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CASCADIA TIMBER SUPPLY AREA BIOMASS AVAILABILITY ESTIMATION

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Unrestricted

ABSTRACT:

The biomass yield per hectare predicted for the Cascadia TSA is 29.6 oven-dried tonnes per hectare (odt/ha) from harvest residues. Over the next 20 years a total of 866,000 odt of available biomass could be generated by harvest in the Cascadia TSA, or approximately 43,000 odt/yr. Of this, 11%, approximately 95,000 odt in total, or 4,800 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. Delivery of biomass from the most expensive (distant) block is projected at $110/odt and the average delivered price for all biomass is $77.06/odt. Delivery location were the mill sites at Kitimat, Terrace, Dunkley, Quesnel, Revelstoke, Naksup.

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CONTRACT REPORT

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EXECUTIVE SUMMARY

Forest origin, harvest residue, biomass estimates were made by FPInnovations for the Cascadia Timber Supply Area (TSA), largely following the process previously established for several BC TSAs using FPInterface (2010-2020). The biomass inventory was based on 20-year harvest and road network plans for Crown land provided by the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) and excludes Tree Farm Licenses, Community Forest Agreements, and First Nations tenures. Delivery location were the mill sites at Kitimat, Terrace, Dunkley, Quesnel, Revelstoke, Naksup.

The biomass yield per hectare predicted for the Cascadia TSA is 29.6 oven-dried tonnes per hectare (odt/ha) from harvest residues. (Table 4 from the text, follows.)

Biomass Yield
29.6 odt/ha

The biomass ratio, which is the ratio of recoverable biomass to recoverable merchantable roundwood, is estimated at 15.2%. Over the next 20 years a total of 866,000 odt of available biomass could be generated by harvest in the Cascadia TSA, or approximately 43,000 odt/yr. Of this, 11%, approximately 95,000 odt in total, or 4,800 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. Delivery of biomass from the most expensive (distant) block is projected at $110/odt and the average delivered price for all biomass is $77.06/odt. (Table 5 from the text, follows.)

Biomass Available (odt)	
up to $60/odt	total ($172/odt)
95,185	865,869
per year	per year
4,759	43,293

Because the TSA is so scattered geographically, whether or not biomass is economically available (> $60/odt) is highly dependent on the local logistics and time to the desired delivery point. Nearly eight times as much biomass is available at $90/odt than is available at the perceived economic rate of $60/odt. This is nearly all the biomass in the TSA, 84% of the total. This means that if demand for biomass is high, much more can become available if purchasers are willing to pay more.

The biomass yield per hectare remained relatively constant through the four time periods and averaged 29.6 odt/ha. The amount of biomass available in period 1 is about a third less than the other three periods. This means that there is less harvest planned during this period. Because the recoverable amount per hectare is not significantly lower than in other periods, it means that less hectares of harvest are planned in period 1 compared to other periods.

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1. INTRODUCTION

Forest origin, harvest residue, biomass estimates were made by FPInnovations for the Cascadia Timber Supply Area (TSA), largely following the process previously established for previous BC TSAs using FPInterface (2010-20). The biomass inventory was based on 20-year harvest and road network plans for Crown land provided by the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) and excludes Tree Farm Licenses (TFLs), Community Forest Agreements (CFAs), and First Nations tenures. Detailed introductory statements applying to this project and the greater project as a whole may be found in the report "Estimating Quesnel Biomass Supply Using FPInterface®." It is hoped that the information in this report will assist in understanding biomass availability for industrial proposals**.**

2. OBJECTIVE

The objective of the project was to calculate the cost of forest-origin biomass as a feedstock in the Cascadia TSA.

Specific deliverables include:

a. An analysis showing the delivered cost of biomass from point of origin; and
b. An analysis showing the amount of biomass delivered at different price points. A value of $60 for one oven-dried tonne (odt) is regarded as the market value for biomass, in accordance with the previous analyses.

3. METHODS

3.1 Overall Process

The basic methodology for determining biomass supply in western Canada was established during analysis of the Quesnel and Williams Lake Timber Supply Areas (TSAs). It is reviewed below.

The analysis focused on the Cascadia TSA and was based on polygon data (tree characteristics) and a road data set supplied by the Ministry. It did not include any nearby woodlots, CFA's, or any First Nations tenures. Including some of these areas could alter the available supply of biomass.

Additionally, stands with small piece size that are not considered merchantable were not included in the analysis. The analysis focused on recovering harvest residues from merchantable stands. Purpose-harvesting unmerchantable stand for biomass could add to the biomass supply and further analysis could be undertaken to determine its profitability. Recent analysis has shown that harvesting these stands is not yet profitable.

The following process map (Figure 1) graphically displays the steps taken to build the final inventory of economically available biomass for the Quesnel TSA. A similar process was used for the Cascadia TSA.

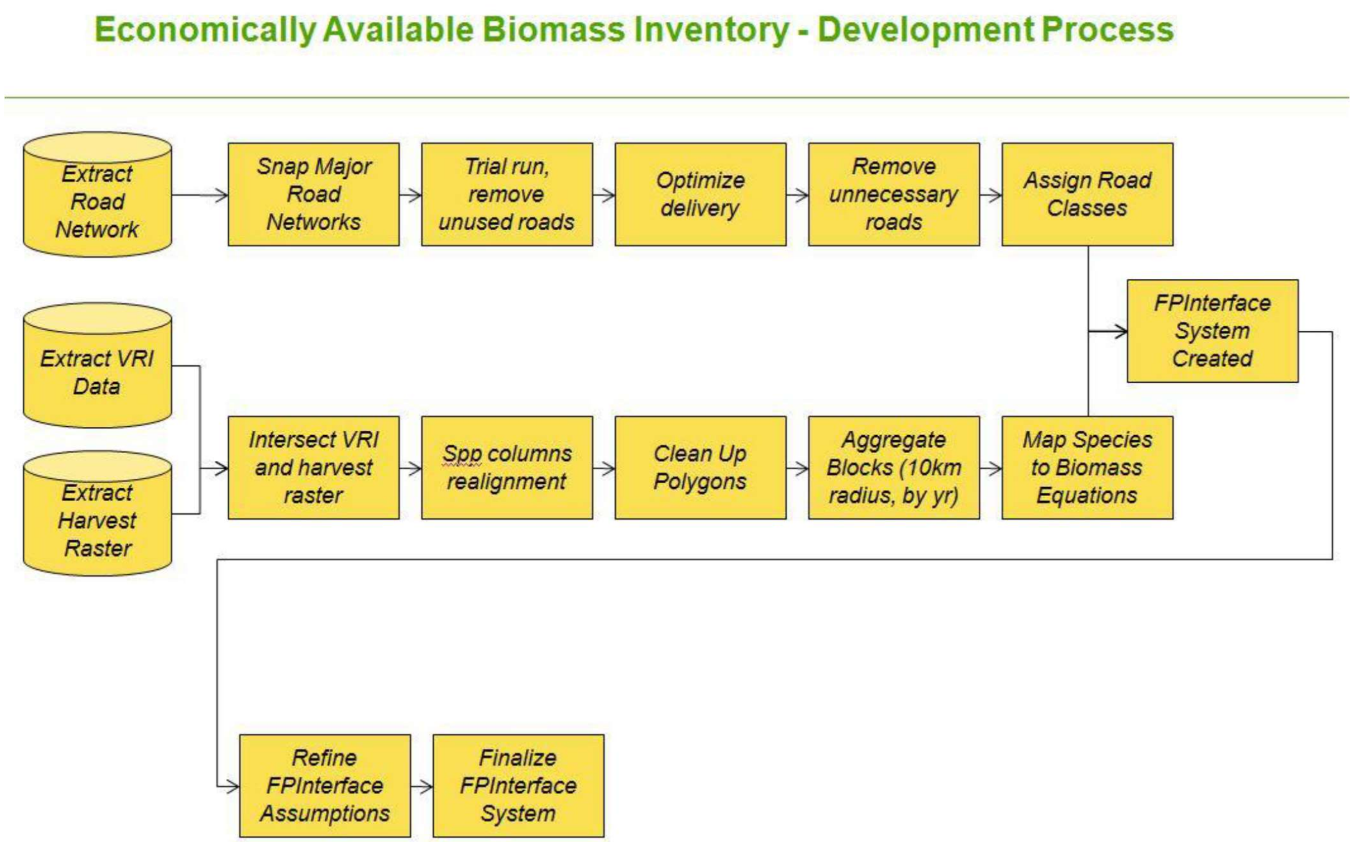

Figure 1. Inventory development process for economically available biomass.

3.2 Data Acquisition

Data layers were acquired from the Ministry for the Cascadia TSA (excluding woodlots, CFA areas, and any First Nations tenure areas), including VRI (Vegetation Resource Inventory) polygons with attributes, and road linework with attributes. The polygon data was for 20 years of harvest in four five-year periods. The polygon data was already populated with species and volume information for each polygon.

The total 20-year harvest raster is a point in time snapshot. It indicates which polygons are expected to be harvested in the next 20 years. No attempt was made to model possible growth or mortality during the 20 year horizon. Any projections of growth or mortality are already accounted for in the harvestable proportion contained in the harvest raster data.

3.3 Data Transformation

FPInterface requires two major inputs – a polygon layer of harvestable blocks with attributes, and a road layer. The polygon layer must also have a harvest raster built into it, indicating which polygons are to be cut in which time period. To calculate biomass amounts, FPInterface requires both tree size data (or height and dbh (diameter at breast height)) and either stand density (stems per ha) or volume per ha by species in each polygon. When the polygon layer is uploaded it is necessary to tie species in the resultant to FPInterface species.

In order to speed calculations, polygons with little or no merchantable volume were removed from the resultant. Some of these polygons resulted from the process of intersecting the VRI and the harvest raster layers. Aggregation rules meant some blocks were grouped if they had an identical harvest period.

FPInterface calculates cost in part by finding a transport route from product origin in a polygon (block) to the mill or delivery site. It relies on a continuous path along the road network. If digital road segments are not joined together (snapped), the program is not able to find a path between block and mill, or may find a sub-optimal circuitous path.

Examination of the received data set showed that road snapping was required. A program was used to identify gaps in the road network and close them.

3.4 Biomass Equations

To perform the analysis, tree species indicated in the inventory are tied to single-tree biomass equations in FPInterface. For the Quesnel analysis in 2010-11, these equations were based on “Canadian national tree above ground biomass equations” by Lambert, M.C., C.H. Ung, and F. Raulier, 1996-2008. Although this equation set includes trees from all across Canada including western and northern Canada, there were very few samples from BC. More recently, Lambert et al. have released tree equations for BC (accepted by the BC ministry) and these were incorporated into FPInterface for the Williams Lake and subsequent analyses, including this one.

3.5 FPInterface Parameters

3.5.1 Tree species associations

Species associations were made as follows in Table 1.

Table 1. Species associations

FPInterface species	System label	Named	Original data set
Spruce, white	S	Spruce	S, Ss, Se, Sx, Sw, Sb
Aspen, trembling	ACT	Trembling aspen	Ac, At, Act
Fir, balsam	BL	Subalpine fir	Ba, Bl, B
Birch, white	EP	Birch	Ep, E
Pine, lodgepole	PL	Lodgepole Pine	Pl, Pli
Cedar, western red	CW	Western redcedar	Cw
Douglas-fir (interior)	FD	Douglas fir	Fd, Fdi
Hemlock, western	HW	Western hemlock	Hw, H, Hm
Larch, western	LW	Larch	Lw

3.5.2 Road classes

Unlike the Quesnel dataset, there were no road classes contained in the road data set. However, FPInterface has the ability to assign road classes based on the amount of volume hauled over each section of the road. The volume hauled is for merchantable volume as calculated by FPInterface. The volume and speeds associated with each road class were assigned according to Table 2.

Table 2. Road class associations

FPInterface road class	Minimum volume (m^3)	Maximum volume (m^3)	Road speed (95% / 85%*)
Paved	10,000,001	50,000,000	90 km/h (86 / 77)
Class 1 (off highway)	0	0	70 km/h (67 / 60)
Class 1	2,000,001	10,000,000	70 km/h (67 / 60)
Class 2	1,000,001	2,000,000	50 km/h (48 / 43)
Class 3	500,001	1,000,000	40 km/h (38 / 34)
Class 4	5,001	500,000	20 km/h (19 / 17)
Class 4 (operational)	0	0	20 km/h (19 / 17)
Class 5 (winter)	0	5,000	20 km/h (19 / 17)

* percent of posted speed

3.5.3 General parameters

The price of fuel can have significant impacts on model results. Some equipment in the model can use diesel and some is eligible for marked fuel. A price of $1.40/litre was assigned which is slightly higher than current rates for diesel but approximates a medium-term average.

The program's default values for productivities and costs of forestry equipment rely on FPInnovations studies and information. If a user has specific values or costs they wish to apply to any phase or machine, these can be used instead of the defaults. For this project, only the default values were used.

Average slope for the area was assigned to CPPA Class 2 (10-19%). Ground strength was rated CPPA Class 3 (moderate), and ground roughness was rated CPPA Class 3 (uneven).

3.5.4 Comminution cost

Working time for BC conditions was based on previous base case studies cand consists of one 12-hour shift per day, 200 days per year. Grinder utilization was set at 60% and fuel used per productive machine-hour for the grinder was the standard 150 L/PMH (litres per productive machine hour). These are the standard base case parameters used in past FPInnovations studies and enable comparisons to those studies. Here, they produced a grinding cost of $29.20/odt.

3.5.5 Topping diameter

Although BC regulations require a topping diameter of 10.0 cm for most merchantable species, this analysis used 12.5 cm to reflect more common industrial practise. Topping diameter can have a significant impact on the volume of a tree available for biomass use.

3.5.6 Parameters as entered into FPInterface

A summary of some of the parameters as entered into FPInterface follows for the base case, which produces grinding costs of $29.20/odt (Table 3).

Table 3. FPInterface parameters

Run Descriptor	Base Case - Default Grinding Efficiency
run name	Cascadia TSA
output name	Biomass – Cascadia TSA
block system	Blocks.shp
road system	Roads.shp
transfer yard(s)	Kitimat, Terrace, Dunkley, Quesnel, Revelstoke, Nakusp
cost per transfer yard, respectively	$0
year(s) analyzed	All
species attribute linking	BC
automatic assignment of road class by volume	Yes
road maintenance	Yes
haul speeds	Graduated
haul speeds at 95% / 85% of posted	Yes
transport shifts / day	1
transport hours / shift	12
transport days / year	200
transport fuel price / litre	$1.40
ground strength	3 – moderate
ground roughness	3 – uneven
average slope %	10-19
slash used for biomass	Yes
full stem used for biomass	No
chip destination	Kitimat, Terrace, Dunkley, Quesnel, Revelstoke, Nakusp
topping diameter	12.5 cm
truck used for logs	Tridem B-train
truck used for chips	3-axle
harvesting fuel price / litre (x3)	$1.40
harvesting shifts / day (x3)	1
harvesting hours / shift (x3)	1

harvesting days / year (x3)	200
harvesting system	full tree with roadside processing
felling & processing	mechanized and bunched
skid type	skidder with grapple
type of roadside processing	cut-to-length
on site biomass treatment (roadside)	Comminution
recovery season	Winter
slash freshness	>3 months
slash pre-piled at roadside	Yes
grinder size type	horizontal 600 kW
biomass fuel price / litre (x2)	$1.40
biomass hours / shift (x2)	12
biomass shifts / day (x2)	1
Biomass days / year (x2)	200
grinder efficiency	60%
Grinder fuel use (L/PMH)	150
indirect costs - biomass ($ value)	$0.00
indirect costs - harvesting ($ value)	$0.00

3.6 Delivery Locations

All harvest residues from in-woods operations (not from mills) were directed to mill sites in or near the Cascadia TSA. In this model, delivery locations were Kitimat, Terrace, Dunkley, Quesnel, Revelstoke, and Nakusp. Initial comminution was set to take place at roadside, and costs are calculated for biomass delivered to the delivery locations.

3.7 Biomass Calculations

The biomass calculations in FPInterface produce a volume of total available biomass once merchantable roundwood has been removed. For this project, only biomass transported to roadside was considered recoverable while biomass likely to remain at the stump or dispersed on the cutblock was not. Once it is transported to roadside, some biomass becomes unavailable due to handling and technical losses. The remainder is considered recovered biomass. Figure 2 shows this breakdown with the numbers from the 20-year harvest of the base case with normal grinder utilization of 60% and fuel usage of 150 L/PMH.

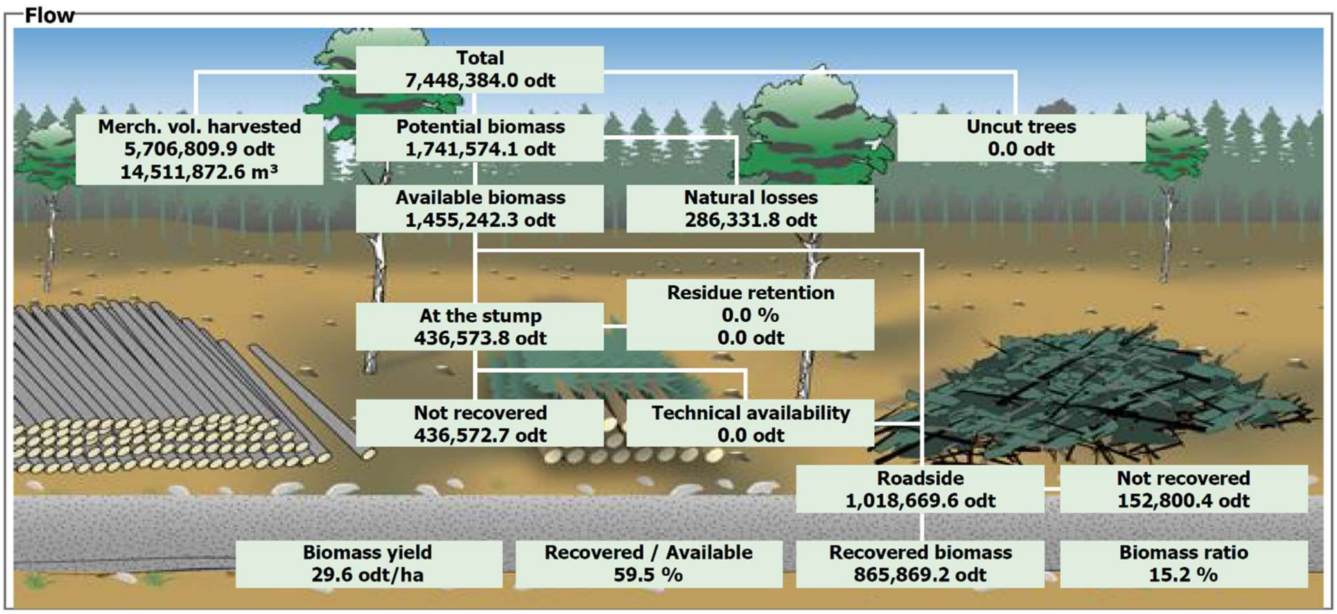

Figure 2. Recoverable biomass at delivery locations.

4. RESULTS AND DISCUSSION

4.1 Summary of Key Results

All results from the different runs performed in FPInterface are summarized in Appendix 1. The FPInterface analysis of biomass supply in the Cascadia TSA, based on inventory information and the road network supplied by the Ministry, indicates an average biomass yield of 29.6 oven-dried tonnes (odt) per hectare for the base case. This is in the form of comminuted hog fuel and comes from harvest residues only – tops, branches, and other roadside logging waste. Mill residues are not predicted by the model. Biomass yield is shown in Table 4.

Table 4. Biomass yield for Cascadia TSA

Biomass Yield
29.6 odt/ha

4.2 Biomass amounts

In total, for the base case (all periods) there are predicted to be 865,869.2 odt that could be recovered from roadside and delivered to the delivery location over the course of 20 years. The amount of biomass available each year is approximately 43,000 odt/yr, with the highest cost being $110.08/odt. The amount of biomass available in each five-year period varies from 150,000 odt/yr in period 1 to 268,000 odt/yr in period 3. The economically available volume at $60/odt is estimated at 4,800 odt/year, as described below. Key amounts of biomass availability are shown in Table 5.

Table 5. Key availability amounts

Biomass Available (odt)

up to $60/odt	total ($110/odt)
95,185.2	865,869.2
per year	per year
4,759	43,293

Additionally, the model indicates that there are about 875,000 odt of biomass that would be left on the cutblock, (including unrecoverable material at roadside), of which 723,000 odt would not make it to roadside. This 723,000 odt is approximately 83% of the amount recoverable for biomass and includes material that falls off trees naturally and material that breaks off timber and is left on the ground during normal harvesting operations. This vast amount of material retained in the forest is much higher than that deemed necessary to replenish the forest floor and prevent nutrient degradation to the soil. Additionally, 153,000 odt of biomass material that makes it to roadside is not recovered due to technical handling efficiencies, that is, the material is too small or large for machine handling or is incorrectly positioned for economic accessibility.

4.3 Biomass ratio

The biomass ratio (BR) is the ratio of recoverable biomass to recoverable merchantable roundwood. The BR is 15.2% for the all-period scenario. In this case 5,706,810 odt of roundwood are expected along with 865,869 odt of biomass. The BR is shown in Table 6.

Table 6. Biomass ratio

Biomass Ratio	
865,869	odt of biomass
5,706,810	odt of roundwood
15.2%	

Knowing the biomass ratio for an area can be useful in making rough predictions of the amount of available harvest residue if the amount of merchantable timber harvest is known.

4.4 Cost availability

FPInterface breaks down the available supply into delivered cost in $10 increments. At the presumed market rate of $60/odt, the amount available over 20 years is predicted at 95,185 odt or an average 4,759 odt per year. The complete results in $10 increments for the entire 20-year period can be seen below in Table 7 and Figure 3.

Table 7. Cascadia TSA biomass ‘cost-availability’ for all periods

Base Case		
Cost $/odt	Odt Available	Odt/year
10	-	-
20	-	-
30	-	-
40	-	-

50	14,162	708
60	95,185	4,759
70	244,419	12,221
80	493,714	24,686
90	727,414	36,361
100	853,144	42,657
110	865,860	43,293
120	865,869	43,293

The amounts are cumulative. So the amount available at $60/odt, for example, includes all the biomass at $50/odt plus the additional biomass available between $50 and $60 per odt.

Because the TSA is so scattered geographically, whether or not biomass is economically available (> $60/odt) is highly dependent on the local logistics and time to the desired delivery point.

Nearly eight times as much biomass is available at $90/odt than is available at the perceived economic rate of $60/odt. This is nearly all the biomass in the TSA, 84% of the total. This means that if demand for biomass is high, much more can become available if purchasers are willing to pay more.

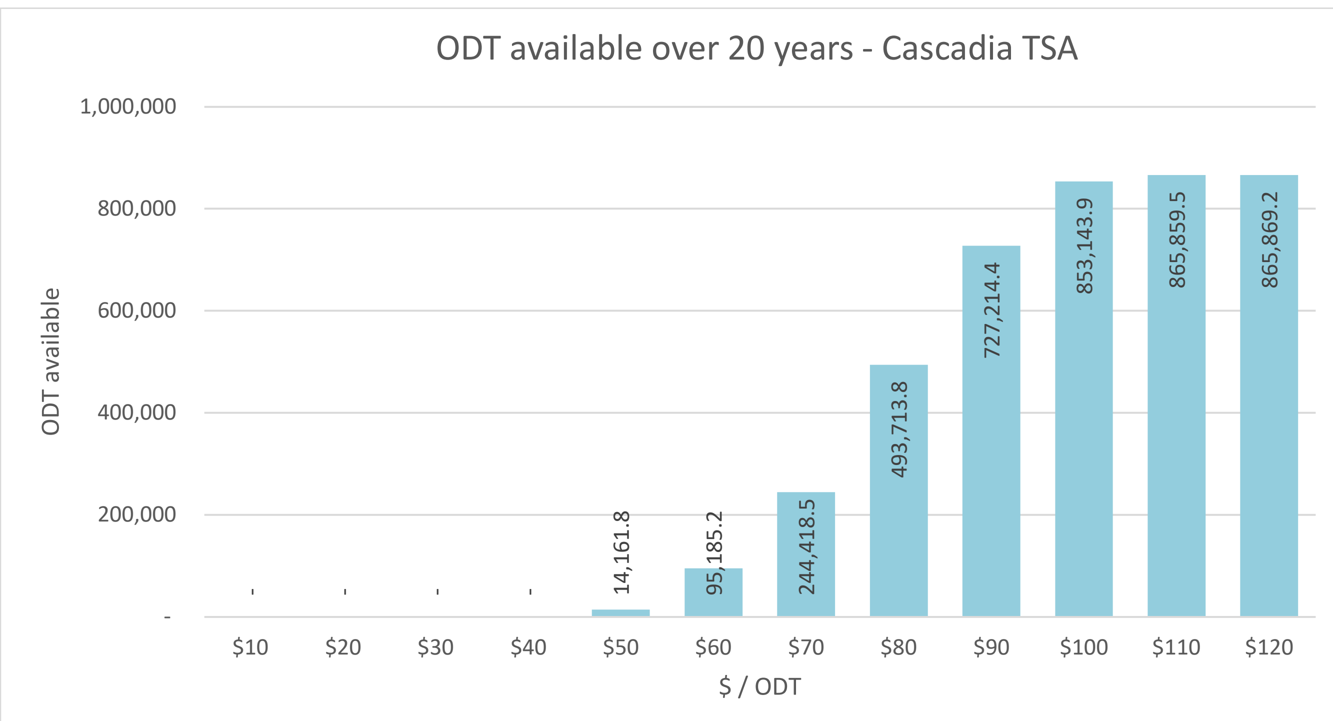

Figure 3. Cascadia TSA biomass 'cost-availability' all periods.

4.5 Mapping

The distribution of costs by cutblock is shown in the heat map, as shown in Figures 4, below. The costs range to $110/odt for the blocks farthest from the delivery points. The blocks are coloured in $15 colour increments as shown on the legend in Figure 4, with the dark green points being the ones with the lowest delivered biomass costs, and the reddest ones being the most expensive, with a yellow transition in the middle.

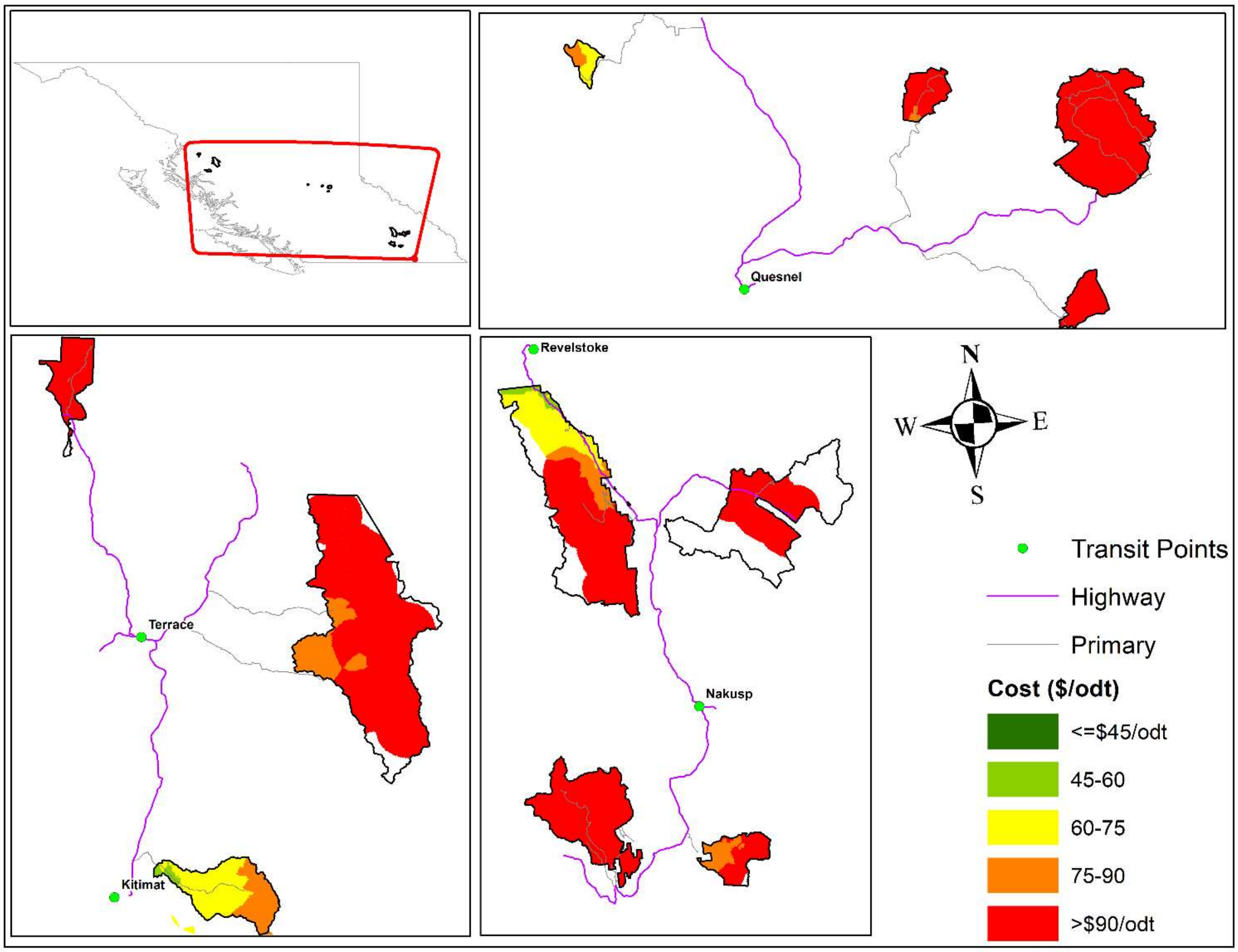

Figure 4. Spatial distribution of cutblocks by delivered biomass cost per odt.

The delivery points are represented by small green dots. Most of the cutblocks in this analysis are not close to the delivery points, which is why such a small percentage of the total biomass is available at the economic rate of $60/odt. However most of the volume is available for $90/odt.

4.6 Temporal distribution of harvest

The harvest data contains a temporal period assigned to each cutblock. There are four periods in the data representing five-year periods. The first period covers the first five years of cutblocks, and the second period covers the second five years, etc. The dataset begins with year one as 2021.

The biomass yield per hectare remained relatively constant through the time periods and averaged 29.6 odt/ha. As shown in Figure 5, the amount of biomass available in period 1 is about a third less than the other three periods (the shorter blue bars). This means that there is less harvest planned during this period. Because the recoverable amount per hectare is not significantly lower than in other periods, it means that less hectares of harvest are planned in period 1 compared to other periods.

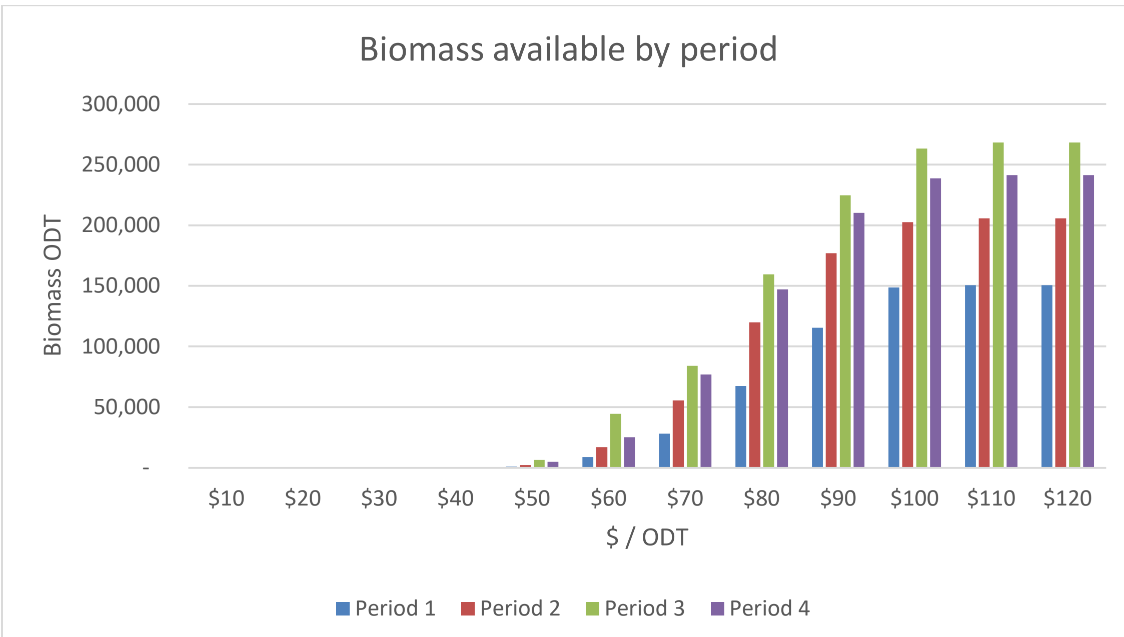

Figure 5. Biomass recoverable by period.

Table 8 shows some of the numbers behind Figure 6, and includes the harvest area scheduled in each period. It also includes the biomass yield for each period.

Table 8. Availability by period

	Years 1-5	Years 6-10	Years 11-15	Years 16-20
Available biomass (odt)	150,469	205,832	268,308	241,259
Economic biomass (@ $60/odt)	8,731	16,940	44,414	25,100
Harvest area (ha)	5,307	6,678	8,866	8,374
Yield (odt/ha)	28.4	30.8	30.3	28.8
Biomass ratio (biomass/sawlog) (odt)	14.9%	14.2%	15.3%	16.2%

4.7 Results appendices

Appendices summarizing the different runs performed in FPInterface and showing the results of each run are included in Appendix 1.

5. CONCLUSION

The biomass yield per hectare predicted for the Cascadia TSA is 29.6 oven-dried tonnes per hectare (odt/ha) from harvest residues. The biomass ratio, which is the ratio of recoverable biomass to recoverable merchantable roundwood, is estimated at 15.2%. Over the next 20 years a total of 866,000 odt of available biomass could be generated by harvest in the Cascadia TSA, or approximately 43,000 odt/yr. Of this, 11%, approximately 95,000 odt in total, or 4,800 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. Delivery of biomass from the most expensive (distant) block is projected at $110/odt and the average delivered price for all biomass is $77.06/odt.

Because the TSA is so scattered geographically, whether or not biomass is economically available (> $60/odt) is highly dependent on the local logistics and time to the desired delivery point. Nearly eight times as much biomass is available at $90/odt than is available at the perceived economic rate of $60/odt. This is nearly all the biomass in the TSA, 84% of the total. This means that if demand for biomass is high, much more can become available if purchasers are willing to pay more.

The biomass yield per hectare remained relatively constant through the four time periods and averaged 29.6 odt/ha. The amount of biomass available in period 1 is about a third less than the other three periods. This means that there is less harvest planned during this period. Because the recoverable amount per hectare is not significantly lower than in other periods, it means that less hectares of harvest are planned in period 1 compared to other periods.