info@fpinnovations.ca
www.fpinnovations.ca

INVERMERE TIMBER SUPPLY AREA BIOMASS AVAILABILITY ESTIMATION

CONTRACT NUMBER : 1070-20/OT20FHQ182

Charles Friesen

March 2020

Unrestricted

ABSTRACT:

The biomass yield per hectare predicted for the Invermere TSA is 30.6 oven-dried tonnes per hectare (odt/ha) from harvest residues. Over the next 20 years a total of 0.93 million odt of available biomass are predicted to be generated by harvest in the Invermere TSA, or approximately 46,500 odt/yr. Of this, 94%, approximately 879,000 odt in total, or 44,000 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. All of the total predicted volume is expected to be available at $75/odt. Delivery locations were the mills at Canal Flats, Skookumchuk, Radium Hot Springs, and Golden.

301013814: FOREST BIOMASS INVENTORY ANALYSIS

CONTRACT REPORT

ACKNOWLEDGEMENTS

This project was financially supported by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development: Innovation, Bioeconomy and Indigenous Opportunities Branch

The author(s) would also like to thank Mehdi Bagheri and Qinglin Li

APPROVER CONTACT INFORMATION

Charles Friesen

Senior Researcher

Charles.friesen@fpinnovations.ca

REVIEWERS

Ken Byrne, Manager, Fibre Supply

AUTHOR CONTACT INFORMATION

Charles Friesen

Senior Researcher

Fibre Supply

(604) 222-5622

charles.friesen@fpinnovations.ca

EXECUTIVE SUMMARY

Forest origin, harvest residue, biomass estimates were made by FPInnovations for the Invermere Timber Supply Area (TSA), largely following the process previously established for several BC TSAs using FPInterface (2010-2019). 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.

The biomass yield per hectare predicted for the Invermere TSA is 30.6 oven-dried tonnes per hectare (odt/ha) from harvest residues. (Table 4 from the text, follows.)

Biomass Yield
30.6 odt/ha

The biomass ratio, which is the ratio of recoverable biomass to recoverable merchantable roundwood, is estimated at 21.8%. Over the next 20 years a total of 0.93 million odt of available biomass are predicted to be generated by harvest in the Invermere TSA, or approximately 46,500 odt/yr. Of this, 94%, approximately 879,000 odt in total, or 44,000 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. All of the total predicted volume is expected to be available at $75/odt. (Table 5 from the text, follows.)

Biomass Available (odt)	
up to $60/odt	total ($75/odt)
879,039	930,626
per year	per year
43,952	46,531

Delivery locations were the mills at Canal Flats, Skookumchuk, Radium Hot Springs, and Golden. Only a small amount of volume was directed to Golden (which is 45 km outside of the TSA), and this could easily be directed to Radium for little additional cost.

Almost all of the biomass in the TSA is considered economically available (<= $60/odt) because of the small size of the TSA and the relatively central locations of the delivery points. The biomass yield per hectare remained relatively constant through the four time periods and averaged 30.6 odt/ha, however the amount of land area modelled in the fourth five-year period was 7% larger than the average of the other three periods, and the amount of biomass predicted to be recoverable during the fourth period is 9% larger.

TABLES OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Forest origin, harvest residue, biomass estimates were made by FPInnovations for the Invermere Timber Supply Area (TSA), largely following the process previously established for previous BC TSAs using FPInterface (2010-19). 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 Invermere 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

1.1 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 Invermere 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 Invermere TSA.

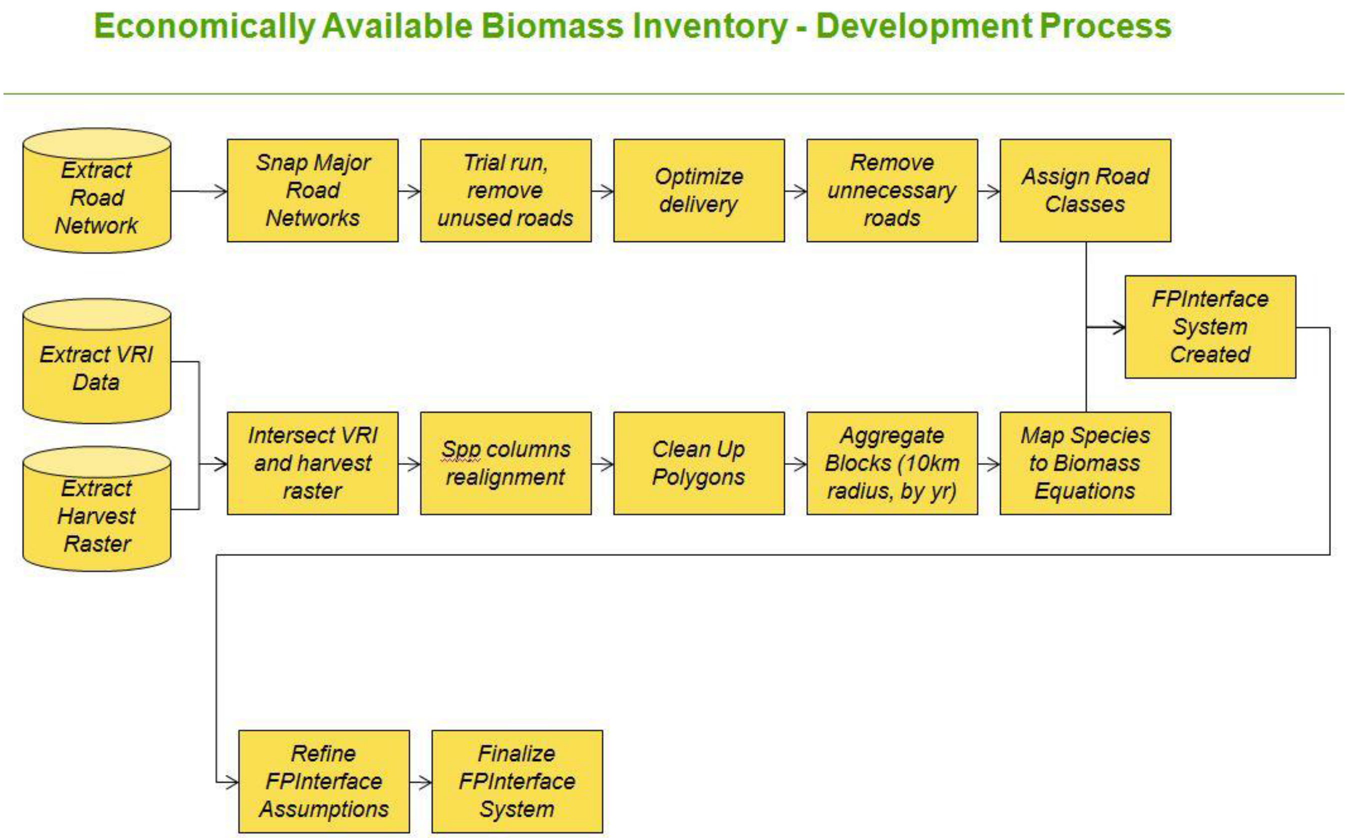

Figure 1. Inventory development process for economically available biomass.

1.2 Data Acquisition

Data layers were acquired from the Ministry for the Invermere 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. This polygon data was overlaid on VRI polygons to populate 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.

1.3 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.

1.4 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.

1.5 FPInterface Parameters

1.5.1 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	Hybrid spruce	S, Sb, Sw, Sx, Se
Aspen, trembling	AT	Trembling Aspen	Act, At, Acb
Fir, alpine	B	Subalpine Fir	Ba, Bl
Larch, western	L	Western Larch	Lw, Lt
Pine, lodgepole	PL	Lodgepole Pine	Pl, Pli
Birch, white	EP	Paper Birch	Ep
Cedar, western red	CW	Western redcedar	Cw
Douglas fir (interior)	FD	Douglas fir	Fd, Fdi
Hemlock, western	HW	Western hemlock	Hw
Pine, western white	PW	White pine	Pw, Pa
Pine, ponderosa	PY	Ponderosa pine	Py

1.5.2 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	1,000,001	25,000,000	90 km/h (86 / 77)
Class 1 (off highway)	0	0	70 km/h (67 / 60)
Class 1	500,001	1,000,000	70 km/h (67 / 60)
Class 2	250,001	500,000	50 km/h (48 / 43)
Class 3	125,001	250,000	40 km/h (38 / 34)
Class 4	4,001	125,000	20 km/h (19 / 17)
Class 4 (operational)	0	0	20 km/h (19 / 17)
Class 5 (winter)	0	4,000	20 km/h (19 / 17)

* percent of posted speed

1.5.3 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 $1.25/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 3 (20-32%). Ground strength was rated CPPA Class 3 (moderate), and ground roughness was rated CPPA Class 3 (uneven).

1.5.4 Comminution cost

Working time for BC conditions was based on previous base case studies and 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 135 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 $27.55/odt.

1.5.5 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.

1.5.6 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 $27.55/odt (Table 3).

Table 3. FPInterface parameters

Run Descriptor	Base Case - Default Grinding Efficiency
run name	Invermere 18mar2020
output name	Biomass - Invermere 18mar2020
block system	Blocks_2019.shp
road system	Roads_Invermere.shp
transfer yard(s)	Canal Flats, Radium Hot Springs, Skookumchuk, Golden (-45 km)
cost per transfer yard, respectively	0, 0, 0, $6
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	$1.25
ground strength	3 – moderate
ground roughness	3 – uneven
average slope %	20-32
slash used for biomass	Yes
full stem used for biomass	No
chip destination	Canal Flats, Radium Hot Springs, Skookumchuk, Golden (-45 km)
topping diameter	12.5 cm
truck used for logs	Tridem B-train
truck used for chips	3-axle
harvesting fuel price / litre (x3)	$1.25
harvesting shifts / day (x3)	1

harvesting hours / shift (x3)	12
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)	$1.25
biomass hours / shift (x2)	12
biomass shifts / day (x2)	1
Biomass days / year (x2)	200
grinder efficiency	60%
Grinder fuel use (L/PMH)	135
indirect costs - biomass ($ value)	$0.00
indirect costs - harvesting ($ value)	$0.00

1.6 Delivery Locations

All harvest residues from in-woods operations (not from mills) were directed to mill sites in or near the Invermere TSA. In this model, delivery locations were the mills at Canal Flats, Skookumchuk, Radium Hot Springs, and Golden. Only a small amount of volume was directed to Golden (which is 45 km outside of the TSA), and this could easily be directed to Radium for little additional cost. Because the road network did not extend to Golden, a proxy mill was established at the edge of the road network. Then, $6/odt was added to deliveries to Golden, which approximates the cost of the added cycle time for 45 km one way (90 km two-way), just over one hour of cycle time.

Initial comminution was set to take place at roadside, and costs are calculated for biomass delivered to the delivery locations.

1.7 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 135 L/PMH.

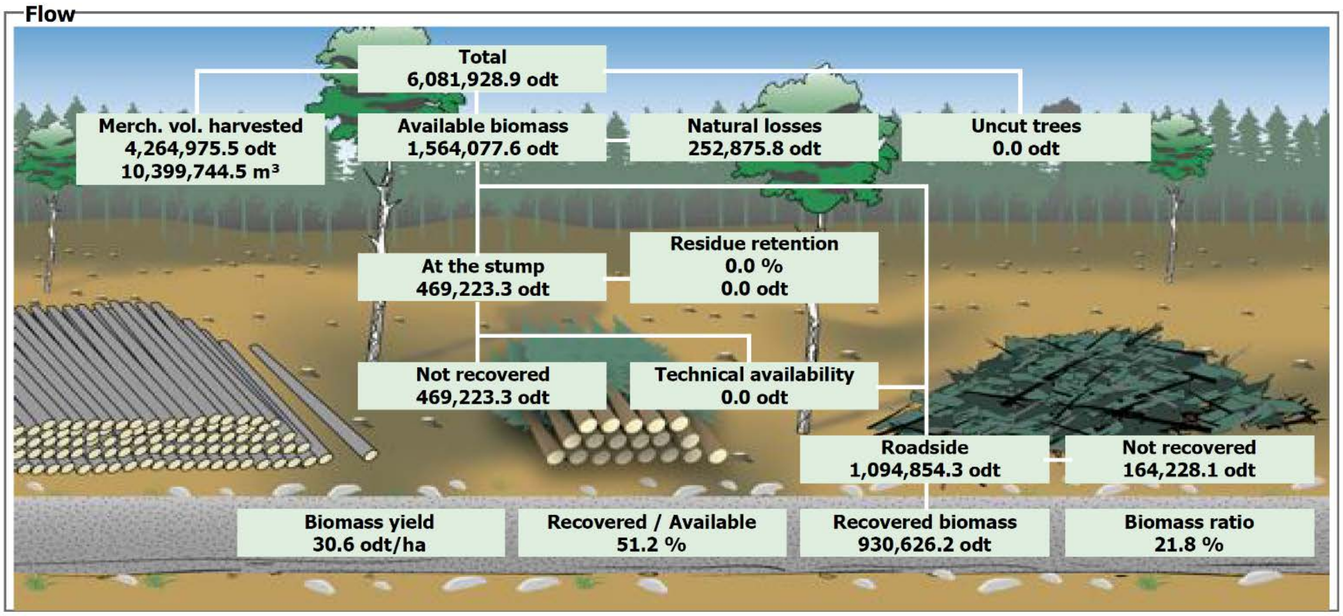

Figure 2. Recoverable biomass at delivery locations.

4. RESULTS AND DISCUSSION

1.8 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 Invermere TSA, based on inventory information and the road network supplied by the Ministry, indicates an average biomass yield of 30.6 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 Cranbrook TSA

Biomass Yield
30.6 odt/ha

1.8.1 Biomass amounts

In total, for the base case (four delivery locations : Skookumchuck, Canal Flats, Radium Hot Springs, and Golden) there are predicted to be 930,626 odt that can be recovered from roadside and delivered to the delivery locations over the course of 20 years. The amount of biomass available each year is approximately 46,500 odt/yr, with the highest cost being $74.21/odt. The amount of biomass available in each five-year period varies from 45,000 odt/yr in period 1 to 50,000 odt/yr in period 4. The economically available volume at $60/odt is estimated at 44,000 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 ($75/odt)
879,039	930,626
per year	per year
43,952	46,531

Additionally, the model indicates that there are about 886,000 odt of biomass that would be left on the cutblock, (including unrecoverable material at roadside), of which 722,000 odt would not make it to roadside. This 722,000 odt is approximately 78% 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, 164,000 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.

1.8.2 Biomass ratio

The biomass ratio (BR) is the ratio of recoverable biomass to recoverable merchantable roundwood. The BR is 21.8% for the base case scenario. In this case 4,264,976 odt of roundwood are expected along with 930,626 odt of biomass. The BR is shown in Table 6.

Table 6. Biomass ratio

Biomass Ratio	
930,626	odt of biomass
4,264,976	odt of roundwood
21.8%	

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.

1.8.3 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 10 years is predicted at 879,039 odt or about 44,000 odt per year. The complete results in $10 increments for the entire 10-year period can be seen below in Table 7 and Figure 3.

Table 7. Cranbrook biomass ‘cost-availability’ for base case

Base Case		
Cost $/odt	Odt Available	Odt/year
10	-	-
20	-	-
30	-	-
40	59,290	2,964

50	662,578	33,129
60	879,039	43,952
70	928,301	46,415
80	930,626	46,531

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

Almost all of the biomass in the TSA is considered economically available (<= $60/odt) because of the small size of the TSA and the relatively central locations of the delivery points.

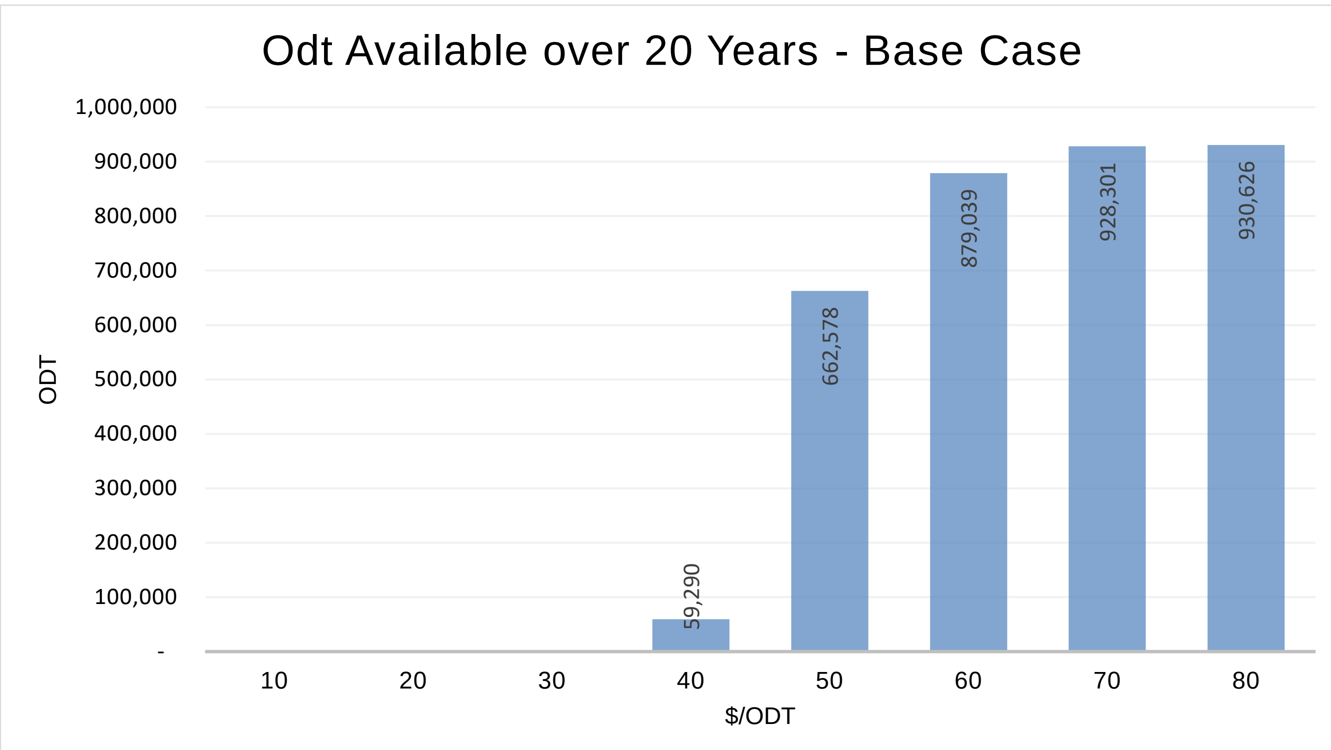

Figure 3. Cranbrook biomass 'cost-availability' in base case.

1.8.4 Mapping

The distribution of costs by cutblock is shown graphically in FPInterface with a colour scale ranging from green to orange, as in Figure 4, below. The costs range to $75/odt for the blocks farthest from the delivery points. The blocks are coloured in $10 colour increments as shown on the legend in Figure 4, with the greenest points being the ones with the lowest delivered biomass costs, and the pinkest ones being the most expensive, with a grey transition in the middle. The brightest green blocks did not produce biomass because of small piece size.

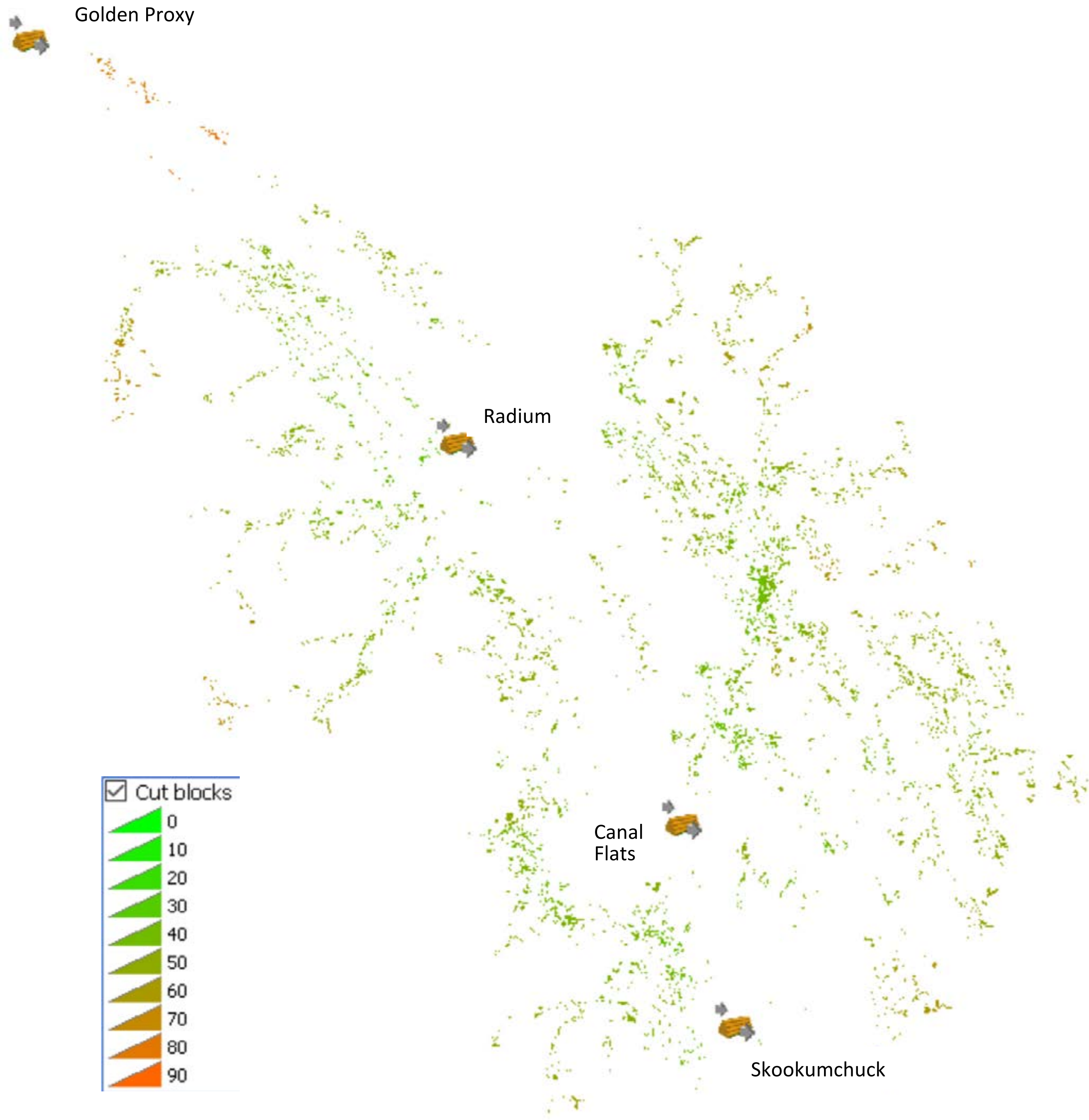

Figure 4. Spatial distribution of cutblocks by delivered biomass cost per odt (South).

The delivery points are represented by small brown log piles.

Showing the roads on the map makes it a little more difficult to distinguish the blocks but these are shown in Figure 5.

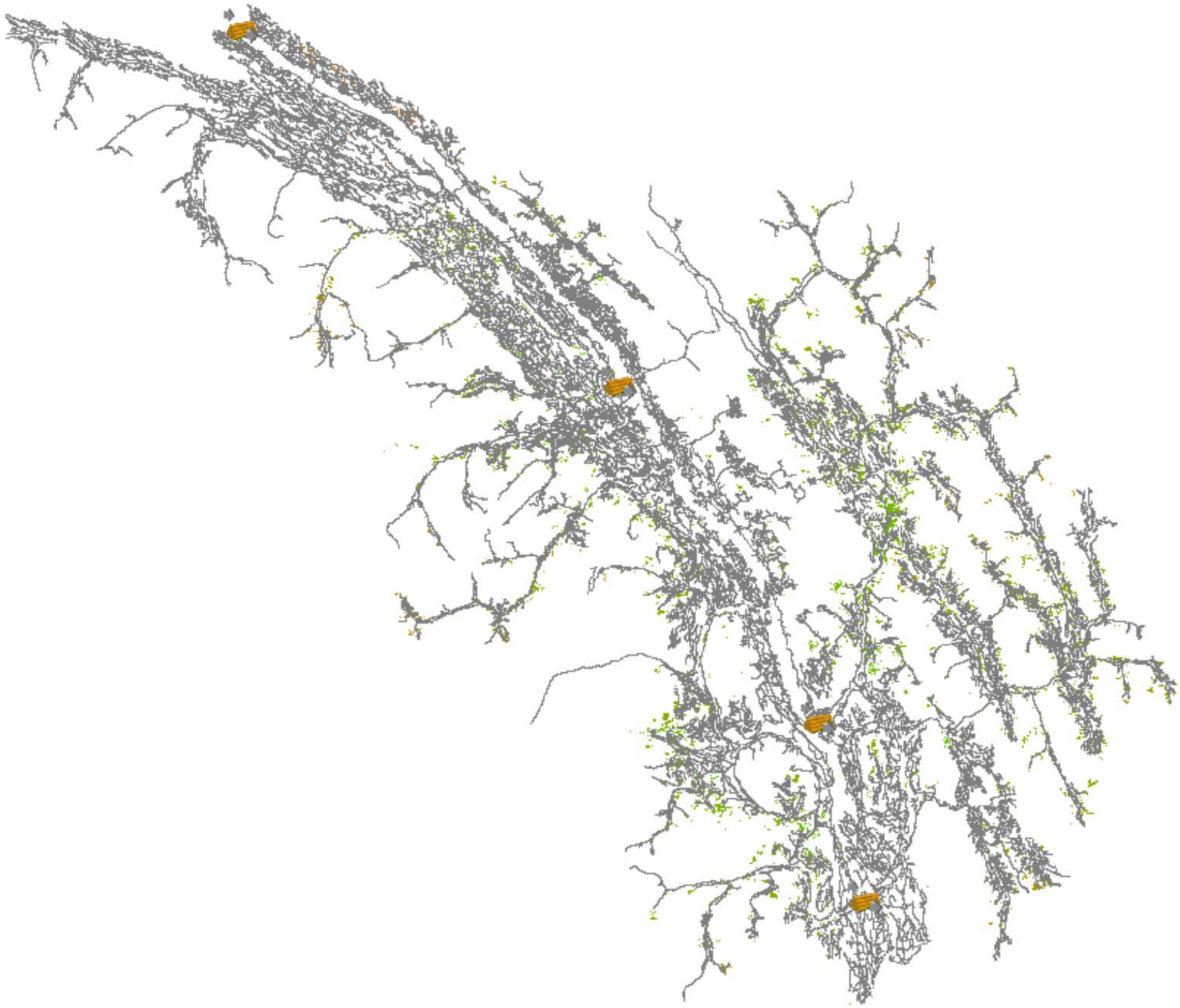

Figure 5. Road classification in the Cranbrook TSA.

The different colours associated with the roads represent different classes of roads. Each road class has a unique set of speed associations for loaded and empty trucks that help to determine the cycle times used to calculate the delivery cost for biomass, as shown above in Table 2. The slowest roads, Class 5, are in light blue on this map. Class 4 roads are brown, Class 3 roads are green, Class 2 roads are navy, Class 1 roads are red, while the fastest roads, Class Public, are coloured black. Road class is determined by the amount of harvest volume that passes over the road.

1.8.5 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 5 years, etc. The dataset begins with year one as 2019.

The biomass yield per hectare remained relatively constant through the four time periods and averaged 30.6 odt/ha, however the amount of land area modelled in the fourth five-year period was 7% larger than the average of the other three periods, and the amount of biomass predicted to be recoverable during the fourth period is 9% larger.

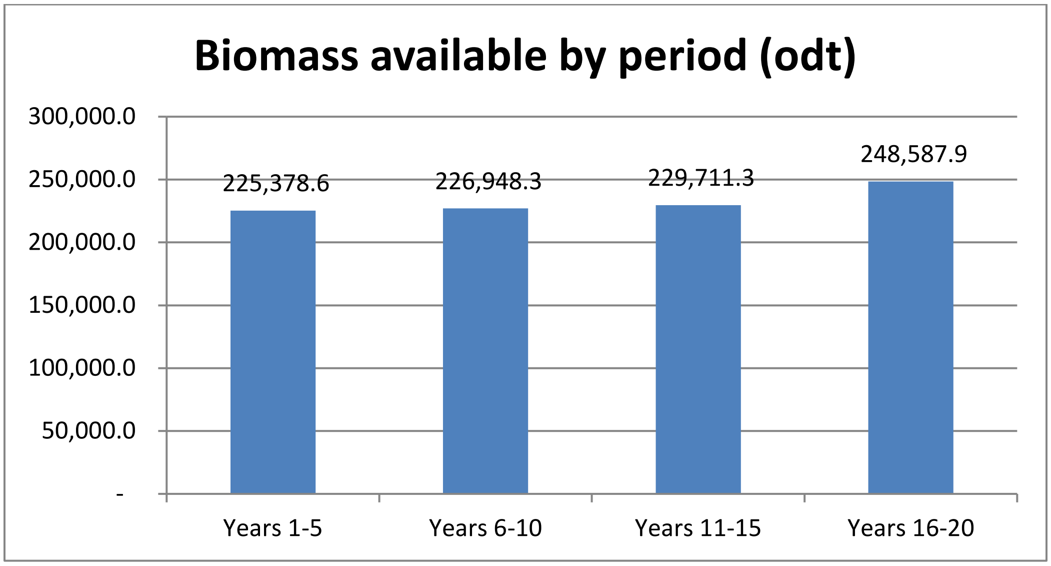

Figure 6. Biomass recoverable by period.

Table 8 shows the numbers behind Figure 7, and includes the harvest area scheduled in each period. It also includes the biomass yield for each period.

Table 8. Availability by period – base case

	Years 1-5	Years 6-10	Years 11-15	Years 16-20
Available biomass (odt)	225,379	226,948	229,711	248,588
Economic biomass (@ $60/odt)	206,720	209,988	213,861	246,470
Harvest area (ha)	7,141	7,531	7,711	8,016
Yield (odt/ha)	31.6	30.1	29.8	31.0
Biomass ratio (biomass/sawlog) (odt)	21.2%	20.7%	21.8%	23.6%

1.8.6 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 Invermere TSA is 30.6 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 21.8%. Over the next 20 years a total of 0.93 million odt of available biomass are predicted to be generated by harvest in the Invermere TSA, or approximately 46,500 odt/yr. Of this, 94%, approximately 879,000 odt in total, or 44,000 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. All of the total predicted volume is expected to be available at $75/odt.

Almost all of the biomass in the TSA is considered economically available (<= $60/odt) because of the small size of the TSA and the relatively central locations of the delivery points. The biomass yield per hectare remained relatively constant through the four time periods and averaged 30.6 odt/ha, however the amount of land area modelled in the fourth five-year period was 7% larger than the average of the other three periods, and the amount of biomass predicted to be recoverable during the fourth period is 9% larger.