netdown areas are shown in Figure 7. The Effingham Inlet area was deemed 25% operable, the Vernon Bay peninsula area was deemed 50% operable and the Alberni Inlet area was deemed 60% operable. In addition, any West or Clayoquot Hemlock/Cedar stands more than 300 m from a road were considered 50% operable.

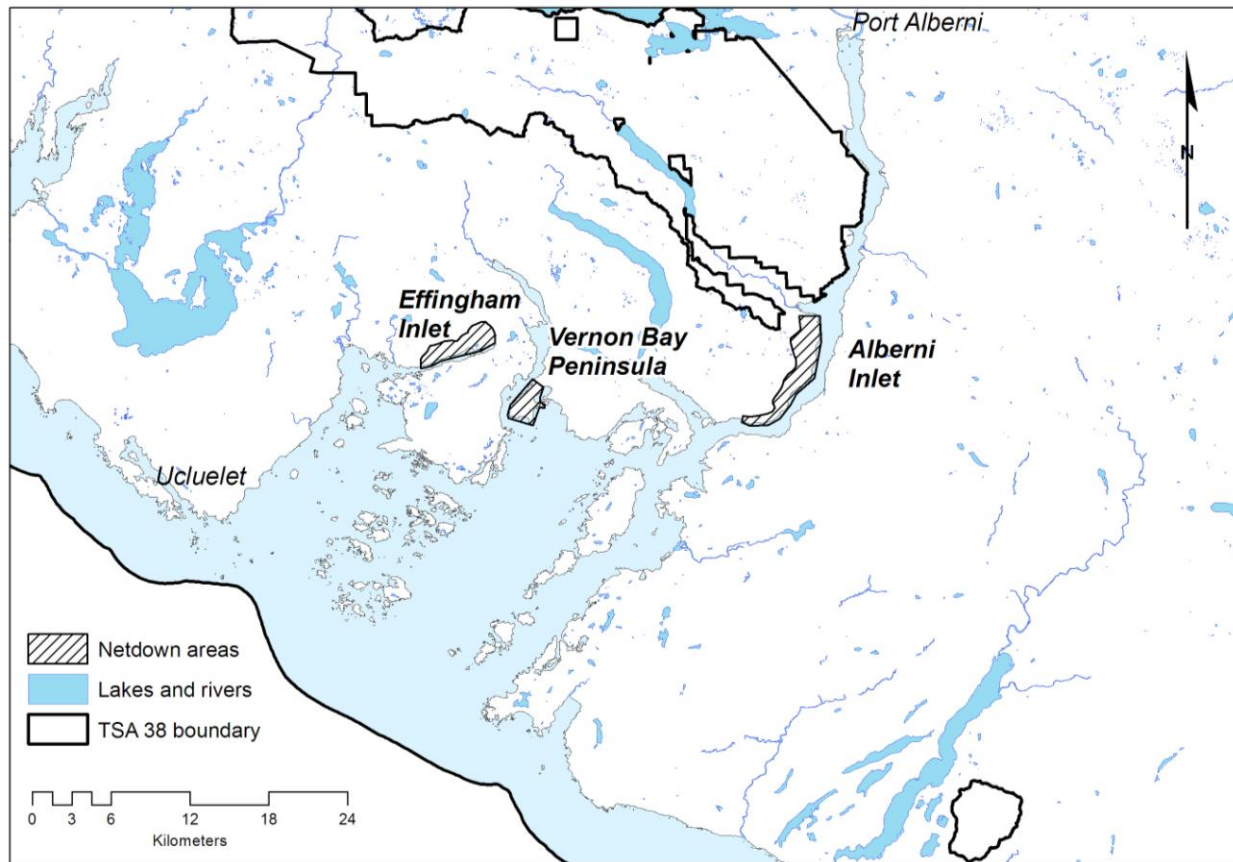


Figure 7: Aspatial Netdown Areas

The area of the forested Crown managed land base in the Arrowsmith TSA classified as economic was 86,909 ha (74% of the forested area). The economic area is broken down by zone and species analysis unit in Table 9. A map of the economic classification is shown in Figure 8.

There were three different economic classifications for each forested stand: economic, partially economic and not economic. Partially economic areas were economic stands that were located within one of the netdown areas or were a Hemlock/Cedar analysis unit more than 300 m from a road. Table 9 breaks the partially economic areas into their economic and non-economic areas. The sum of the economic areas and the economic portion of the partially economic areas forms the total economic area.

Table 9: Arrowsmith TSA Economic Area

Zone	AU Name	Economic Area (ha)	Not Economic Area (ha)	Partially Economic Area (ha)		Total Economic Area (ha)	Total Not Economic Area (ha)
				Economic	Not Economic		
Clayoquot	Cedar	11,700	4,911	0	0	11,700	4,911
	Hemlock	4,190	2,241	0	0	4,190	2,241
	Hemlock/Cedar	3,464	1,981	573	573	4,037	2,555
East	Fir/Cedar	7,070	360	0	0	7,070	360
	Fir	7,471	401	0	0	7,471	401
	Fir/Decid	2,175	32	0	0	2,175	32
	Fir/Hemlock	11,145	210	0	0	11,145	210
West	Cedar	17,156	6,983	292	507	17,449	7,490
	Fir/Hemlock	4,830	274	415	277	5,245	550
	Hemlock	6,276	4,255	54	44	6,330	4,299
	Hemlock/Cedar	5,941	5,234	1,232	1,256	7,174	6,490
All	Alder	2,906	841	18	12	2,924	853
	Cottonwood	0	32	0	0	0	32
Total		84,324	27,755	2,585	2,670	86,909	30,425

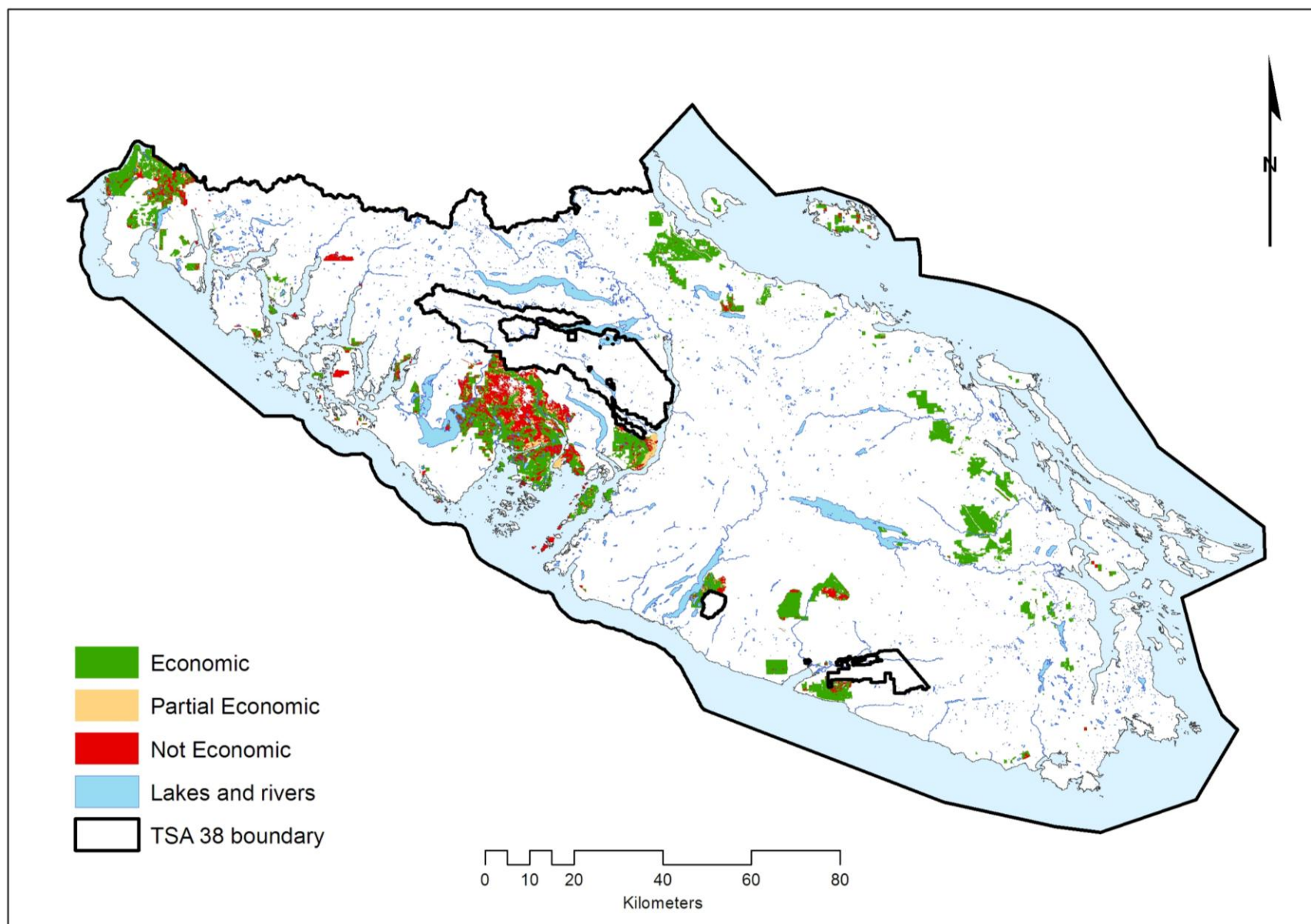
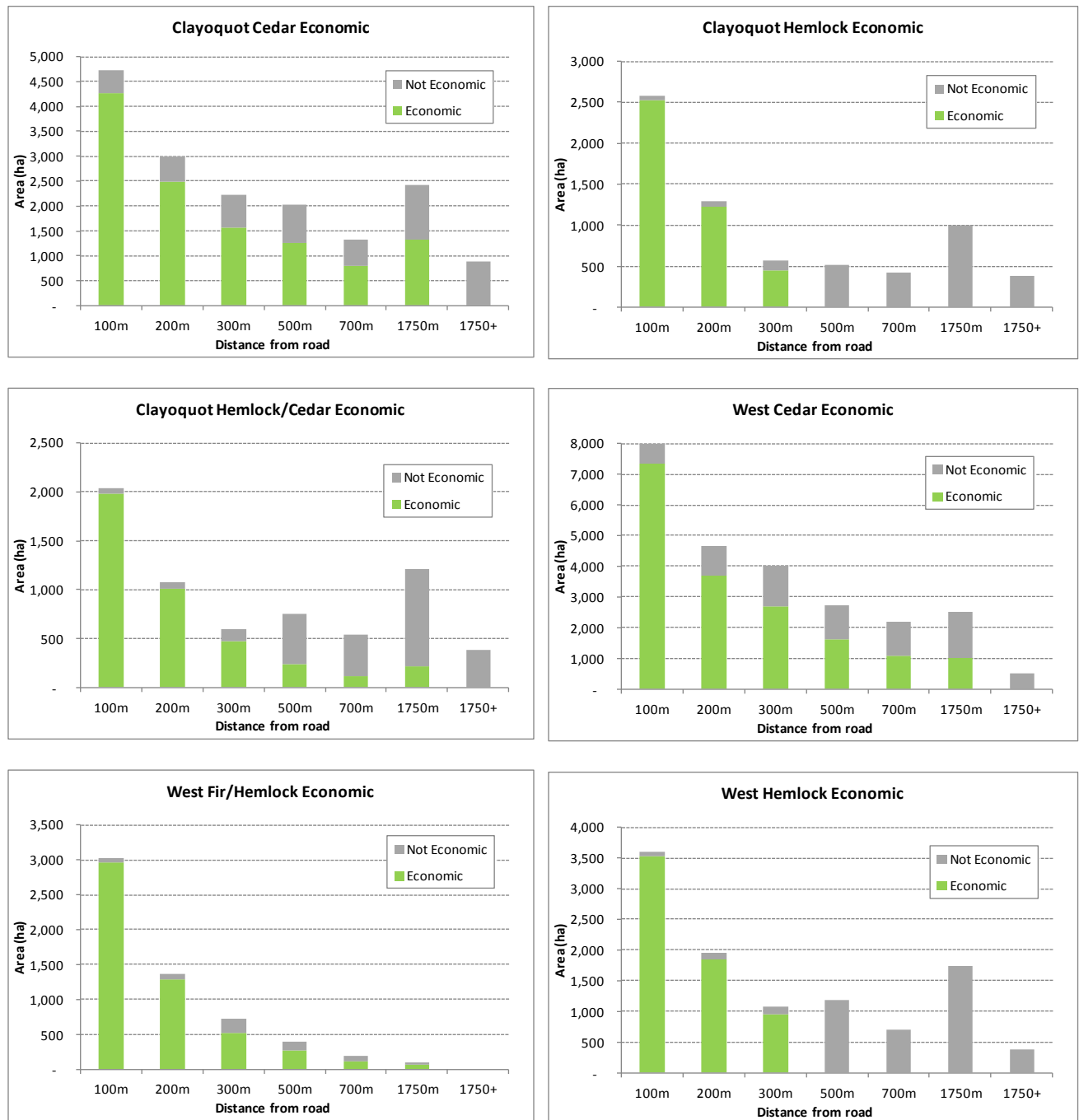


Figure 8: Economic Operability Classification for the Crown managed forest area of the Arrowsmith TSA

The economic area for each analysis unit is broken down by distance class in Figure 9. Hemlock and Alder analysis units do not have any economic area beyond 300 m from a road, as these areas were considered to be too far to be economical. This is also seen in the East Fir/Hemlock analysis unit beyond 500 m from a road, though there very little area over 500 m from a road.



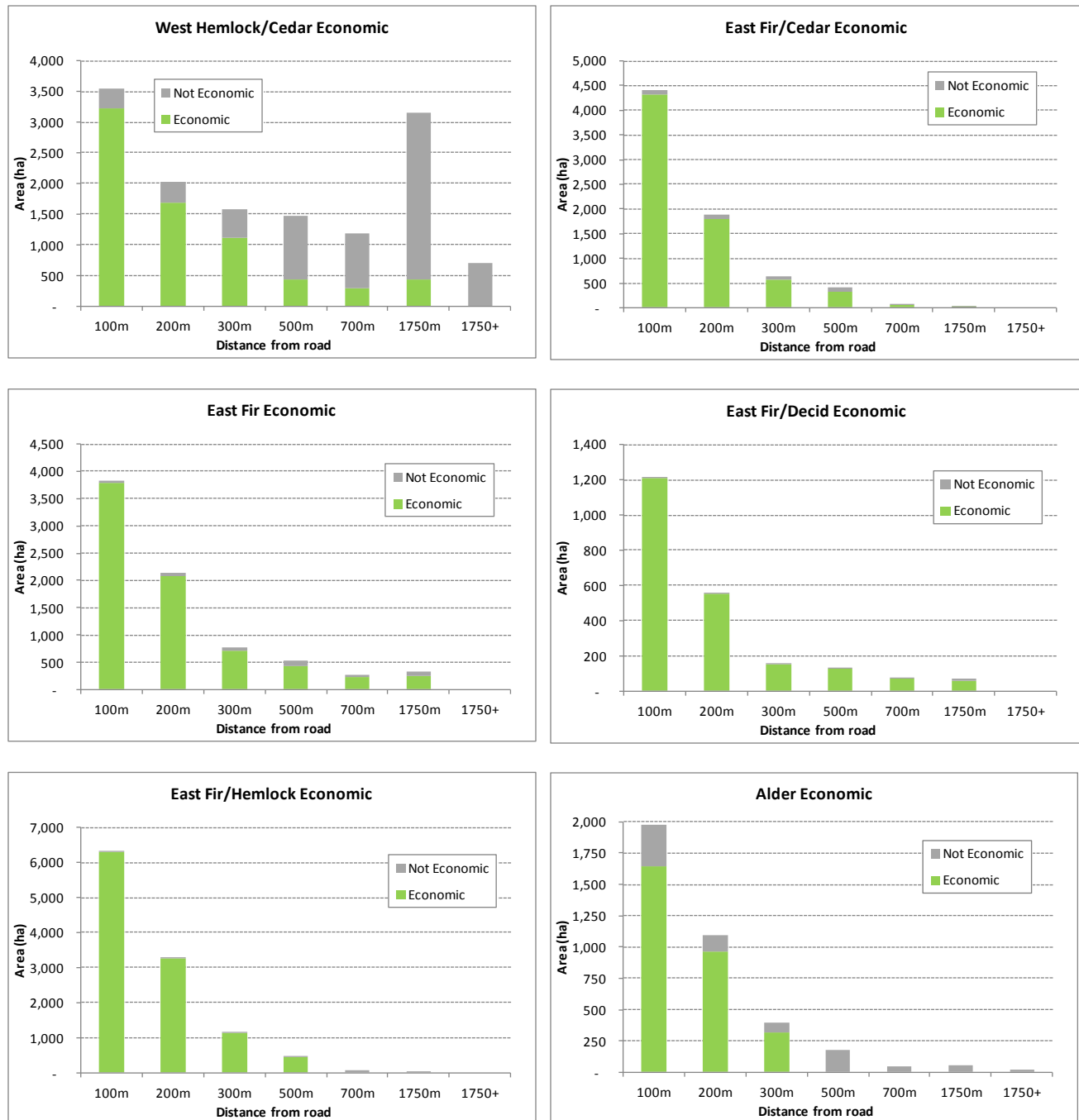
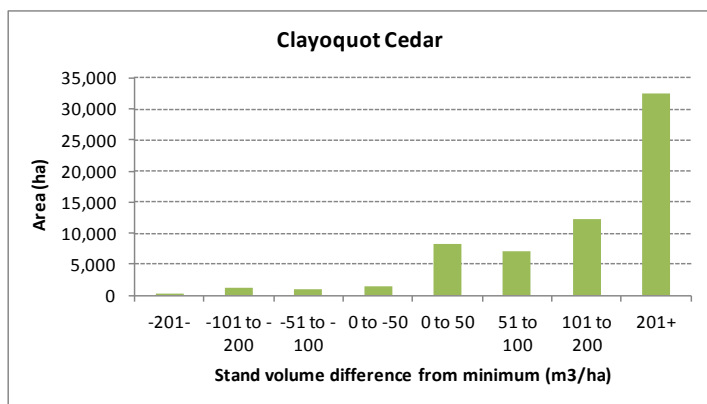
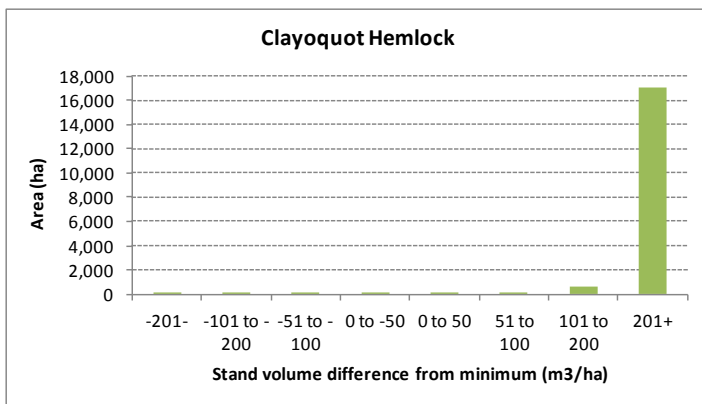
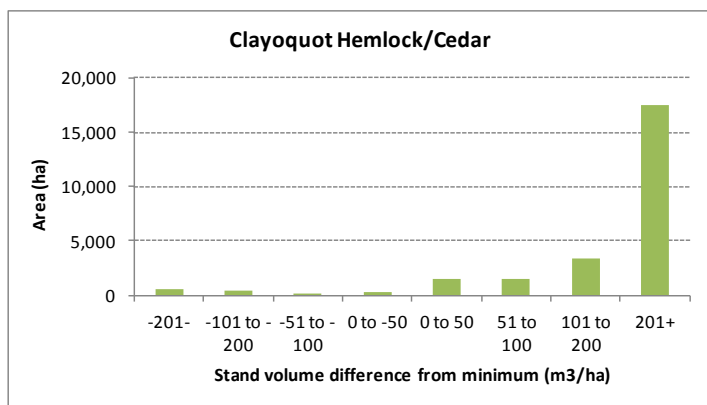
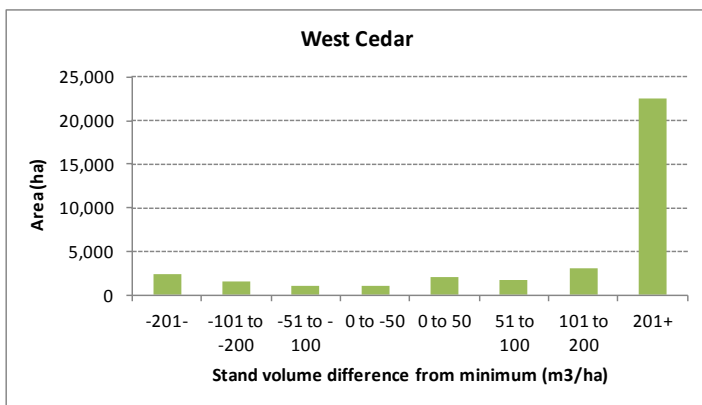
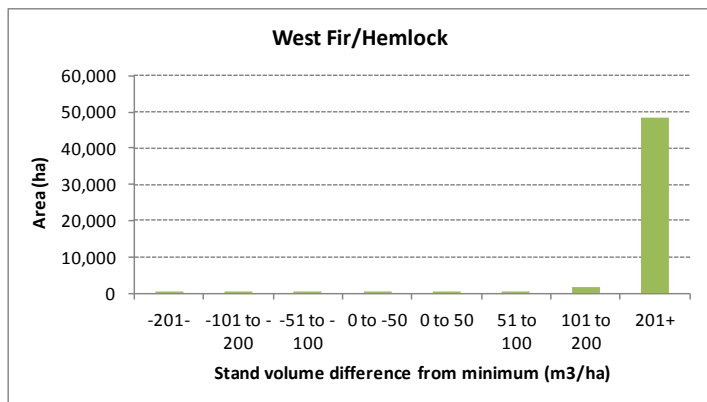
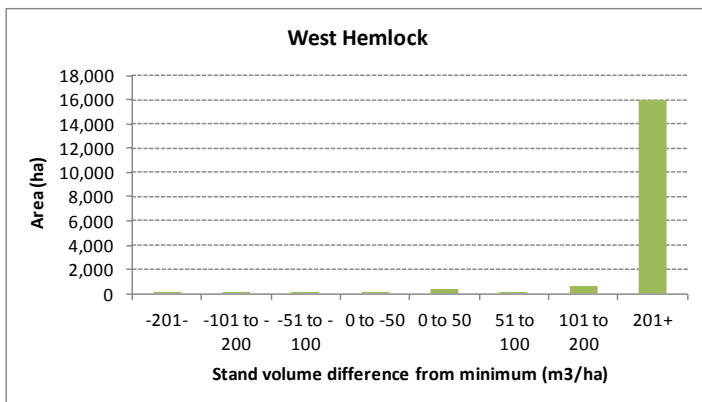


Figure 9: Economic area by distance class for each zone and analysis unit

The area of economic and non-economic stands is grouped into classes based on the difference between the stand volume and minimum economic volume in Figure 10. Areas with a positive difference are economic, while those with a negative difference were classified as not economic. Stands that were not economic due to their slope, distance from road, species, or being on an island were not included. In all but a few cases, the majority of the area within each analysis unit was over 200 m³/ha above the minimum volumes. This is further explored in a sensitivity analysis below.



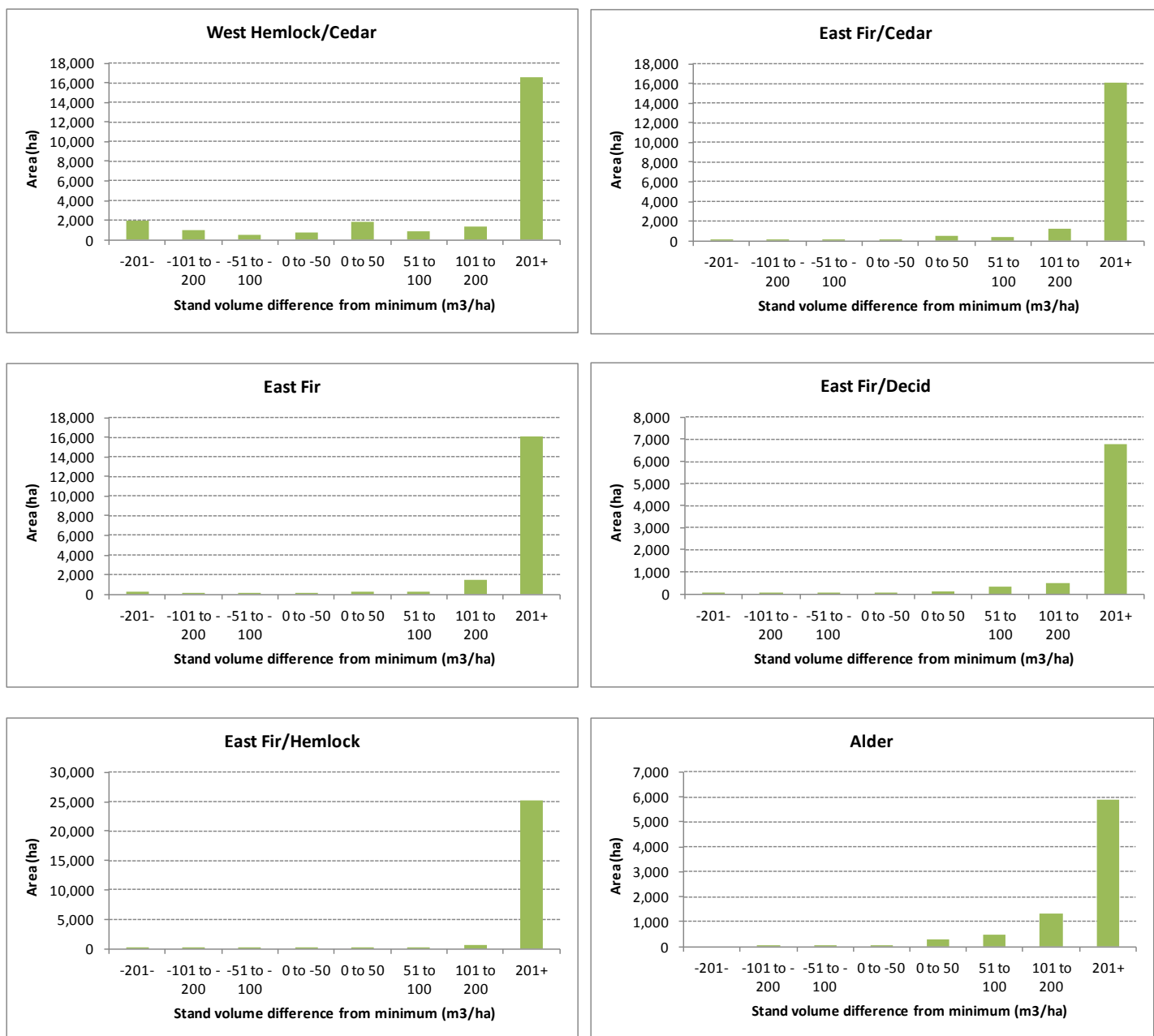


Figure 10: Difference between stand volume and minimum volume for economic and non-economic stands

6.1. Assessment of Non-Economic Areas

The reasons that 27,755 ha were classified as not economic are broken down in Table 10. The majority of the area classified as not economic was due to not meeting the minimum volume requirements for their analysis unit. The second highest reason for a stand being classified as not economic was that they were beyond the maximum distance from a road of 1750 m (or 300 m for Alder or 500 m for East Fir/Hemlock). Only six percent of the not economic stands were located on steep slopes > 120% (or >80 % for Alder). A small amount of the non-economic areas had leading species of Cottonwood or Alder (in the Clayoquot zone) or were located on small un-roaded islands.

Table 10: Reasons for not economic classification

Not Economic Description	Zone Area (ha)			Total Area (ha)	Total Percent Area
	Clayoquot	East	West		
Slope	540	24	992	1,555	6%
Distance	3,197	317	5,014	8,528	31%
Species	513	20		533	2%
Small Islands	80	6	230	316	1%
Volume	5,342	928	10,553	16,823	61%
Total	9,672	1,294	16,789	27,755	
Total Percent	35%	5%	60%		

6.2. Sensitivity Analysis

A sensitivity analysis of the projected stand volumes used for the economic classification was performed by increasing and decreasing the volumes by 10 percent. As shown in Table 11, when the projected volumes were increased by 10 percent, the economic area increased by 1,799 ha. A 10 percent decrease in the stand volumes resulted in a 2,313 ha decrease to the economic land base.

Table 11: Sensitivity of stand volumes

Zone	AU Name	Change in Economic Area (ha)	
		Increase Stand Volume 10%	Decrease Stand Volume 10%
Clayoquot	Cedar	766	-915
	Hemlock	49	-35
	Hemlock/Cedar	113	-118
East	Fir/Cedar	22	-120
	Fir	41	-13
	Fir/Decid	13	-11
	Fir/Hemlock	15	-21
West	Cedar	446	-625
	Fir/Hemlock	28	-34
	Hemlock	50	-120
	Hemlock/Cedar	245	-253
All	Alder	12	-47
	Cottonwood	0	0
Total		1,799	-2,313

6.3. Assessment of Previously Harvested Areas

An examination of the areas that have any past harvest history within Crown managed land base (based on the 2013 consolidated cut blocks data) shows that the majority of past harvest areas were classified by the empirical model as economic or partially economic (Table 12).

Table 12: Area of past harvest activity (1912-2012)

Economic	Zone Area (ha)			Total Area (ha)	Total Percent Area
	Clayoquot	East	West		
Not Forested	255	574	1,068	1,897	4%
Not Economic	463	114	440	1,017	2%
Partial Economic	158	0	865	1,023	2%
Economic	8,632	14,530	15,118	38,280	91%
Total Area	9,507	15,218	17,491	42,217	
Total Percent	23%	36%	41%		

6.3.1. Not Economic

Only 2 percent of the past harvest areas were classified as not economic and the reasons for this classification are explored in Table 13. Over half of the past harvest areas classified as not economic were too far from an access road to be considered economic. A third of them have regenerated to non-economic species; most of this area was Alder leading stands in the Clayoquot zone. Only a very small amount of past harvest areas were located on steep slopes. The small area not meeting minimum volume targets indicates that the minimum volumes used were not too high.

Table 13: Area of past harvest activity classified as not economic

Not Economic Description	Zone Area (ha)			Total Area (ha)	Total Percent Area
	Clayoquot	East	West		
Slope	15	2	21	38	4%
Distance	128	68	406	602	59%
Species	315	13	0	328	32%
Small Islands	0	1	4	5	0%
Volume	4	30	9	44	4%
Total Area	463	114	440	1,017	
Total Percent	46%	11%	43%		

6.3.2. Not Forested

The previously harvested areas classified as not forested require attention. 1,703 ha of the 1,897 ha area are classified as forest management land base (FMLB) in the VRI. These areas are mostly described as non-vegetated openings in the VRI with a few of them listed as vegetated non-treed. The area of FMLB that lacks an economic classification indicates that the forest definition used was not inclusive enough.

In the Crown managed portion of the Arrowsmith TSA there are 1,711 ha of forest management land base with no economic classification. Since almost all of this area has a harvest history, adding an exception for past logged areas to the TSR 4 land base classification would ensure that these areas remain part of the land base. Without this exception, these non-vegetated openings may be unreasonably removed from the timber harvesting land base.

7. References

Timberline Natural Resource Group, 2007, Arrowsmith Timber Supply Area TSR3 Data Package, prepared for: Arrowsmith TSA Licencee Group.

Appendix: Model Calibration Data

The following figures show the 5th percentile minimum harvest volume for each analysis unit by distance and slope classes. The figures on the right present the area of harvest data that contributed to each minimum volume summary. These minimum volumes formed the basis for the final minimum economic volumes used to classify the land base as economic.

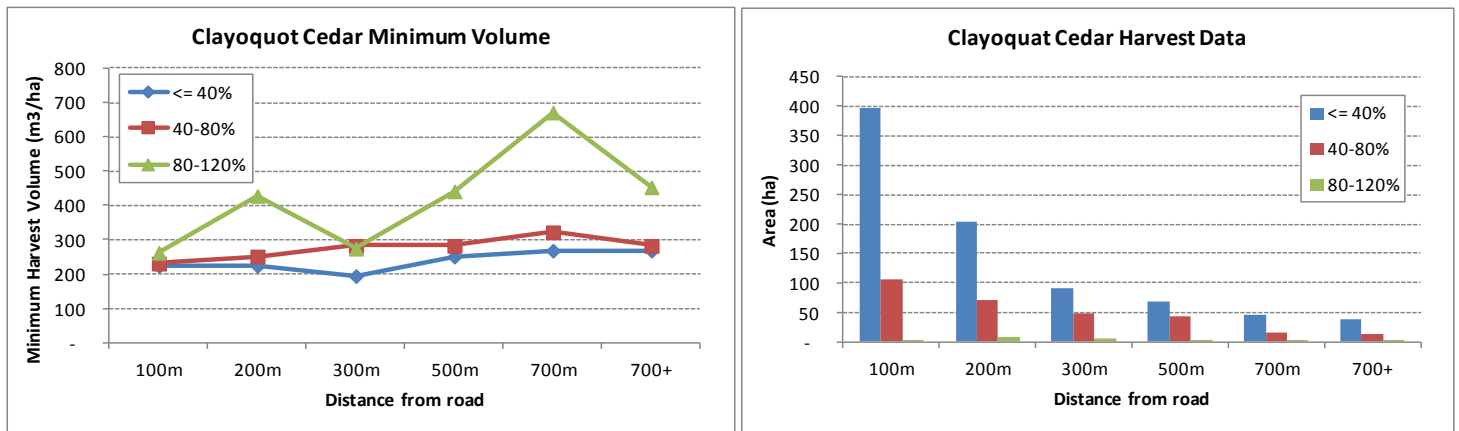


Figure 11: Minimum harvest volume (5th percentile) and area of harvest data for the Clayoquot Cedar analysis unit, by slope class

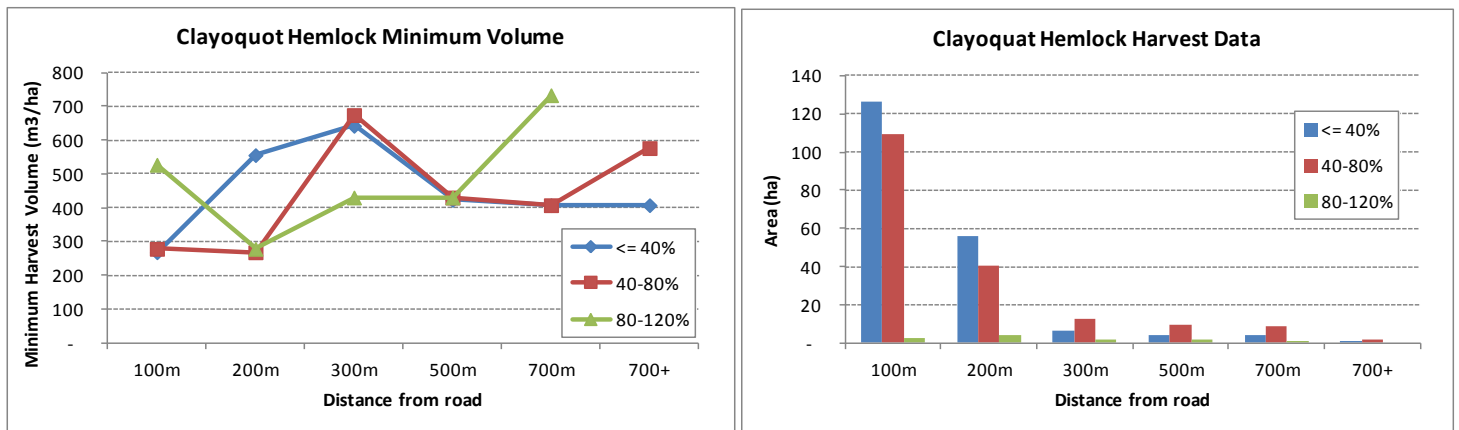


Figure 12: Minimum harvest volume (5th percentile) and area of harvest data for the Clayoquot Hemlock analysis unit, by slope class

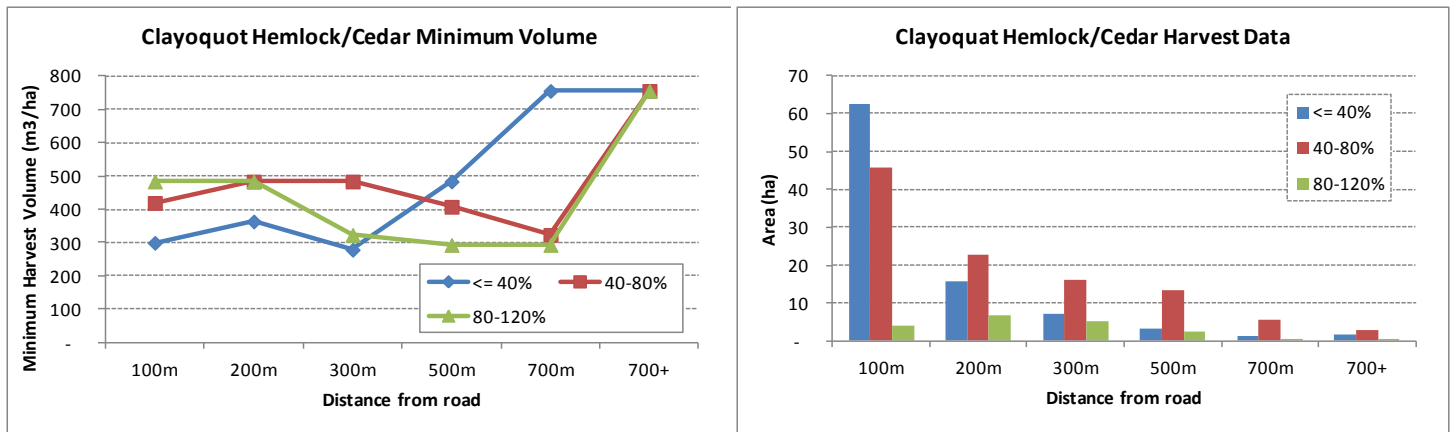


Figure 13: Minimum harvest volume (5th percentile) and area of harvest data for the Clayoquot Hemlock/Cedar analysis unit, by slope class

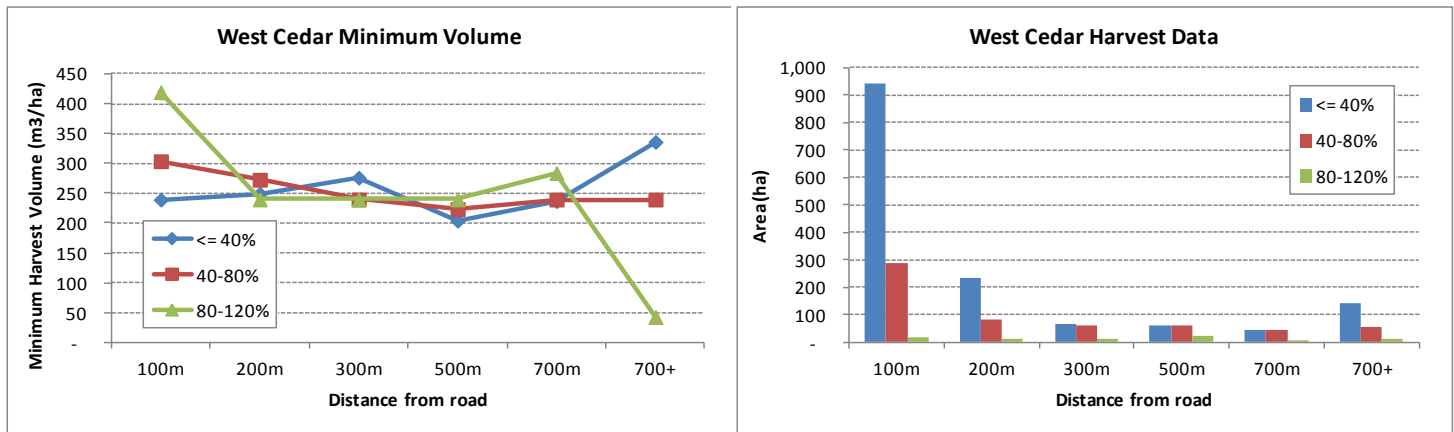


Figure 14: Minimum harvest volume (5th percentile) and area of harvest data for the West Cedar analysis unit, by slope class

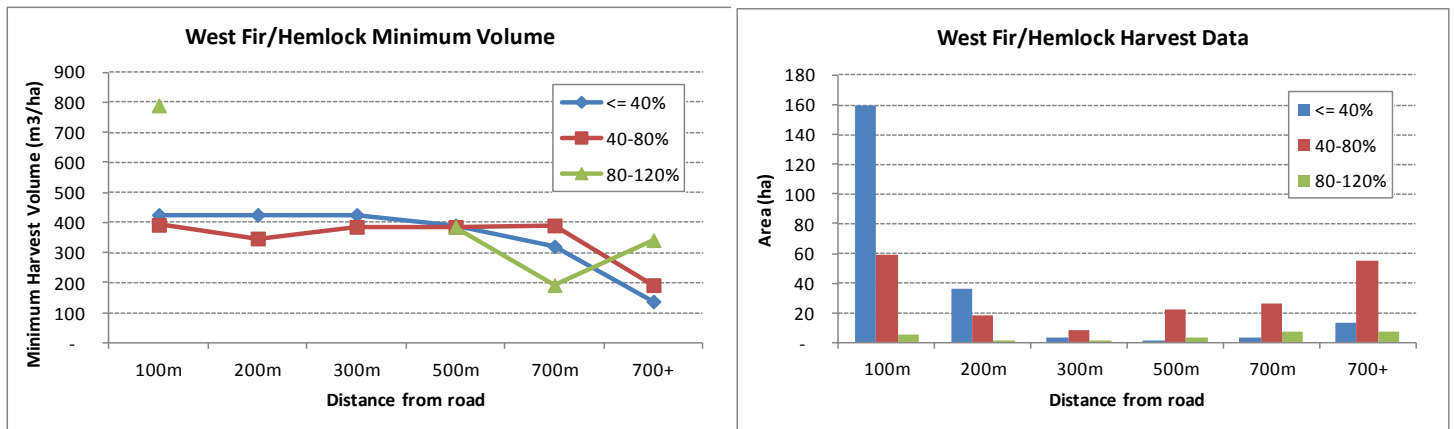


Figure 15: Minimum harvest volume (5th percentile) and area of harvest data for the West Fir/Hemlock analysis unit, by slope class

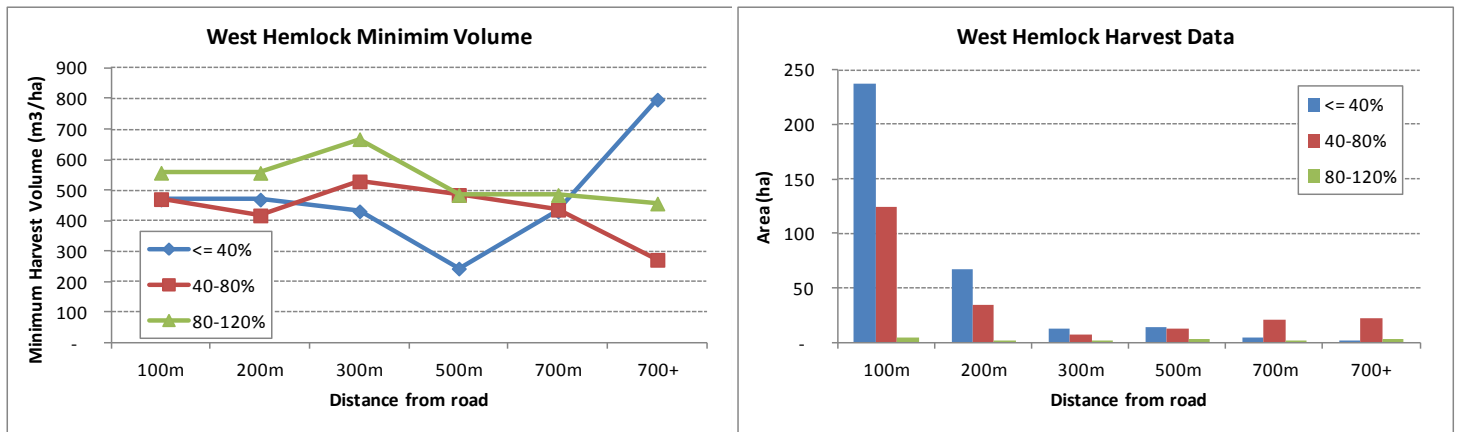


Figure 16: Minimum harvest volume (5th percentile) and area of harvest data for the West Hemlock analysis unit, by slope class

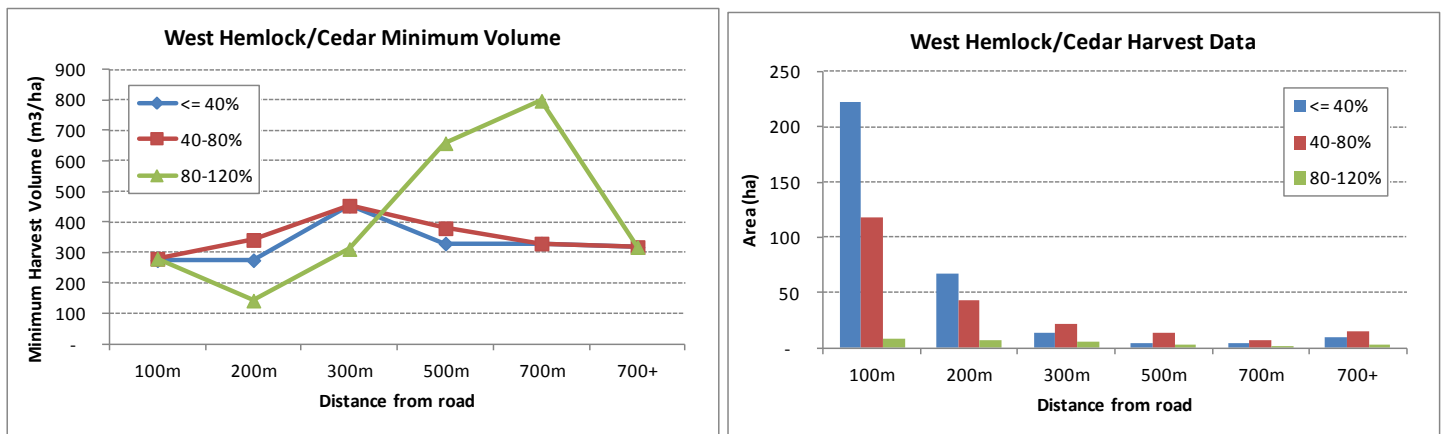


Figure 17: Minimum harvest volume (5th percentile) and area of harvest data for the West Hemlock/Cedar analysis unit, by slope class

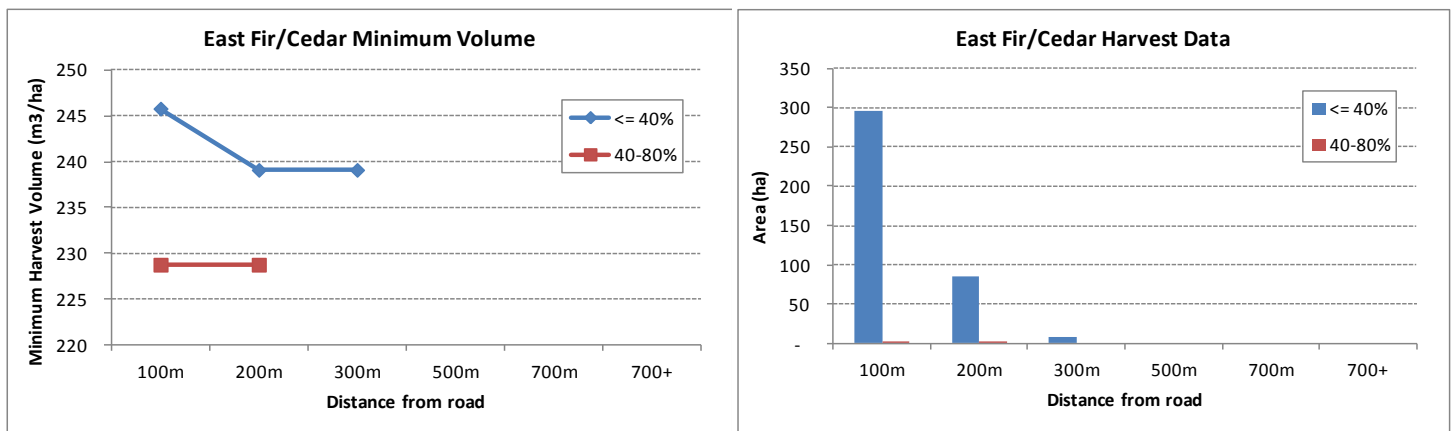


Figure 18: Minimum harvest volume (5th percentile) and area of harvest data for the East Fir/Cedar analysis unit, by slope class

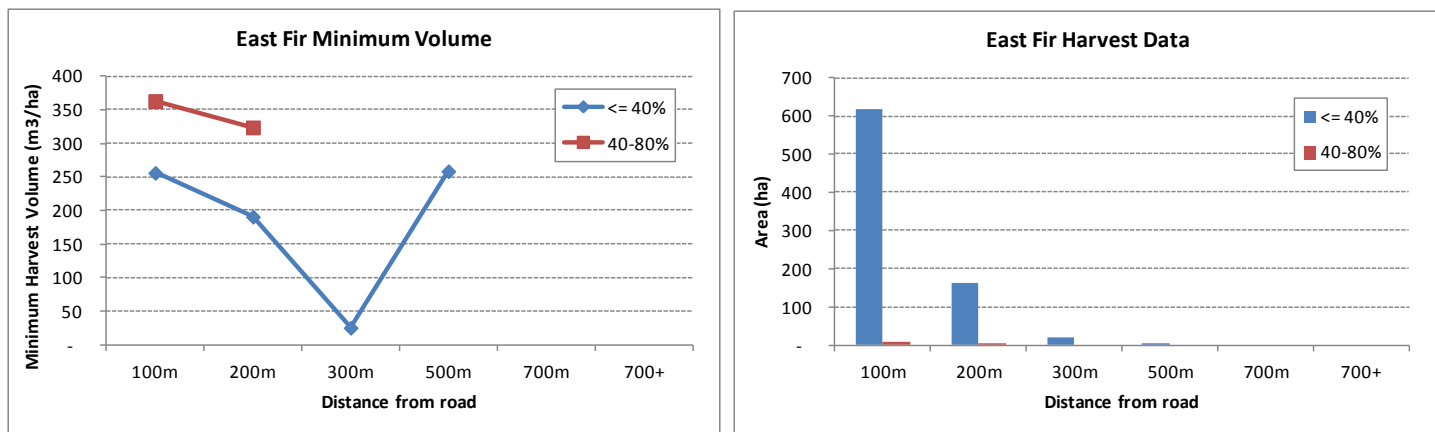


Figure 19: Minimum harvest volume (5th percentile) and area of harvest data for the East Fir analysis unit, by slope class

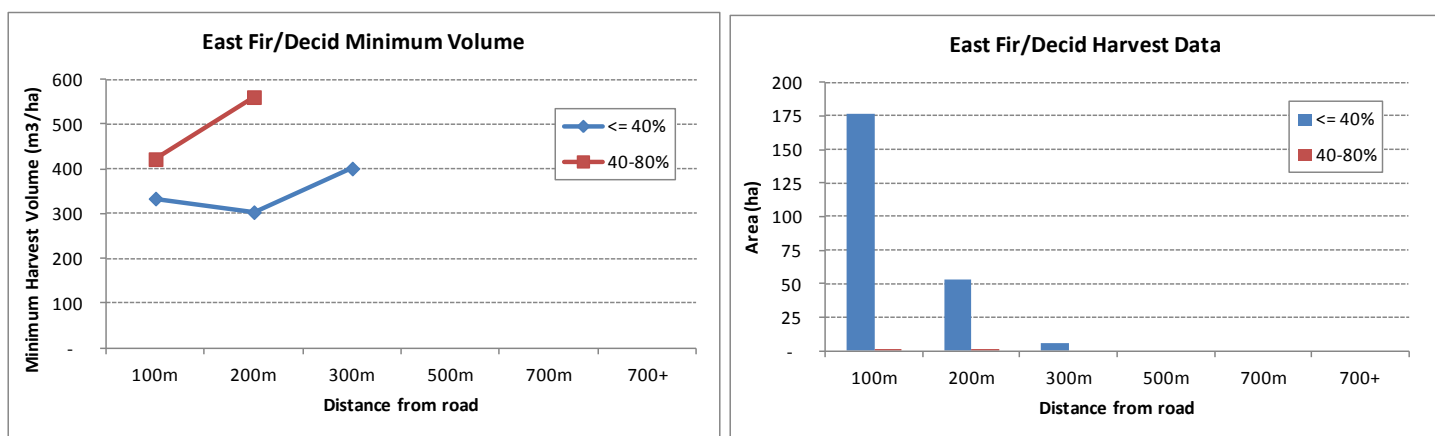


Figure 20: Minimum harvest volume (5th percentile) and area of harvest data for the East Fir/Decid analysis unit, by slope class

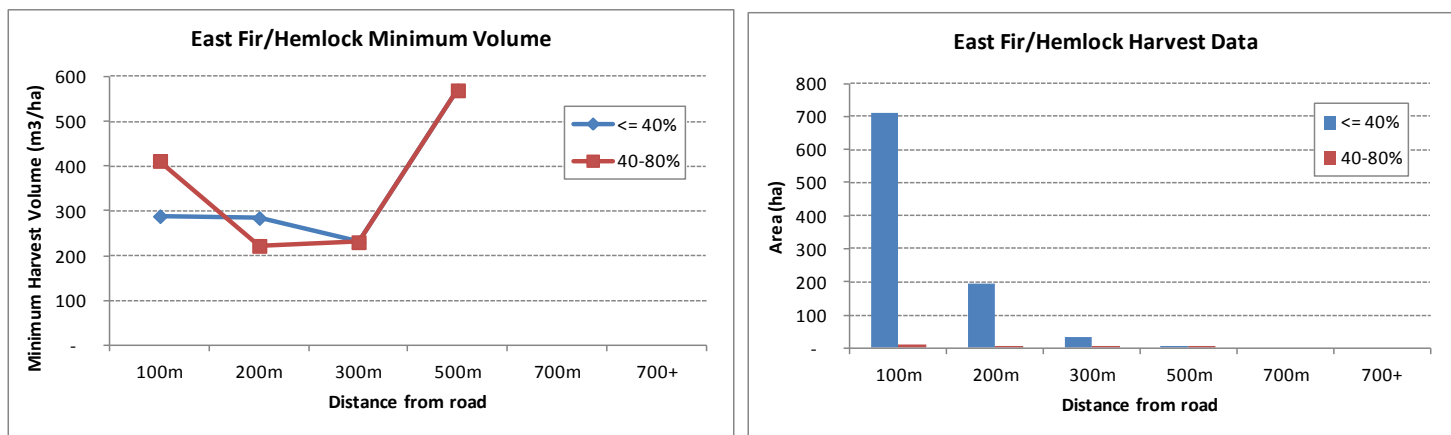


Figure 21: Minimum harvest volume (5th percentile) and area of harvest data for the East Fir/Hemlock analysis unit, by slope class

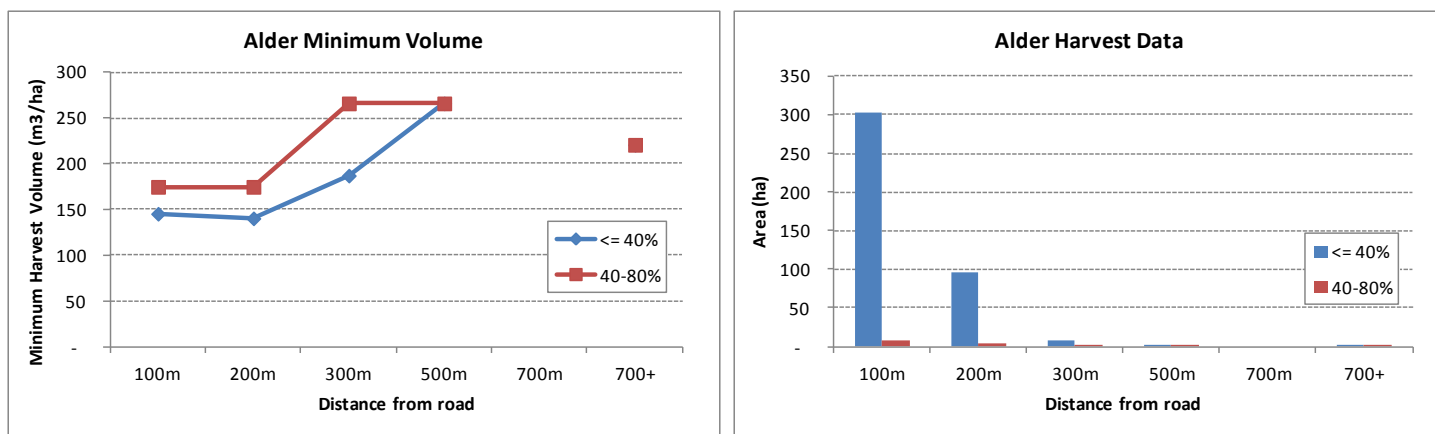


Figure 22: Minimum harvest volume (5th percentile) and area of harvest data for the Alder analysis unit, by slope class