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MORICE TIMBER SUPPLY AREA BIOMASS AVAILABILITY ESTIMATION

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ABSTRACT:

The biomass yield per hectare predicted for the Morice TSA is 19.4 oven-dried tonnes per hectare (odt/ha) from harvest residues. The biomass ratio, which is the ratio of recovered biomass to recovered merchantable roundwood, is estimated at 19.7%. Over the next 25 years at total of 3.3 million odt of available biomass are predicted to be generated by harvest in the Morice TSA, or approximately 132,000 odt/yr. Of this, approximately 2,268,000 odt in total, or 91,000 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. Approximately 100% of the total predicted volume is expected to be available at $90/odt.

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EXECUTIVE SUMMARY

Forest origin, harvest residue, biomass estimates were made by FPInnovations for the Morice Timber Supply Area (TSA), largely following the process previously established for several BC TSAs using FPInterface (2010-2019). The biomass inventory was based on 25-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 Morice TSA is 19.4 oven-dried tonnes per hectare (odt/ha) from harvest residues. The biomass yield is lower than other TSAs, due to the low volume per hectare of merchantable timber being harvested (Table 4 from the text, follows.)

Biomass Yield
19.4 odt/ha

The biomass ratio, which is the ratio of recovered biomass to recovered merchantable roundwood, is estimated at 19.7%. Over the next 25 years at total of 3.3 million odt of available biomass are predicted to be generated by harvest in the Morice TSA, or approximately 132,000 odt/yr. Of this, approximately 2,268,000 odt in total, or 91,000 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. Approximately 100% of the total predicted volume is expected to be available at $90/odt. (Table 5 from the text, follows.)

Biomass Available (odt)		
at $60/odt	at $90/odt	total ($100/odt)
2,267,955	3,297,603	3,297,859
per year	per year	per year
90,718	131,904	131,914

A large portion of the available biomass is considered economically available (<= $60/odt) (approximately 69%). This is mostly due to the delivery points (Houston, Burns Lake) being in a central location of the total harvest blocks. The amount of economically available biomass is variable through time, ranging from as low as approximately 53,000 odt/year in the second period (years 6-10) to as high as approximately 122,000 odt/year in the fourth period (years 16-20). This variability is likely due to inconstant harvest volume between periods and the distance of blocks from delivery points.

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1. INTRODUCTION

Forest origin, harvest residue, biomass estimates were made by FPInnovations for the Morice Timber Supply Area (TSA), largely following the process previously established for previous BC TSAs using FPInterface (2010-19). The biomass inventory was based on 25-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, 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 Morice 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 Morice 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, small piece size stands 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 Morice TSA.

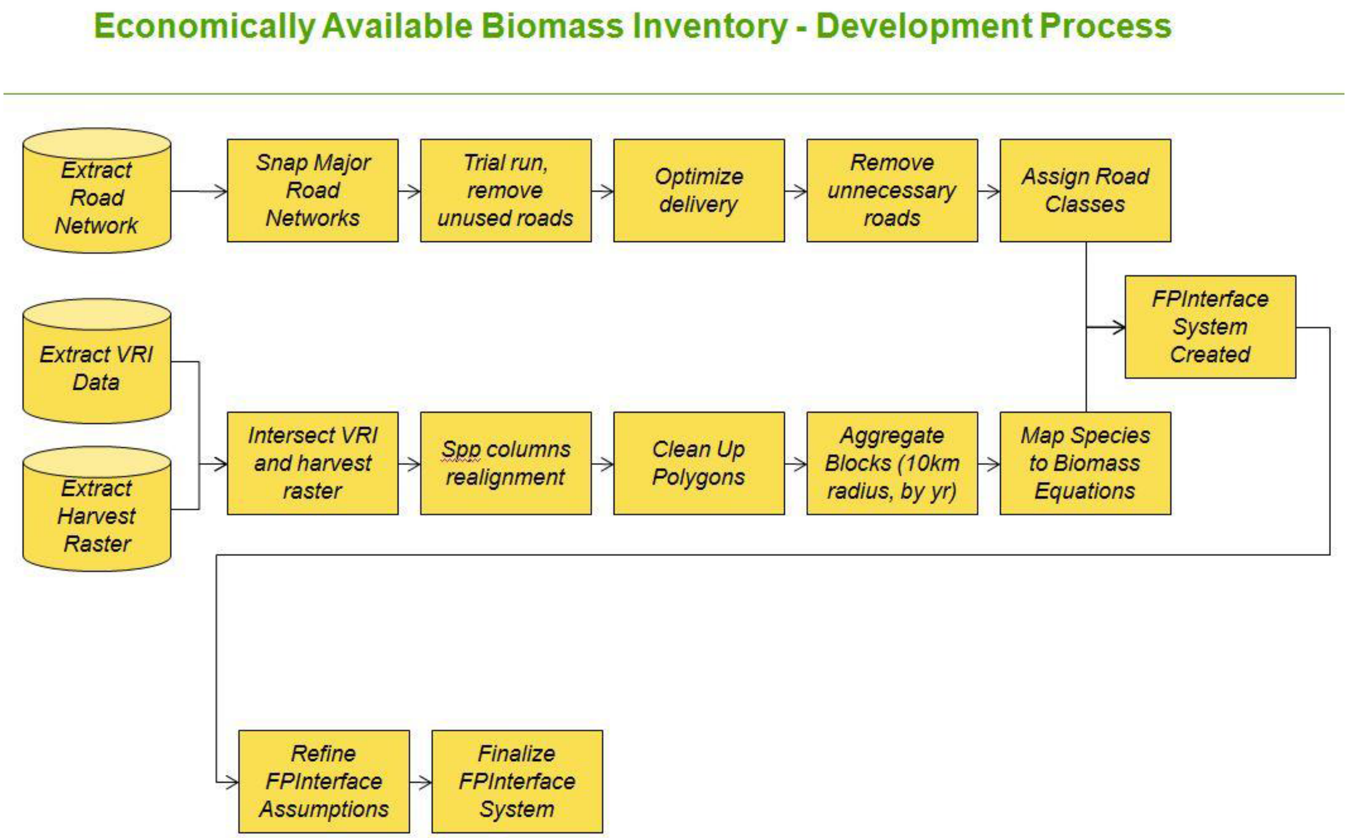

Figure 1. Inventory development process for economically available biomass.

1.2 Data Acquisition

Data layers were acquired from the Ministry for the Morice 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 25 years of harvest in five five-year periods.

The total 25-year harvest raster is a point in time snapshot. It indicates which polygons are expected to be harvested in the next 25 years. No attempt was made to model possible growth or mortality during the 25-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 targeted for elimination. Polygons with no 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 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	Sw	Hybrid Spruce	S, Sb, Sw, Sx, Se
Aspen, trembling	At	Trembling Aspen	At, Act,
Fir, alpine	Bl	Subalpine Fir	B, Bl, Ba
Hemlock, western	Hw	Western Hemlock	H, Hm, Hw
Poplar	Ac	Poplar	Ac
Birch, paper	Ep	Paper Birch	Ep
Pine, lodgepole	Pl	Lodgepole Pine	Pl, Pli, Py

1.5.2 Road classes

Unlike the Quesnel dataset, there were no road classes contained in the road data set. However, FPInterface can 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. Empty and loaded trucks would travel at 95% and 85% of the posted speed respectively.

Table 2. Road class associations

FPInterface road class	Minimum volume (m^3)	Maximum volume (m^3)	Road speed (95% / 85%*)
Paved	1,000,001	40,000,000	90 km/h (86 / 77)
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 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 2 (good), and ground roughness was rated CPPA Class 2 (slightly even).

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 $26.82/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 in FPInterface

A summary of some of the parameters as entered in FPInterface follows for the base case, which produces grinding costs of $26.82/odt (Table 3).

Table 3. FPInterface parameters

Run Descriptor	Base Case - Default Grinding Efficiency
run name	MoriceTSAV1
output name	Biomass – MoriceTSAV1

block system	Blocks_Morice.shp
road system	Roads_Morrice.shp
transfer yard(s)	Houston, Burns Lake
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	$1.25
ground strength	2 - good
ground roughness	2 – slightly even
average slope %	20-32
slash used for biomass	Yes
full stem used for biomass	No
chip destination	Houston, Burns Lake
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 large industrial areas in or near the Morice TSA. In this model, Houston and Burns Lake were used as delivery locations due to having mills in their communities. 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 and 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 25-year harvest of the base case with normal grinder utilization of 60% and fuel usage of 135 L/PMH.

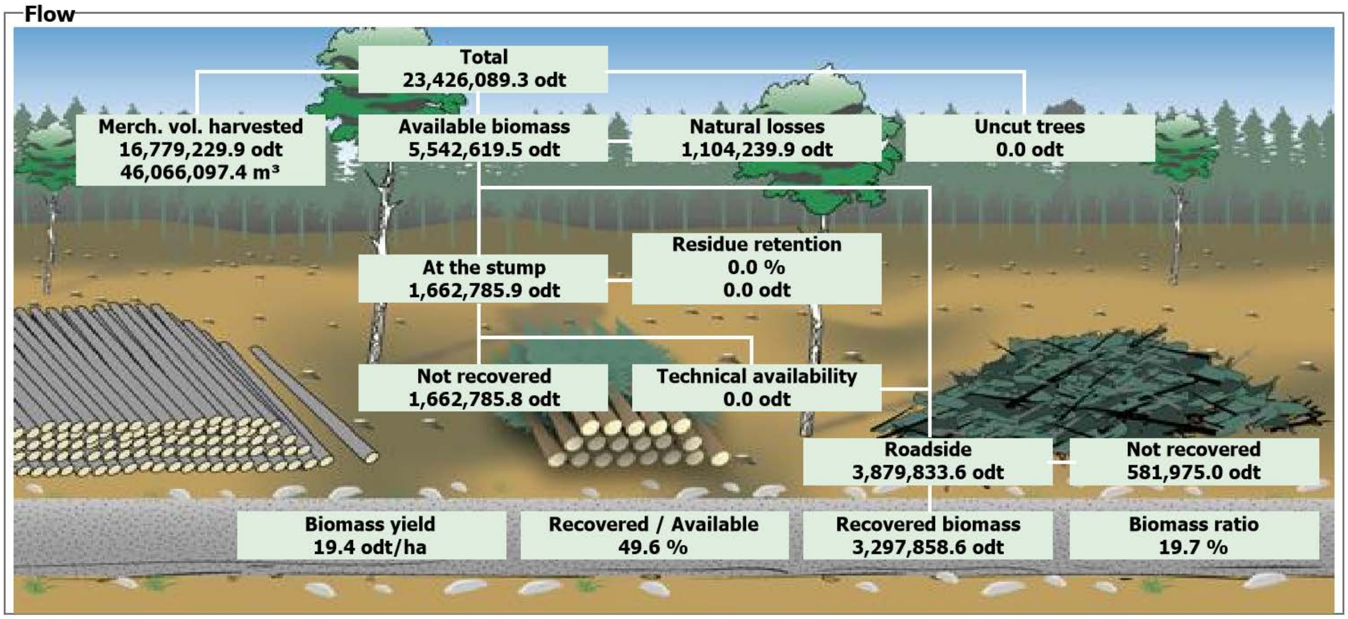

Figure 2. Recoverable biomass at delivery locations.

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 Morice TSA, based on inventory information and the road network supplied by the Ministry, indicates an average biomass yield of 19.4 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 Morice TSA

Biomass Yield
19.4 odt/ha

1.8.1 Biomass amounts

In total, there are predicted to be 3,297,858 odt that can be recovered from roadside and delivered to the delivery locations over the course of 25 years. The amount of available biomass fluctuates over time. The second 5-year period has the lowest amount of available biomass, likely due to a lower harvest volume during that period. The amount of biomass available each year works out to approximately 132,000 odt/yr, at any price point in the study area. However, the amount of biomass available in each 5-year period varies from 53,000 odt/yr in period 2 to 122,000 odt/yr in period 4. (The economically available volume is estimated at 91,000 odt/year, as described below.) Key amounts of biomass availability are shown in Table 5.

Table 5. Key availability amounts

Biomass Available (odt)		
at $60/odt	at $90/odt	total ($100/odt)
2,267,955	3,297,603	3,297,859
per year	per year	per year
90,718	131,904	131,914

Additionally, the model indicates that there are about 2,767,000 odt of biomass that would be left on the cutblock and would not make it to roadside. This is approximately 84% of the amount removed 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, 581,975 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 recovered biomass to recovered merchantable roundwood. The BR is 19.7% for the total scenario. In this case 16,779,229 odt of roundwood are expected along with 3,297,858 odt of biomass. The BR is shown in Table 6.

Table 6. Biomass ratio

Biomass Ratio	
3,297,858	odt of biomass
16,779,229	odt of roundwood
19.7%	

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 conveniently breaks down the available supply into delivered cost in $10 increments. At the presumed market rate of $60/odt, the amount available over 25 years is predicted at 2,267,954 odt or about 91,000 odt per year. The complete results in $10 increments for the entire 25-year period can be seen below in Table 7 and Figure 3.

Table 7. Morice biomass 'cost-availability' for base case

Base Case		
Cost ($/odt)	Odt Available	Odt/year
$10	-	-
$20	-	-
$30	-	-
$40	114,465.7	4,578.6
$50	1,138,707.2	45,548.3
$60	2,267,954.7	90,718.2
$70	3,109,168.5	124,366.7
$80	3,288,727.1	131,549.1
$90	3,297,602.9	131,904.1
$100	3,297,858.6	131,914.3

The amounts are cumulative. 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.

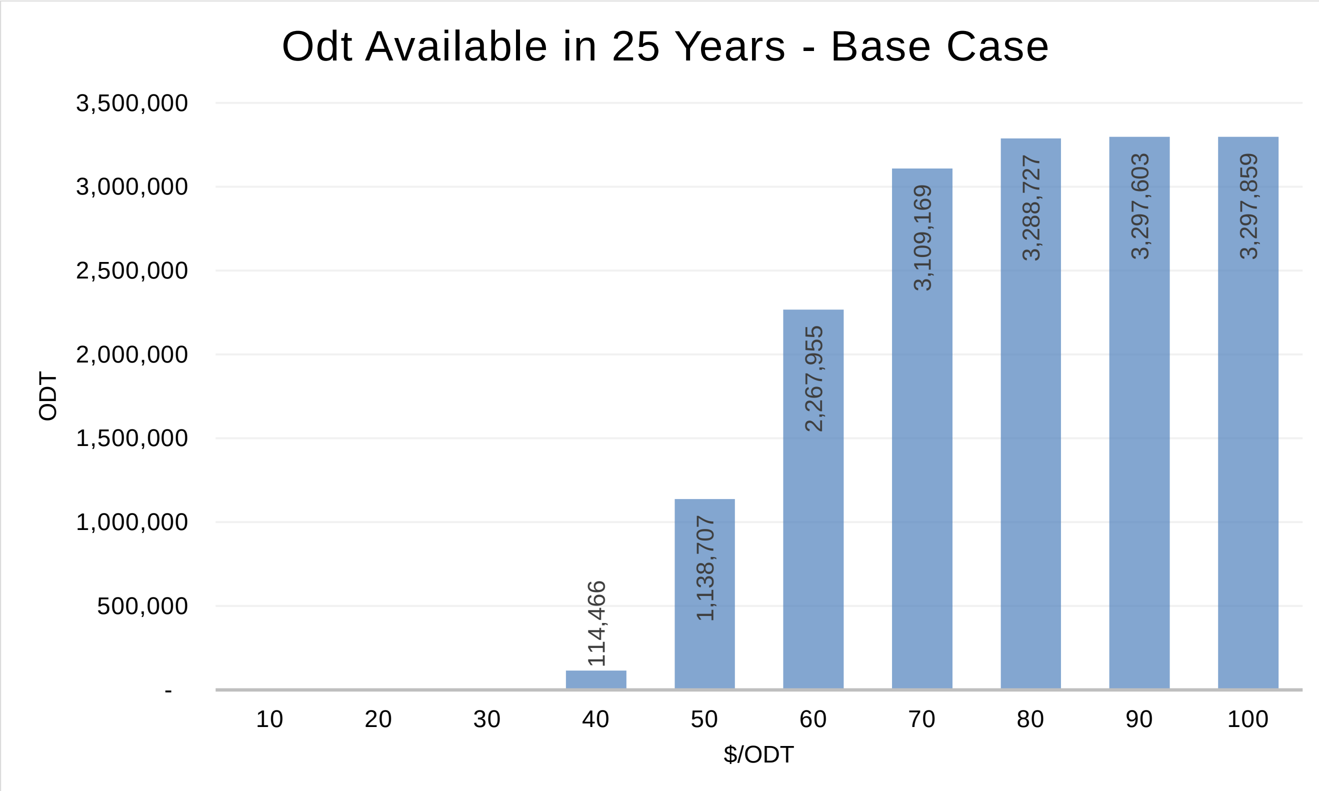

Figure 3. Morice biomass 'cost-availability' in base case.

The average price for delivered biomass across the study area is shown in Table 8.

Table 8. Average cost of delivered biomass across entire study area

Average cost of delivered biomass ($/odt)
54.73

Adding delivery locations near high volume blocks can greatly reduce the overall average cost of delivered biomass. Differences to delivered costs can also be created by changes to equipment or practices that raise or lower operating costs. For example, if greater efficiency in grinding technology is realized, it can dramatically increase the amount of biomass that is economically available, especially, at the lower price points. In this scenario, the average cost of delivered biomass is low at $54.73/odt due to the delivery locations being near the centre of the TSA and therefore, closer to many blocks.

1.8.4 Mapping

The distribution of costs by cutblock is shown graphically in FPInterface with a colour scale ranging from green to red is shown in Figure 4. The costs range to $92/odt for the blocks farthest from the delivery points. The blocks are coloured with the greenest 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.

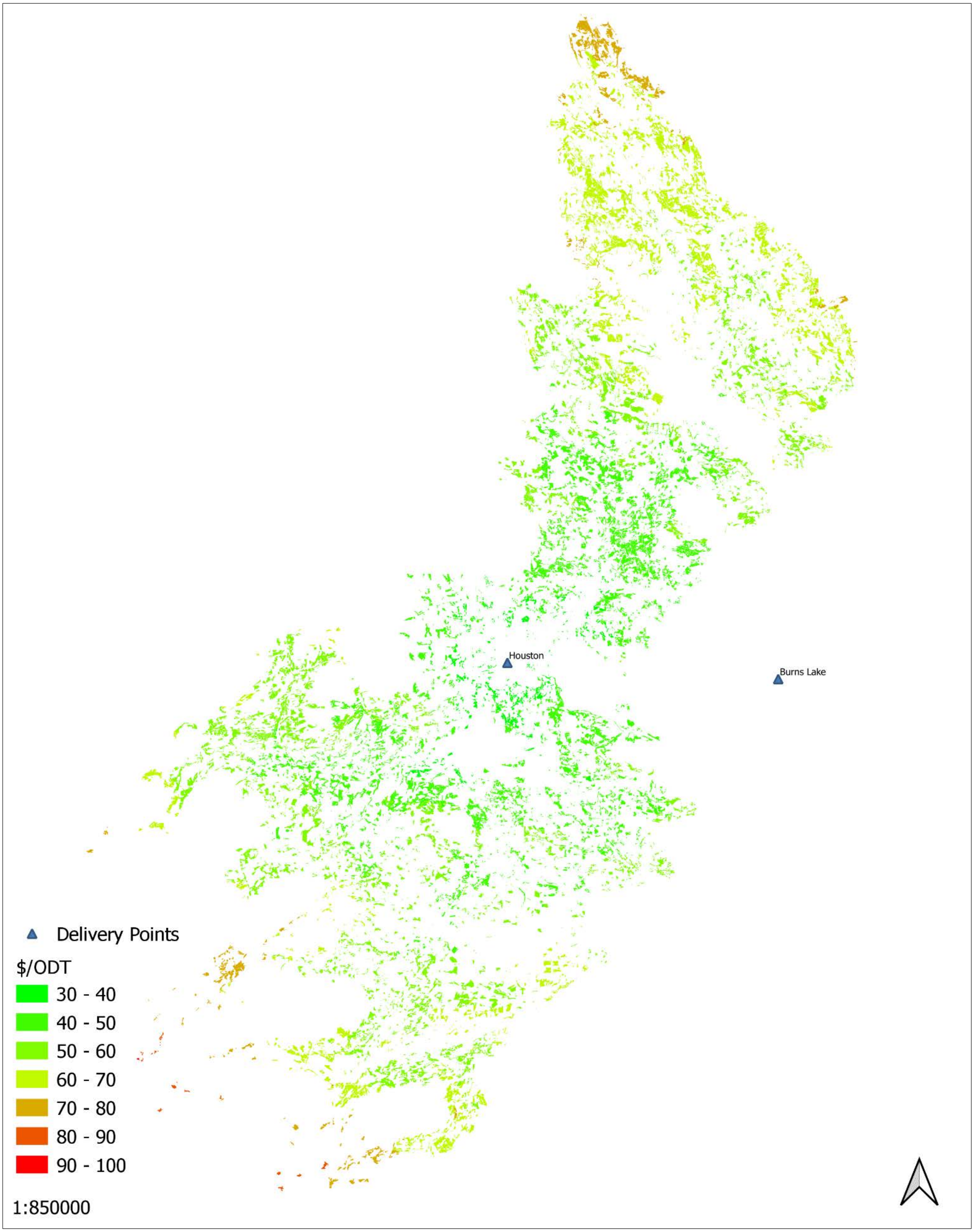

Figure 4. Spatial distribution of cutblocks by delivered biomass cost per odt.

The delivery points are represented by the blue triangles. The low-cost delivered biomass is concentrated near the centre of the TSA, near the delivery points.

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

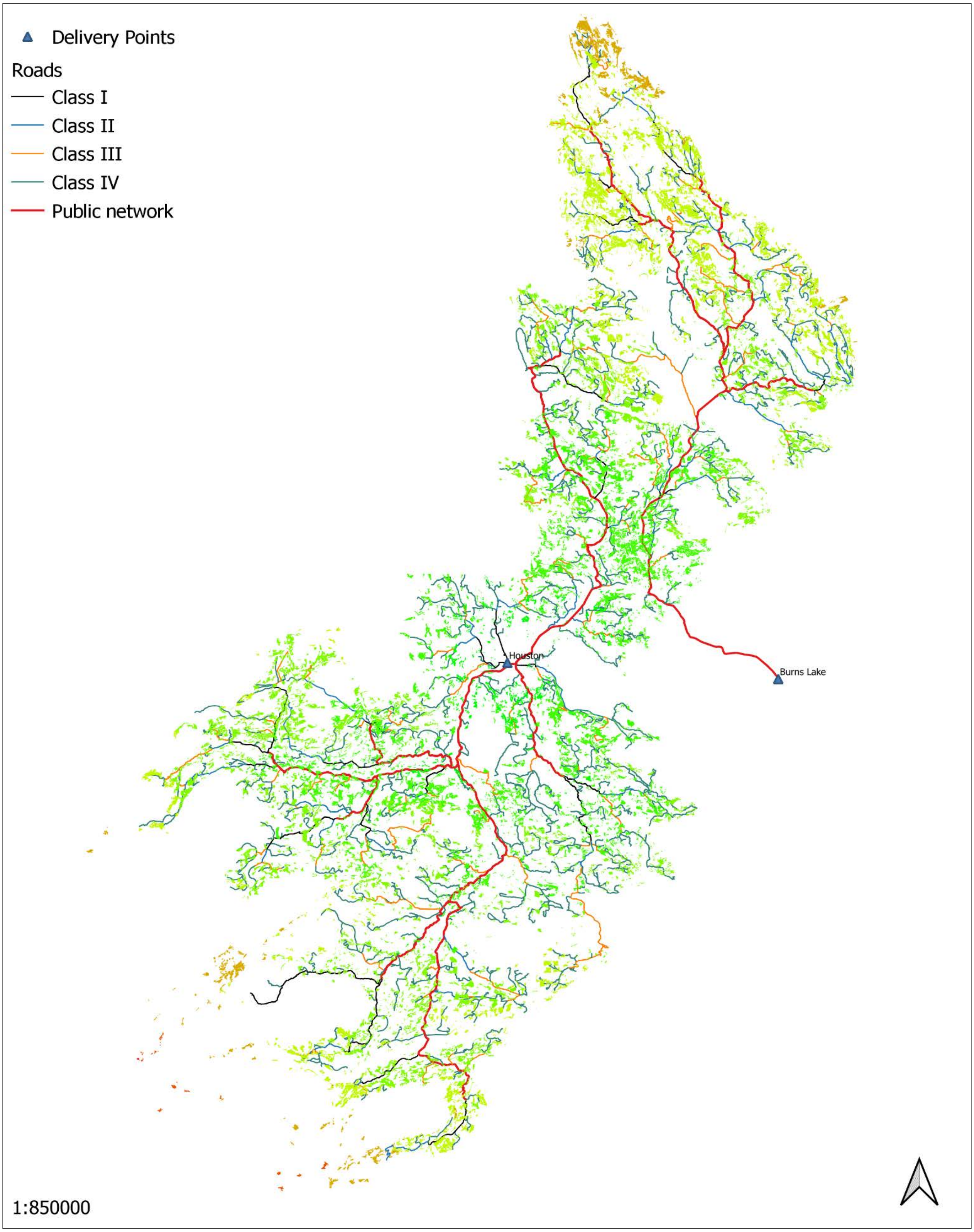

Figure 5. Road classification in the Morice TSA.

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. Most of the slowest roads are in green on this map, while the fastest ones are coloured red and black. Road class is determined by the amount of harvest volume that passes over the road. In order to reduce clutter, winter roads and roads without harvest volume were removed from the map.

1.8.5 Temporal distribution of harvest

The harvest data contains a temporal period assigned to each cutblock. There are five periods in the data representing five-year periods. The first period covers the first five years of cutblocks, the second period covers the next 5 years and so on.

The harvest projection shows a fluctuation in supply of available biomass, as shown in Figure 6. The total amount of available biomass ranges from 486,137 odt in period 2 to 742,211 odt in period 4. These fluctuations are likely due to the variability in merchantable volume between each period.

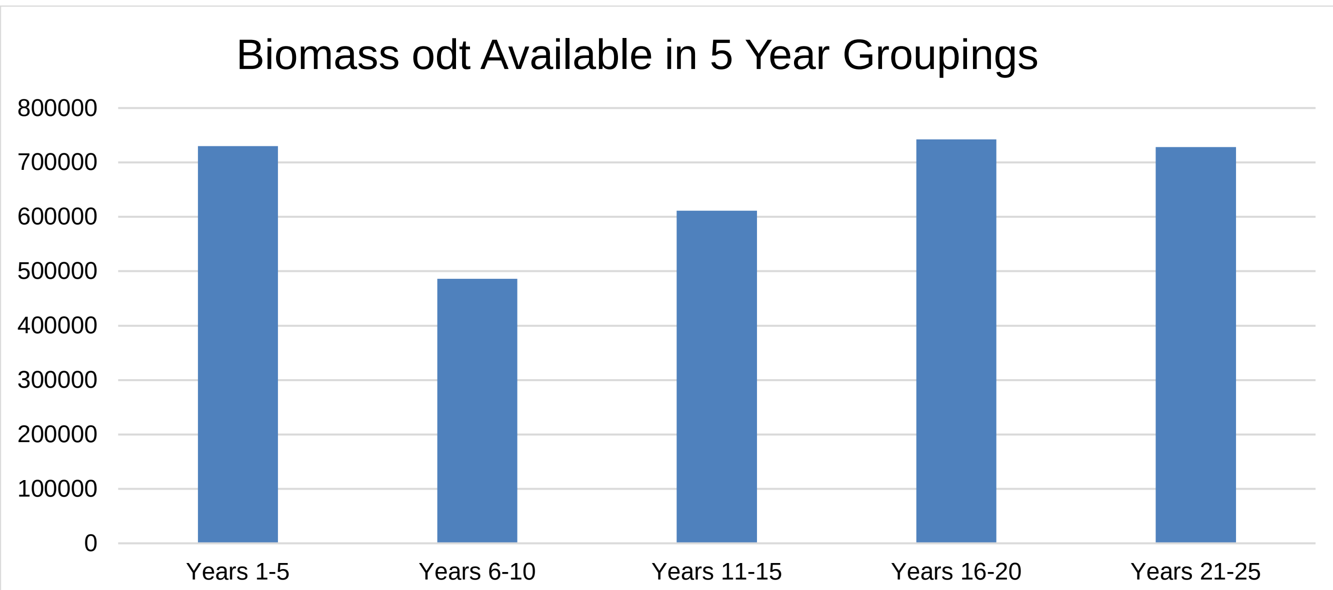

Figure 6. Biomass recoverable by period.

The economic biomass available (the amount at $60/odt or less) in Figure 7 is comparable to the total biomass available at any price point in periods 1, 3, and 5. Between 66%-69% of biomass in these periods is available at $60/odt or less. However, period 2 (Years 6-10) has only 55% of biomass available at the economical price while period 4 (Years 16-20) has 82% of its biomass available at $60/odt or less. These differences are likely due to a lower biomass ratio in period 2 (18.3%) compared to period 4 (21.4%) and also due to having higher volume blocks in period 4 near delivery points.

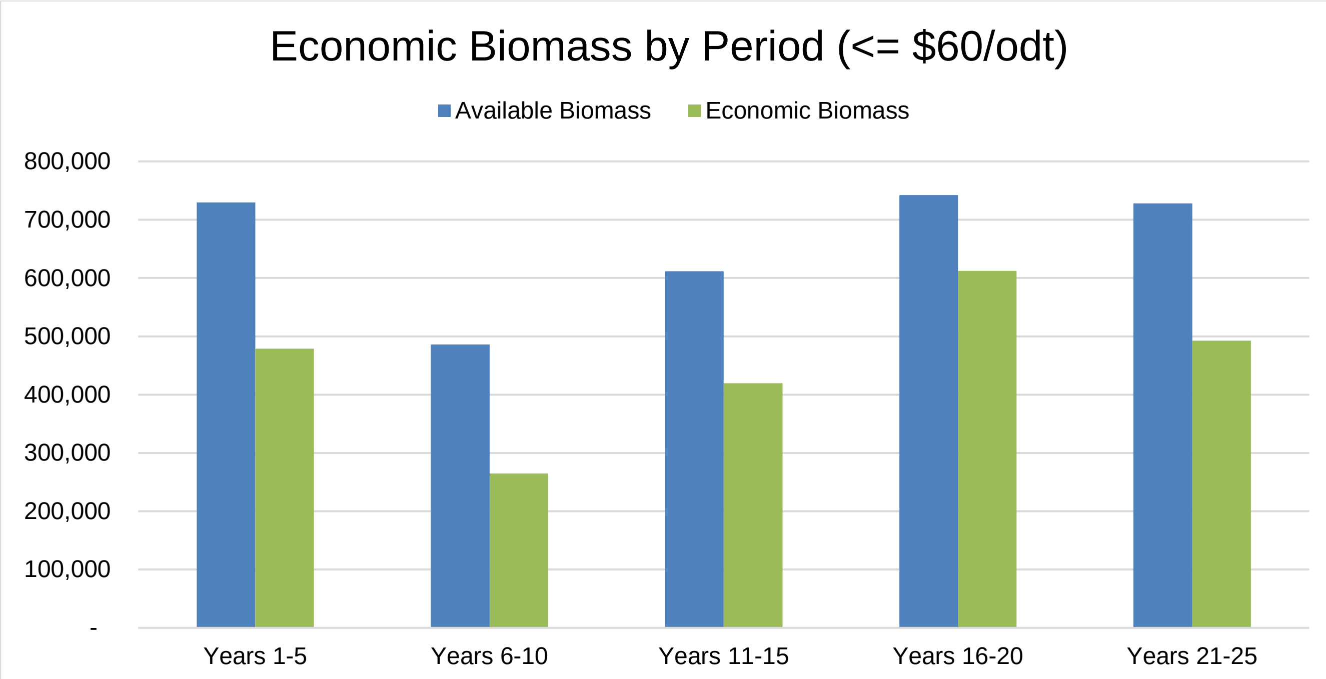

Figure 7. Economic biomass recoverable by 5-year grouping.

The data for cost availability by period at all price points in $10 increments is shown in Table 9 and 10. You can see the differences in economically available biomass fluctuates between periods.

Table 9. Cost availability by period – total odt

Cost $/odt	Period 1 years 1-5	Period 2 years 6-10	Period 3 years 11-15	Period 4 years 16-20	Period 5 years 21-25
10	-	-	-	-	-
20	-	-	-	-	-
30	-	-	-	-	-
40	24,475	14,495	18,780	30,707	26,009
50	303,199	140,210	157,065	273,689	264,544
60	478,786	265,095	419,361	612,247	492,465
70	682,925	446,857	586,380	726,272	666,735
80	729,244	483,606	611,451	742,211	722,215
90	729,880	485,881	611,558	-	728,073
100		486,137			

Table 10. Cost availability by period – odt/year

Cost $/odt	Period 1 - years 1-5	Period 2 - years 6-10	Period 3 - years 11-15	Period 4 - years 16-20	Period 5 - years 21-25
10	-	-	-	-	-
20	-	-	-	-	-
30	-	-	-	-	-
40	4,895	2,899	3,756	6,141	5,202
50	60,640	28,042	31,413	54,738	52,909
60	95,757	53,019	83,872	122,449	98,493
70	136,585	89,371	117,276	145,254	133,347
80	145,849	96,721	122,290	148,442	144,443
90	145,976	97,176	122,312		145,615
100		97,227			

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 Morice TSA is 19.4 oven-dried tonnes per hectare (odt/ha) from harvest residues. This is considered a low volume due to the low volume of merchantable timber within these blocks. Over the next 25 years a total of 3.3 million odt of available biomass are predicted to be generated by harvest in the Morice TSA, or approximately, 132,000 odt/yr. Of this, approximately 2,268,000 odt in total, or 91,000 odt/yr, is expected to be available at the economic price of $60 per oven-dried tonne. Approximately 98% of the available amount is expected to be available at $90/odt: a total of 1.56 million odt, or 156,000 odt/yr. The biomass ratio, which is the ratio of recovered biomass to recovered merchantable roundwood, is estimated at 19.7%.

Most biomass considered economically available (<= $60/odt) is closer to the delivery points. The amount of economically available biomass fluctuates between periods. The Morice TSA has a low average cost of delivered biomass due to the spread-out delivery points and the high-volume blocks located near these delivery points.