Using FPInterface to Estimate Availability of Forest-Origin Biomass in British Columbia: Lakes TSA

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Abstract

Based on inventory information and a 20-year harvest queue, estimates of the amount of biomass available from forest harvest residues are estimated in $10 increments of delivered cost. For the Lakes Timber Supply Area, 76,000 odt/year is projected to be available at $60/odt for years 1-10.

Acknowledgements

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1. Executive summary

In 2011 FPInnovations used FPInterface to develop and demonstrate a method for estimating available forest-origin biomass in British Columbia's Timber Supply Areas: the test case was the Quesnel TSA. The method was subsequently refined and applied to the Williams Lake TSA (2012); the Prince George TSA (2012); and then the Lakes TSA (2012), for which the results are reported here. The biomass inventory was based on 20-year harvest and road network plans for Crown land (excluding Woodlot Licenses, Tree Farm Licenses, Community Forest Agreements, and First Nations tenures) provided by the British Columbia Ministry of Forests, Lands and Natural Resource Operations. The delivery point for biomass was designated as the town of Burns Lake. All planned blocks were assumed to be clearcut harvested, processed at roadside, and accessible to comminution operations.

The total biomass available from harvest residues and mountain pine beetle waste (the portion deemed recoverable) over Year 1 to 10 is projected to be 2.8 million ODT. About 0.76 million ODT, or approximately 76 000 ODT/year, is available at $60/ODT. The amount of biomass available in Years 11 to 20 is about 13 000 ODT/year at $60/ODT. If the acceptable price of delivered biomass rises to $90/ODT, then available biomass is about two times greater.

Very little additional volume is available in Years 11 to 20 at Burns Lake—only about 17% more biomass in total, and 14% more at the $60/ODT price point.

2. Introduction

In order to progress toward full implementation of a bioeconomy in British Columbia a key piece of information is needed—i.e., a detailed inventory of economically available biomass.

To address this need, FPInnovations undertook a project in partnership with the Inventory Branch of the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). The specific goals of the project were to develop a process for calculating biomass inventories in Timber Supply Areas in the Central Interior. The projections of biomass availability were based on 20-year harvest and road network plans for Crown land (excluding Woodlot Licenses, Tree Farm Licenses, Community Forest areas, and First Nations tenures) provided by the MFLNRO.

In 2011 FPInnovations developed a method for estimating available forest-origin biomass in British Columbia's Timber Supply Areas (TSA), using FPInterface: the test case was the Quesnel TSA (Friesen & Goodison, 2011). The method was subsequently refined and applied to the Williams Lake TSA (Friesen, 2012a); the Prince George TSA (Friesen, 2012b); and the Lakes TSA, for which the outcomes are reported here. The aim in providing this information is to help decision makers better understand biomass availability when preparing industrial proposals.

Detailed introductory statements describing the background and rationale of this project and the greater project as a whole are in Friesen & Goodison (2011).

3. Objectives

As abridged from the report about the Quesnel TSA (Friesen & Goodison, 2011) the objectives were:

Calculate biomass supply for volume-based tenures in the Lakes Timber Supply Area (TSA). Specific deliverables include:

a. A map showing the delivered cost of biomass from point of origin by cost gradation.
b. A table showing the amount of biomass delivered at different price points. The market value of one oven-dried tonne (ODT) of biomass could not be specified, but $60 was set as the agreed-upon threshold at which to determine commercial biomass availability.
c. A spreadsheet calculator to determine the amount of available biomass at any user-specified price point.

4. Methods

Overall process

The basic methodology for determining the biomass supply in the Central Interior was established during analysis of the Quesnel TSA (Friesen, 2012a) and the Williams Lake TSA (Friesen, 2012b). It is reviewed below.

The analysis focused on the TSA. It did not include any nearby Woodlot Licenses, Tree Farm Licenses, Community Forest Agreements, or any First Nations tenures. Including any of these areas would have altered the available supply of biomass. Notably, the Community Forest Agreement area near the town of Burns Lake might be a source of low cost biomass, but it was not included in this study.

Additionally, stands considered unmerchantable due to small stem size were not included in the analysis. The analysis focused on recovering harvest residues from merchantable stands. However, purposely harvesting unmerchantable stands for biomass could add to the biomass supply, and further analysis could be undertaken to determine the profitability of this approach.

The process map in Figure 1 graphically displays the steps taken to build the final inventory of economically available biomass for the Quesnel TSA (Friesen & Goodison, 2011). The same process was used for the Lakes TSA.

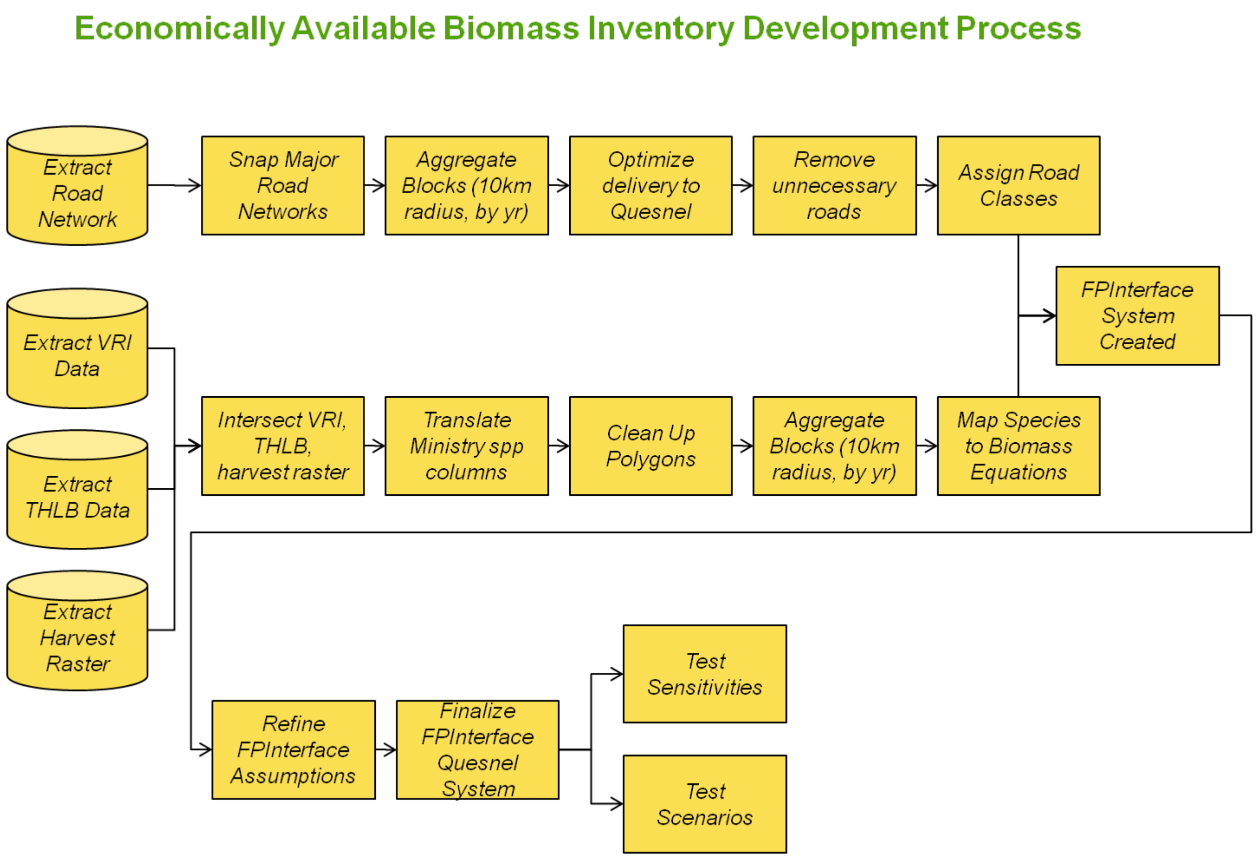

Figure 1. The steps taken to build the final inventory of economically available biomass.

Data acquisition

Data layers for the Lakes TSA (excluding Woodlot Licenses, Tree Farm License areas, Community Forest Agreement areas, and First Nations tenures), including Vegetation Resources Inventory polygons with attributes, and road linework with attributes, were acquired from the MFLNRO. The MFLNRO also supplied a 20-year harvest raster.

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

The harvest raster for the Lakes TSA was in four 5-year periods and not in twenty 1-year periods, which was the case for the Quesnel TSA (Friesen & Goodison, 2011).

Data transformation

FPInterface requires two major inputs—a polygon layer of harvestable blocks with attributes, and a road layer. To acquire the appropriate polygon layer, the Vegetation Resources Inventory, timber harvesting landbase (THLB), and harvest raster were intersected.

To calculate biomass FPInterface requires both tree size data (height and dbh) and either stand density (stems per ha) or volume per ha by species in each polygon. When the polygon layer was uploaded it was necessary to associate the species in the resultant to FPInterface species. The attribute table of the data set did not have columns of species information by species, e.g., there was not a set of lodgepole pine columns. Rather, each polygon had a set of leading species columns and then a set of second species columns, etc. It was necessary to sort the columns into species groups before further analysis.

In order to speed up the calculation, polygons with little or no merchantable volume were targeted for elimination. Polygons with no volume, in which average piece size <0.15 m^3, or being <0.5 ha in size were removed from the resultant. Some of these polygons resulted from the process of intersecting the Vegetation Resources Inventory, THLB, and the harvest raster layers. Removing these polygons caused a reduction in net volume of <4%. Aggregation rules grouped blocks of identical harvest year and within a 10-km radius.

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 it may find a sub-optimal circuitous path. Examination of the data set showed that a great deal of road snapping was required.

Biomass equations

To perform the analysis, tree species indicated in the inventory are tied to single-tree biomass equations in FPInterface. During the analysis of the Quesnel TSA in 2010–11 (Friesen & Goodison, 2011), these equations were based on “Canadian national tree above ground biomass equations” (Lambert et al. 2005). Although this equation set included trees from all across Canada, including western and northern Canada, very few samples were from British Columbia. More recently, Ung et al. (2008) have released tree equations for British Columbia (accepted by the MFLNRO) and these were incorporated into FPInterface for the analyses that were undertaken for the Williams Lake, Prince George, and Burns Lake TSAs (Friesen, 2011, 2012a, 2012b).

FPInterface parameters

Tree species associations

Because of the new set of British Columbia-specific volume equations that were now used in FPInterface, species not previously well represented in the old data set (as in the case of the Quesnel analysis) could now be associated with dedicated equations.

The species associations for the analysis of the Lakes TSA are in Table 1.

Table 1. Tree species associations

Vegetation resources inventory species	FPInterface biomass equation
cottonwood	other poplars
trembling aspen	trembling aspen
subalpine fir	alpine fir
western redcedar	western redcedar
white birch	white birch
Douglas-fir	Douglas-fir (interior)
western hemlock	western hemlock
tamarack	western larch
western larch	western larch
lodgepole pine	lodgepole pine
spruce	white spruce
white spruce	white spruce
Engelmann spruce	white spruce
Sitka spruce	white spruce
hybrid spruce	white spruce
black spruce	white spruce

Road classes

Unlike the dataset provided for the analysis of the Quesnel TSA, the road data set for the Lakes TSA contained no road classes. However, FPInterface has the ability to assign road classes based on the amount of volume hauled over each section of 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	Volume		Road speed		
	Minimum (m^3)	Maximum (m^3)	Posted speed (km/h)	Empty haul[a] (km/h)	Loaded haul[b] (km/h)
Paved	5 000 001	50 000 000	90	86	77
Class 1	1 000 001	5 000 000	70	67	60
Class 1 (off highway)	0	0	70	67	60
Class 2	500 001	1 000 000	50	48	43
Class 3	100 001	500 000	40	38	34
Class 4	50 001	100 000	20	19	17
Class 4 (operational)	0	0	20	19	17
Class 5 (winter)	0	50 000	20	19	17

[a] 95% of posted speed. [b] 85% of posted speed.

General parameters

The price of fuel can have significant impacts on model results. Some equipment in the model can use diesel while other equipment is eligible for marked fuel. A price of $1.25/L was assigned, which was near to commercial rates for diesel but was slightly higher than the price of marked fuel at the time.

The program's default values for productivities and costs of forestry equipment rely on a long history of FPInnovations studies and other information gathered by FPInnovations. 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. For verification of their suitability they were compared with machine costs listed in the *Interior Appraisal Manual* and were found to be close approximates.

Based on a terrain classification system developed by the Canadian Pulp and Paper Association (CPPA) (Mellgren, 1980), average slope for the Mackenzie TSA was assigned to CPPA Class 3 (20 to 32%). Ground strength was rated as CPPA Class 2 (good), and ground roughness was rated as CPPA Class 2 (slightly even).

Although British Columbia regulations require a topping diameter of 10 cm for most merchantable species, the Quesnel TSA analysis used 12.5 cm to reflect more common industrial practise (Friesen & Goodison, 2011). Rounding in FPInterface meant topping diameter was set at 13 cm for Quesnel. Refinements to the program allowed the topping diameter to be set to 12.5 cm for the Burns Lake analysis. Topping diameter has a significant impact on determining the volume of a tree, and therefore on its availability for biomass use.

Utilization of lodgepole pine and mountain pine beetle-attacked wood: considerations

The harvesting of standing trees for biomass purposes is not generally considered economic in British Columbia because their recovery must cover the full costs of planning, developing, and harvesting stands, in addition to costs for biomass recovery[1] operations. However, because of mortality due to mountain pine beetle infestation of lodgepole pine in the Interior, some whole logs were included for biomass chipping. Although the timber harvesting land base (THLB) proportion attribute includes mortality attributed to mountain pine beetle, because of continuing attack by the beetle and the resulting degradation of logs, 30% of lodgepole pine volume was removed from availability as merchantable volume. Half of this (15% of total lodgepole pine volume) was estimated to be available for whole log chipping or grinding at roadside, and the remainder was counted as loss (Figure 2).

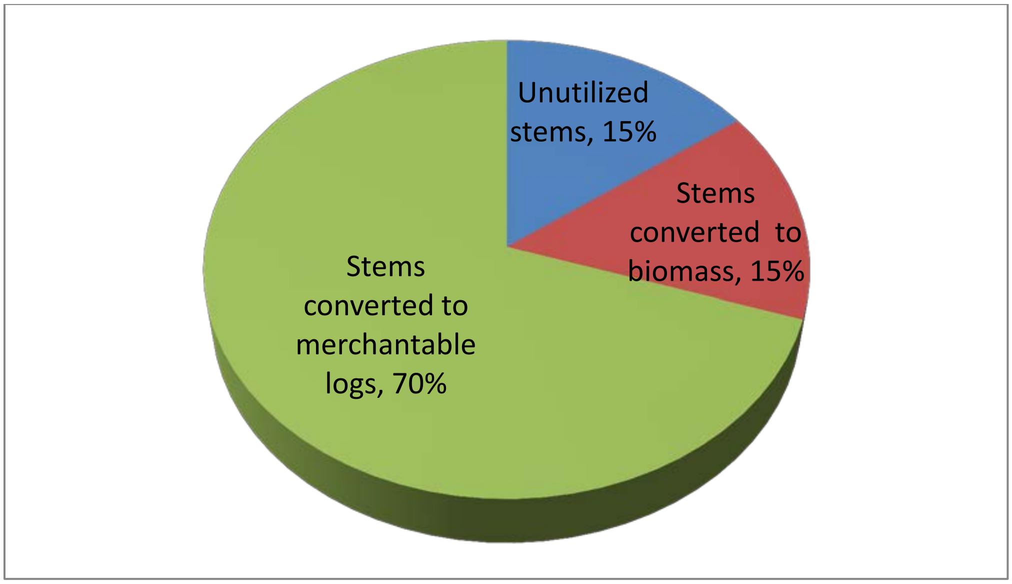

Figure 2. Utilization of mountain pine beetle-affected stems: standards used in the analysis.

Time frame

The data identified 20 years of harvest. Like Quesnel, an examination of the merchantable output showed a merchantable volume fall down projected for Years 11 to 20. Therefore, and to be consistent with the methodology used in the analysis of the Quesnel TSA, the base case was considered to be the 10-year harvest, although results for both the 10-year base case and 20-year scenario are included here.

Mill location

With the largest population in the TSA, the town of Burns Lake was used as the delivery point for the biomass.

[1] biomass recovery = comminution + transport of harvest residues

Biomass calculations

The biomass calculations in FPInterface produce an amount 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 3 shows this breakdown with the numbers from the 10-year base case harvest.

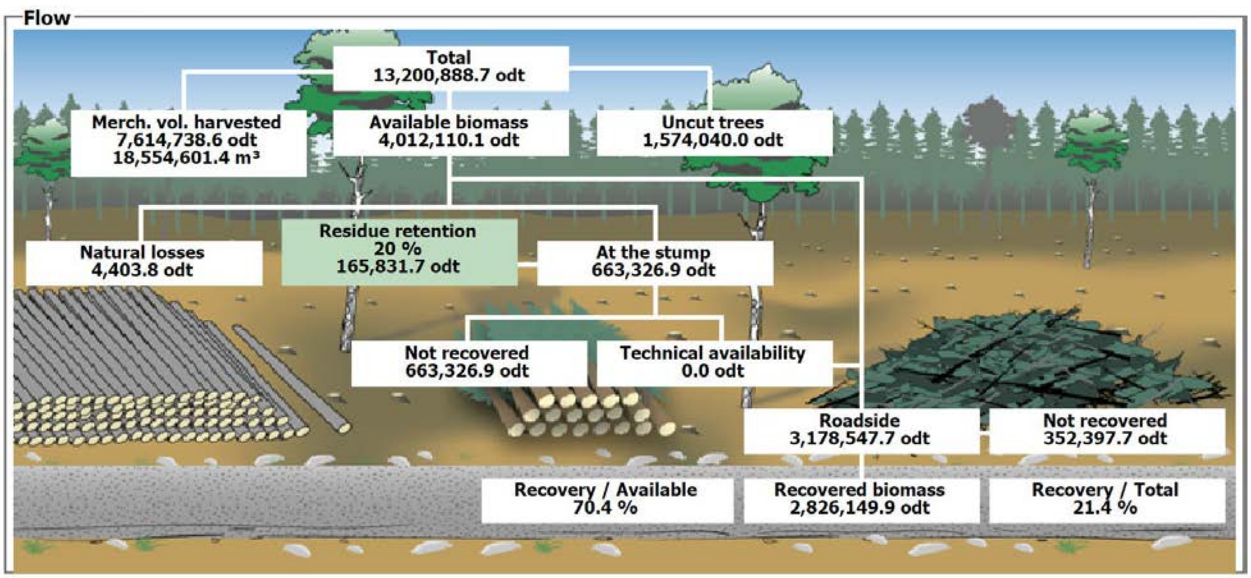

Figure 3. Recoverable biomass, Lakes TSA: 10-year harvest base case.

5. Results and discussion

Summary — key results

Key results from the base case runs for the 10 and 20 years of harvest are summarized in Tables 3 and 4. More detailed results are in Appendix 2.

The total biomass available at any price point from harvest residues and mountain pine beetle waste (the portion deemed recoverable) over Years 1 to 10 was projected to be 2.8 million ODT. About 760 000 ODT (or approximately 76 000 ODT/year) would be available for $60/ODT. The amount of biomass available in Years 11 to 20 was about 13 000 ODT/year at a $60/ODT price point. If the acceptable price of delivered biomass rose to $90/ODT, then available biomass would be about two times greater.

Each cut period is 5 years in length (Figure 4). The falldown between the first and second decades (between cut periods 2 and 3) is evident.

There is very little additional volume available in Years 11 to 20 at Burns Lake (Figure 4)—only about 17% more biomass in total, and 14% more at the $60/ODT price point. These results show that a significant falldown is projected for the Lakes TSA based on the harvest plan.

In Years 1 to 10 about 68% of harvest residues come from lodgepole pine. In Years 11 to 20, only 14% of harvest residues come from pine because the harvest shifts to non-pine species (Table 5).

Annualized, the base case shows that approximately 76 000 ODT/year from harvest residues (at $60/ODT) could become available during Years 1 to 10, provided it is not already fully or partially allocated. During Years 1 to 20 a much lesser amount, i.e., 13 000 ODT/year, would be available for $60/ODT.

The biomass ratio (the ratio of recovered biomass to recovered merchantable roundwood) for the base case was 37%. This was slightly higher than is usually predicted for harvest residues, partially because 15% of lodgepole pine stems were designated for biomass. If only slash (harvest residues, no stems) is used to produce biomass, the biomass ratio becomes 19%. Based on other FPInnovations studies, this is a typical number for roadside harvesting in the Central Interior.

Table 3. Harvest availability for bioenergy, by cost per ODT: 10-year base case

Cost ($/ODT)	Available volume	
	Total (ODT)	Annually (ODT/year)
40	0	0
50	101 566	10 157
60	761 256	76 126
70	1 272 376	127 238
80	1 371 634	137 163
90	1 555 587	155 559
100	1 619 175	161 918
110	1 644 725	164 473
120	1 808 851	180 885
130	2 220 067	222 007
140	2 539 973	253 997
150	2 686 407	268 641
160	2 774 868	277 487
170	2 813 585	281 359
180	2 823 224	282 322
190	2 826 149	282 615

Table 4. Harvest availability for bioenergy: by cost per ODT: 20-year scenario

Cost ($/ODT)	Available volume	
	Total (ODT)	Annually (ODT/year)
40	0	0
50	108 022	10 802
60	888 824	88 882
70	1 478 297	147 830
80	1 658 231	165 823
90	1 897 196	189 720
100	1 983 958	198 396
110	2 035 106	203 511
120	2 279 237	227 924
130	2 702 221	270 222
140	3 039 738	303 974
150	3 186 442	318 644
160	3 298 377	329 838
170	3 359 830	335 983
180	3 375 724	337 572
190	3 380 754	338 075
200	3 381 678	338 168
210	3 385 108	338 511
220	3 392 601	339 260
230	3 397 775	339 778
240	3 398 816	339 882
250	3 399 569	339 957

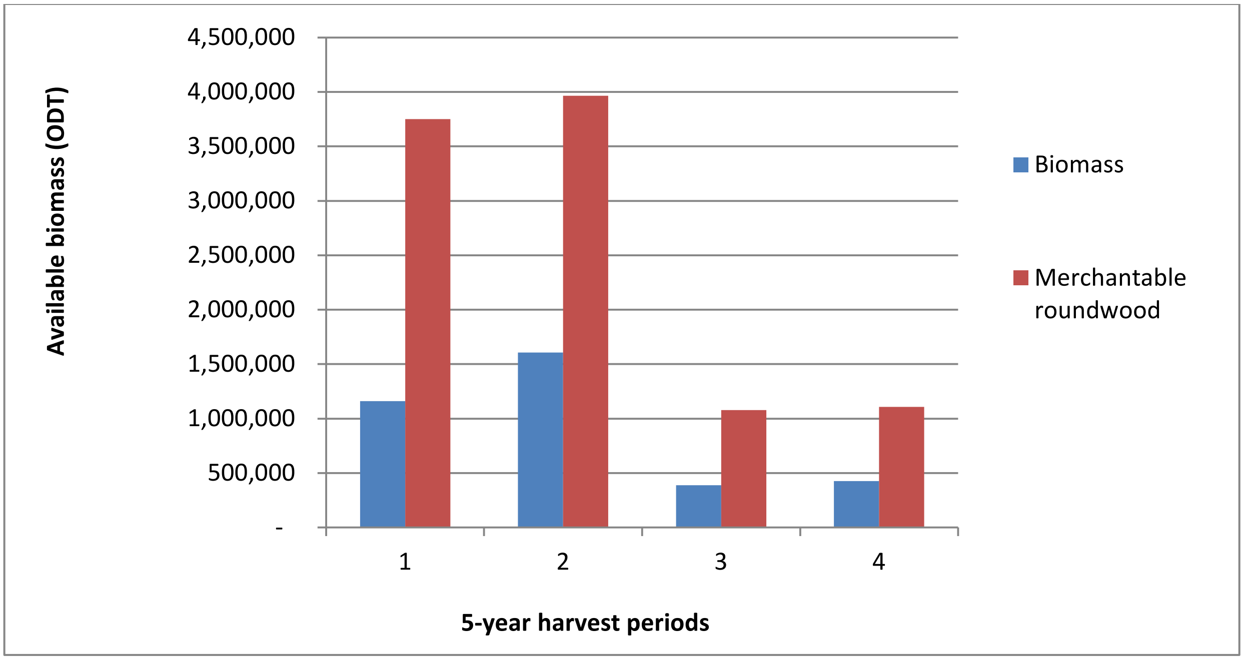

Figure 4. Projected annual biomass harvests for the Lakes TSA.

Table 5. Breakdown of biomass volumes, by source and time period

Biomass harvest characteristics	Volume (ODT)
First decade (Years 1 to 10)	
Total biomass	2 826 149
Biomass from residues	1 644 498
Pine residues	1 126 410
Non-pine residues	518 088
Both decades (Years 1 to 20)	
Total biomass	3 399 569
Residues	2 127 372
Pine residues	1 195 283
Non-pine residues	932 089
Second decade (Years 11 to 20)	
Total biomass	573 420
Residues	482 874
Pine residues	68 873
Non-pine residues	414 001
Non-pine residues as % of total second decade residues	86%
Pine residues as % of first decade pine residues	6%

Base case

Some of FPInterface's more significant settings for the base case are listed in Table 6.

The topping diameter was previously discussed in section 1.4.3. In the analysis of the Quesnel TSA (Friesen & Goodison, 20111), the harvest system was set to "full tree" and then processing activities were set to occur at roadside. However, FPInterface has a harvest setting called "full tree with roadside processing", that is backed with a different set of data points, and which has been used for runs subsequent to the one for Quesnel. The change produces a very small variation in results (<2%), so it was decided to use this new setting because it more accurately describes operations typical to interior British Columbia.

Figure 5 presents an isometric map of harvest blocks by biomass cost, and Table 7 presents cost-availability data in $10/ODT increments. The recovered biomass from logs column is biomass from mountain pine beetle stems, and the recovered biomass from harvest residues column is biomass from tops and branches after processing at roadside. Harvest residues are cheaper because the felling and extraction costs are applied to the conventional merchantable harvest volumes. In the case of recovered biomass from logs, all costs of harvest are applied to biomass, instead of being written off against roundwood, making it much more expensive. Table 7 shows that purpose-harvested wood for biomass is expensive, with costs being >$100/ODT.

The output report for the base case (Appendix 1) shows that comminution costs average $31.80/ODT. For the harvest residues component, the remainder of the costs are in the transport phase. For the full stem (recovered biomass from logs) component, the average harvest cost is $68.45/ODT[2], comminution costs are $31.80/ODT, and transport costs make up the balance.

The graph of available biomass (Figure 6) shows bimodal (two hump) distribution. The first mode is biomass from harvest residues; the second mode reflects full stems from mountain pine beetle-affected lodgepole pine (recovered biomass from logs).

[2] $28.62 x 2 826 149 / 1 181 651 = (harvest cost x (total biomass / pine stem biomass))

Table 6. FPInterface parameters: base case[a]

Run descriptor	Base case
run name	Burns_Lake_17apr2012
output name	Burns_Lake_17apr2012
transfer yard(s)	Burns Lake
year(s) analyzed	1-10
species attribute linking	BC
haul speeds	graduated
haul speeds at 95% / 85% of posted	y
transport shifts / day	1
transport hours / shift	10
transport days / year	180
transport fuel price / litre	$1.25
average slope	20-32
slash used for biomass	y
full stem used for biomass	n
Pl utilization of THLB merchantable timber (%)	70
Pl unutilized merchantable used for biomass (%)	15
Pl stems for biomass chipped where?	roadside
Pl merchantable stemwood for biomass directed where	closest yard
chips destination	closest yard
topping diameter (cm)	12.5
truck used for chips	3-axle
truck used for logs	B-train
harvesting fuel price / litre (x3)	$1.25
harvesting shifts / day (x3)	1
harvesting hours / shift (x3)	10
harvesting days / yr (x3)	180
harvesting system	full tree with roadside processing
on site biomass treatment (roadside)	comminution
recovery season	winter
slash freshness	fresh
slash pre-piled at roadside	y
grinder size type	horizontal 600 kW
biomass fuel price / litre (x2)	$1.25
biomass hours / shift (x2)	10
biomass shifts / day (x2)	1
biomass days / yr (x2)	180
indirect costs - biomass ($ value)	$0.00
indirect costs - harvesting ($ value)	$0.00

[a] The parameters highlighted in yellow indicate differences from those used for the analysis of the Quesnel TSA (Friesen & Goodison, 2011).

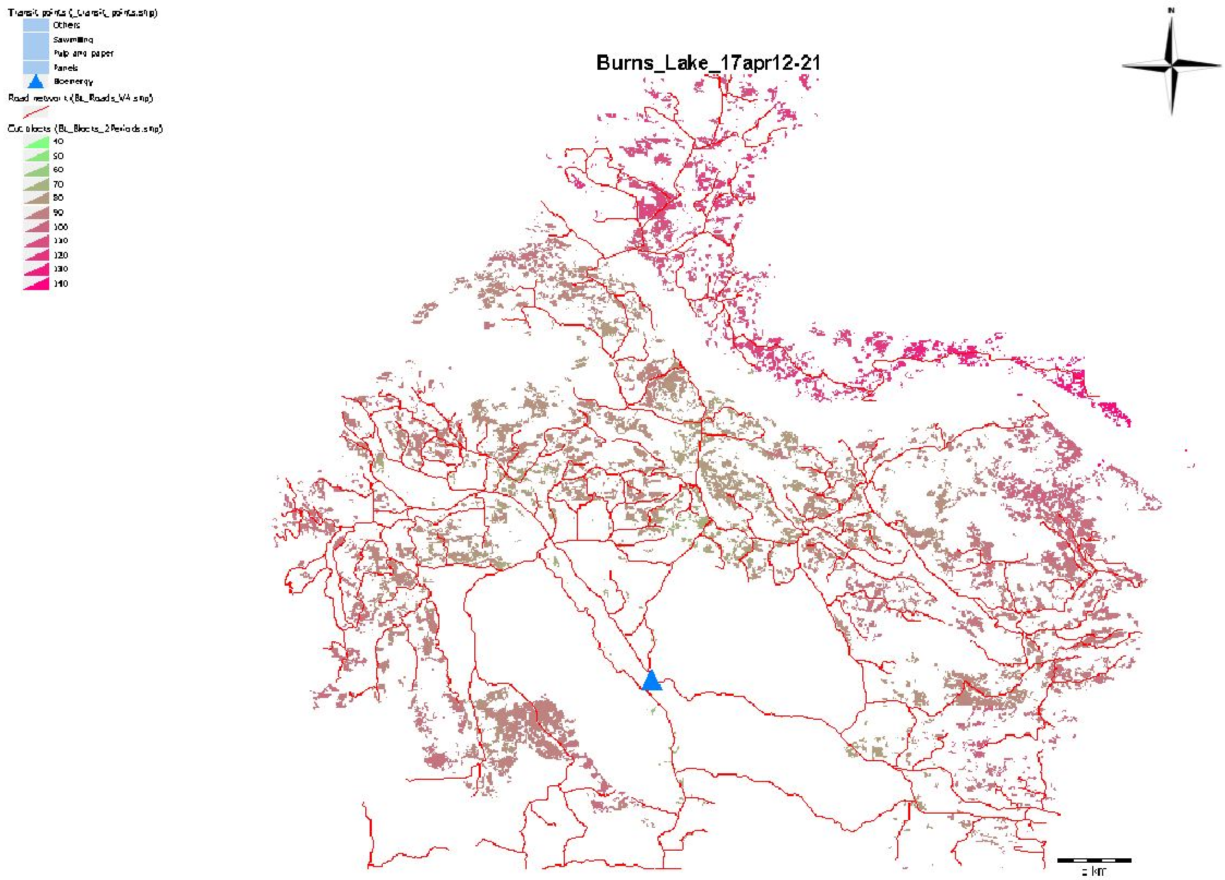

Figure 5. Cost of delivered biomass from point of origin, in increments of $10 /ODT: 10-year base case, upper middle portion of Lakes TSA. The cost of biomass from roadside residues is averaged with the cost of residue obtained from mountain pine beetle stems. Blocks closest to the delivery points have the lowest delivered costs and are the greenest in colour. Blocks furthest from the mills are the most expensive and the reddest.

Table 7. Cost-availability of biomass, Lakes TSA: 10-year base case

Cost ($/ODT)	Recovered biomass		
	From logs (ODT)	From harvest residues ODT)	Total (ODT)
10	-	-	-
20	-	-	-
30	-	-	-
40	-	-	-
50	-	101 567	101 567
60	-	761 256	761 256
70	-	1 272 356	1 272 356
80	-	1 371 634	1 371 634
90	-	1 555 588	1 555 588
100	-	1 619 176	1 619 176
110	227	1 644 498	1 644 725
120	164 353	1 644 498	1 808 851
130	575 570	1 644 498	2 220 068
140	895 475	1 644 498	2 539 973
150	1 041 919	1 644 498	2 686 417
160	1 129 370	1 644 498	2 773 868
170	1 169 088	1 644 498	2 813 586
180	1 178 727	1 644 498	2 823 225
190	1 181 652	1 644 498	2 826 150

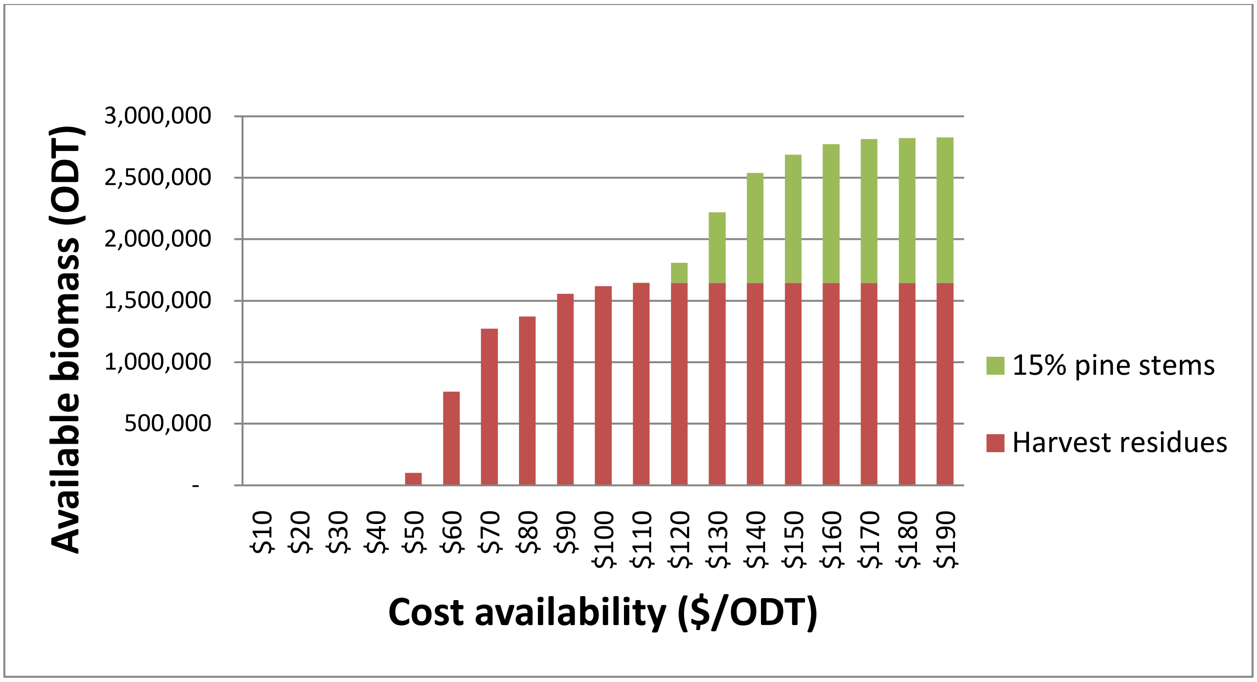

Figure 6. Cost availability of biomass in the Lakes TSA: 10-year base case.

Residue cost calculator, by mill

Based on the Excel output from FPInterface, it is possible to see how much biomass was available at each delivery point at a price point specified by the user. Appendix 1 of this report consists of an Excel workbook, i.e., the Burns Lake Residue Cost Calculator. A snip of the sheet is in Figure 7.

By entering the target price for delivered biomass (dollar amount in green), the amount of ODT available at that price point is shown for each delivery point (labelled “transfer yards”).

This calculator shows the available biomass from residues only. Because full log biomass (15% of lodgepole volume) would not become available until the price point rises above $100/ODT, amounts up to $100/ODT also reflect total biomass available.

Calculators for both the 10-year base case and 20-year scenario are included in Appendix 1.

There is great sensitivity to supply at prices between $60 and $70/ODT (Table 8). The table shows that even small increases in price make much more biomass available. If ways can be found to save costs, even slightly, significantly more biomass could become available.

	A	B	C	D	E	F	G	H	I	J	K
1	**Burns Lake - 10 year harvest**				amounts available at		$64	/odt	Transfer yard: Transit point # 1	961,378	odt
2											
3	(does not include biomass from 15% Pl full stem - min price $110/odt)								Total	961,378	odt
4											

Figure 7. Snip of “Residue cost calculator, by delivery point”.

Table 8. Supply sensitivity to biomass prices between $60 and $70/ODT: 10-year base case

Price ($/ODT)	10-year supply at $60/ODT (ODT)
60	761 257
61	795 615
62	823 431
63	886 698
64	961 378
65	999 474
66	1 057 824
67	1 111 039
68	1 188 665
69	1 243 262
70	1 272 376

6. Conclusions

We developed a method for estimating available forest-origin biomass for British Columbia Timber Supply Areas, using FPInterface. The Quesnel TSA was the test case (Friesen & Goodison, 2011). Extrapolating on that experience and subsequent runs for the Williams Lake TSA (Friesen, 2012a) and the Prince George TSA (Friesen, 2012b), estimates were made for the Lakes TSA. The biomass inventory was based on 20-year harvest and road network plans for Crown land (excluding Woodlot Licenses, Tree Farm Licenses, Community Forest Agreements, and First Nations tenures) provided by the British Columbia Ministry of Forests, Lands and Natural Resources. The delivery point for biomass was designated at Burns Lake only. All planned blocks were assumed to be clearcut harvested, processed at roadside, and accessible to comminution operations.

The total biomass available from harvest residues and mountain pine beetle waste in Years 1 to 10 was projected to be 2.8 million ODT. About 0.76 million ODT (or approximately 76 000 ODT/year) was available at $60/ODT. The amount of biomass available over Years 1 to 20 was about 13 000 ODT/year at $60/ODT. If the acceptable price of delivered biomass rose to $90/ODT, then available biomass would be about two times greater.

Very little additional volume would be available in Years 11 to 20 at Burns Lake—only about 17% more biomass in total, and 14% more at the $60/ODT price point. These results showed a significant falldown projected for the Lakes TSA, based on the harvest plan provided by MFLNRO.

The analysis focused on the TSA. It did not include any nearby Woodlot Licenses, TFLs, Community Forest Agreements, or any First Nations tenures. Including some of these areas may have altered the available supply of biomass. Notably, the Community Forest Agreement area near the town of Burns Lake might be a source of low-cost biomass. If another processing centre were established that optimized the location of the First Nations tenures, the cost-effective biomass supply could increase.

Additionally, stands considered unmerchantable due to small stem size were not included in the analysis. The analysis focused on recovering harvest residues from merchantable stands only. Purposely harvesting unmerchantable stands for biomass could add to the biomass supply, and further analysis with FPInterface could be undertaken to determine the profitability.

7. References

Friesen, C. (2012a). *Using FPInterface to estimate available forest-origin biomass in British Columbia: Williams Lake TSA* (Technical Report). Vancouver, British Columbia: FPInnovations.

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8. Appendix

Appendix 1

Excel spreadsheet: Burns lake residue cost calculator

Appendix 2

Output maps and cost-availability tables

2.1 10-Year Base Case

2.2 20-Year Base Case

Territory:	Unknown territory
Sector:	Unknown sector
Cut block:	<Multiple selection>

Statistics - Selected Items

Area	69,869.2 ha
Number of cut blocks	407
Recovered biomass	2,826,149.9 odt
Recovery rate	40.4 odt/ha
Biomass odt / Merchantable m³	0.1462 odt/m³
Delivered products	
• Chips	100 %
• Bundles	0 %
• Trunks and Residues	0 %
Energy balance	37 : 1
Available energy	10,234,718 MWh
Fuel consumption	11.3 L/odt

Cost

Harvesting	28.62 $/odt
Biomass recovery	31.80 $/odt
Transfer yard	0.00 $/odt
Transportation	32.33 $/odt
Stumpage fees	0.00 $/odt
Road network - Maintenance	0.62 $/odt
Indirect costs	0.00 $/odt
Total	93.37 $/odt

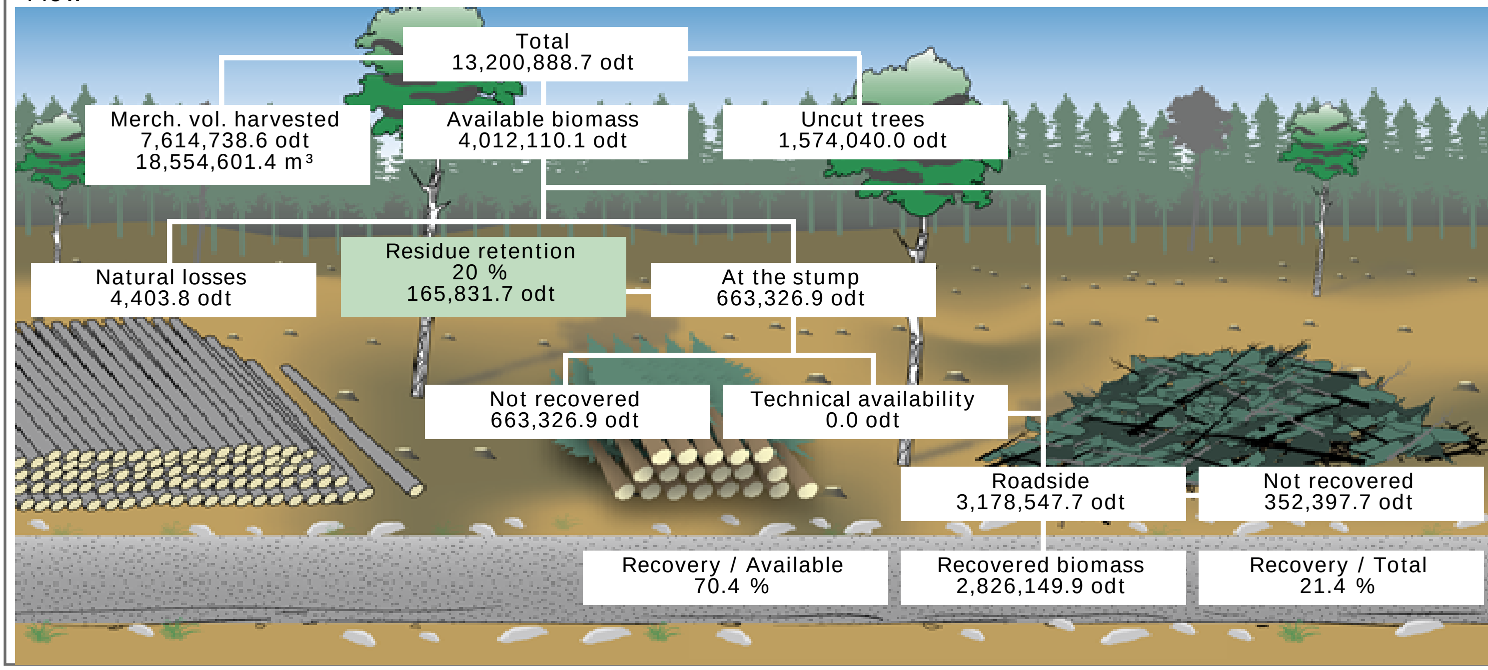
Revenue

Sale value	0.00 $/odt
Silvicultural discount	0.00 $/odt

Net

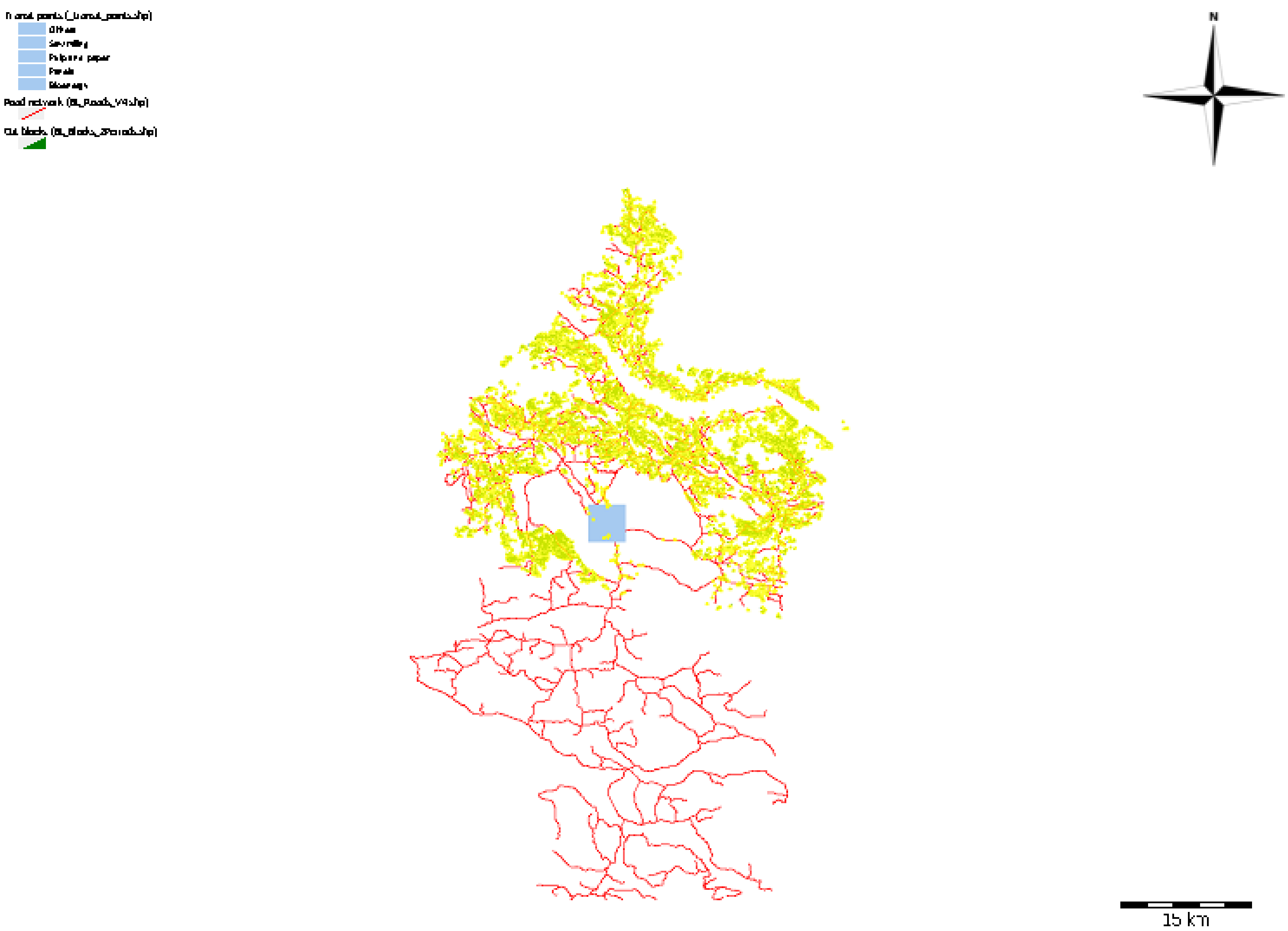
Profit	-93.37 $/odt

Flow



Products

Product name	odt	odt/m³	odt/ha
Lodgepole Pine-Biomass	1,181,651.9	28.4344	16.91
Lodgepole Pine (residues)	927,632.3	0.0764	13.28
Spruce (residues)	418,203.7	0.1196	5.99
Lodgepole Pine-Biomass (residues)	198,778.3	0.0764	2.85
Balsam (residues)	66,861.6	0.0970	0.96
Trembling Aspen (residues)	30,951.0	0.0925	0.44
Birch (residues)	1,040.7	0.1736	0.01
Douglas Fir (residues)	1,030.4	0.1763	0.01
	2,826,149.9	0.1462	40.45



407 selected site(s) / 407

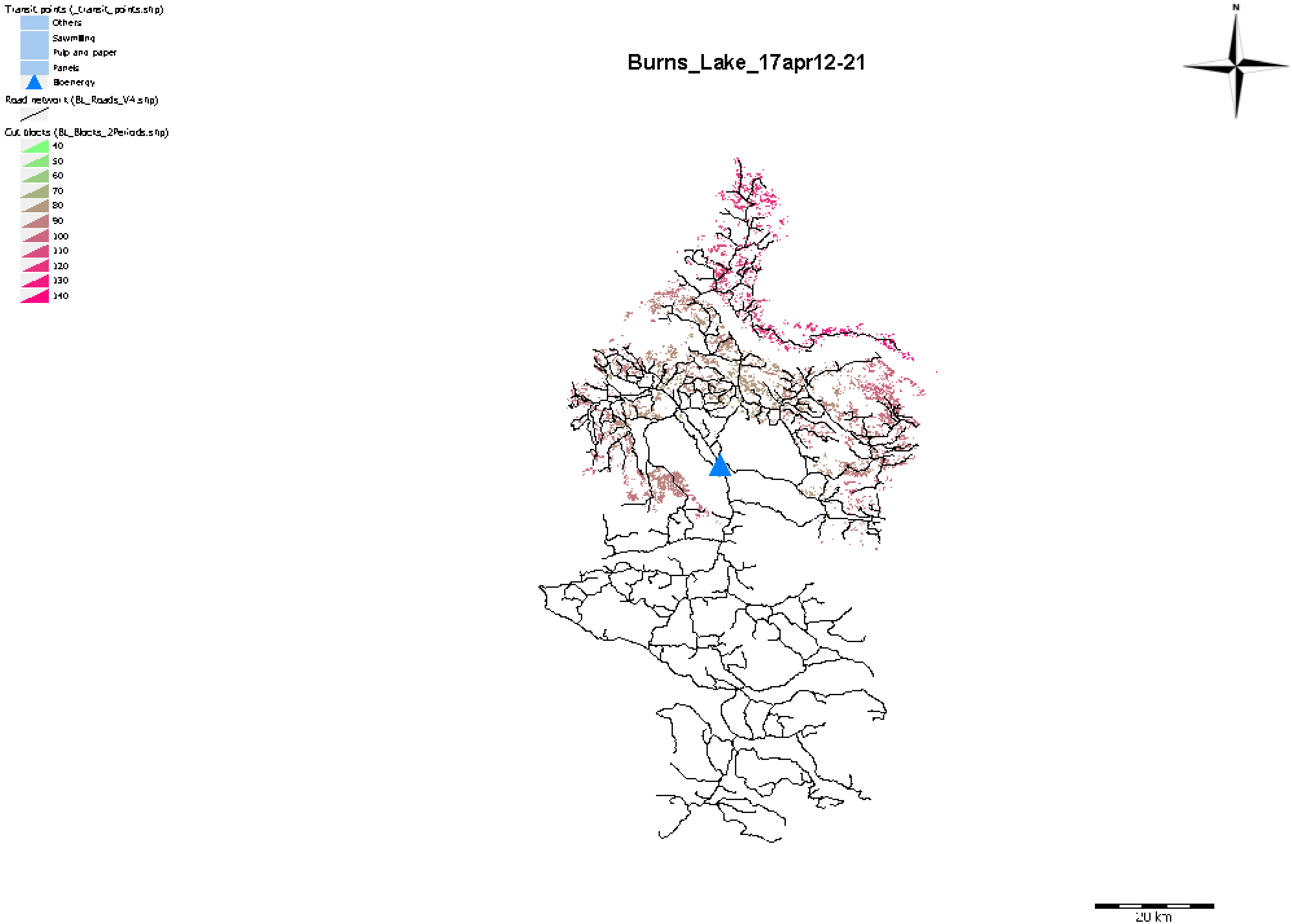
Area covered: 69,869 ha / 69,869 ha

Recovery summary

	Volume(odt)	Area(ha)	Number of cut blocks
• Biomass recovery location			
At the stump	0.0	0.0	0
Roadside	2,826,149.9	69,869.2	407
• Recovery season			
Summer	0.0	0.0	0
Winter	2,826,149.9	69,869.2	407
• Residue freshness			
Fresh	2,826,149.9	69,869.2	407
Brown	0.0	0.0	0
Brittle	0.0	0.0	0

Supply summary

Recovered biomass to	Merchantable volume (odt)	Residues (odt)	Total biomass (odt)
10 $/odt	0.0	0.0	0.0
20 $/odt	0.0	0.0	0.0
30 $/odt	0.0	0.0	0.0
40 $/odt	0.0	0.0	0.0
50 $/odt	0.0	101,566.9	101,566.9
60 $/odt	0.0	761,256.4	761,256.4
70 $/odt	0.0	1,272,376.0	1,272,376.0
80 $/odt	0.0	1,371,634.1	1,371,634.1
90 $/odt	0.0	1,555,587.8	1,555,587.8
100 $/odt	0.0	1,619,175.8	1,619,175.8
110 $/odt	227.0	1,644,498.1	1,644,725.0
120 $/odt	164,353.4	1,644,498.1	1,808,851.5
130 $/odt	575,569.8	1,644,498.1	2,220,067.9
140 $/odt	895,475.3	1,644,498.1	2,539,973.4
150 $/odt	1,041,909.0	1,644,498.1	2,686,407.1
160 $/odt	1,129,370.4	1,644,498.1	2,773,868.4
170 $/odt	1,169,087.6	1,644,498.1	2,813,585.6
180 $/odt	1,178,726.5	1,644,498.1	2,823,224.5
190 $/odt	1,181,651.9	1,644,498.1	2,826,149.9
Maximum cost	182.00 $/odt	108.05 $/odt	


Burns_Lake_17apr12-21
Transit points (_transit_points.shp)
Others
Sawmilling
Pulp and paper
Panels
Bioenergy
Road network (BL_Roads_V4.shp)
Cut blocks (BL_Blocks_2Periods.shp)
40
50
60
70
80
90
100
110
120
130
140
N
20 km

Territory:	Unknown territory
Sector:	Unknown sector
Cut block:	<Multiple selection>

Statistics - Selected Items

Area	84,667.9 ha
Number of cut blocks	881
Recovered biomass	3,399,569.4 odt
Recovery rate	40.2 odt/ha
Biomass odt / Merchantable m³	0.1370 odt/m³
Delivered products	
• Chips	100 %
• Bundles	0 %
• Trunks and Residues	0 %
Energy balance	36 : 1
Available energy	12,285,151 MWh
Fuel consumption	11.6 L/odt

Cost

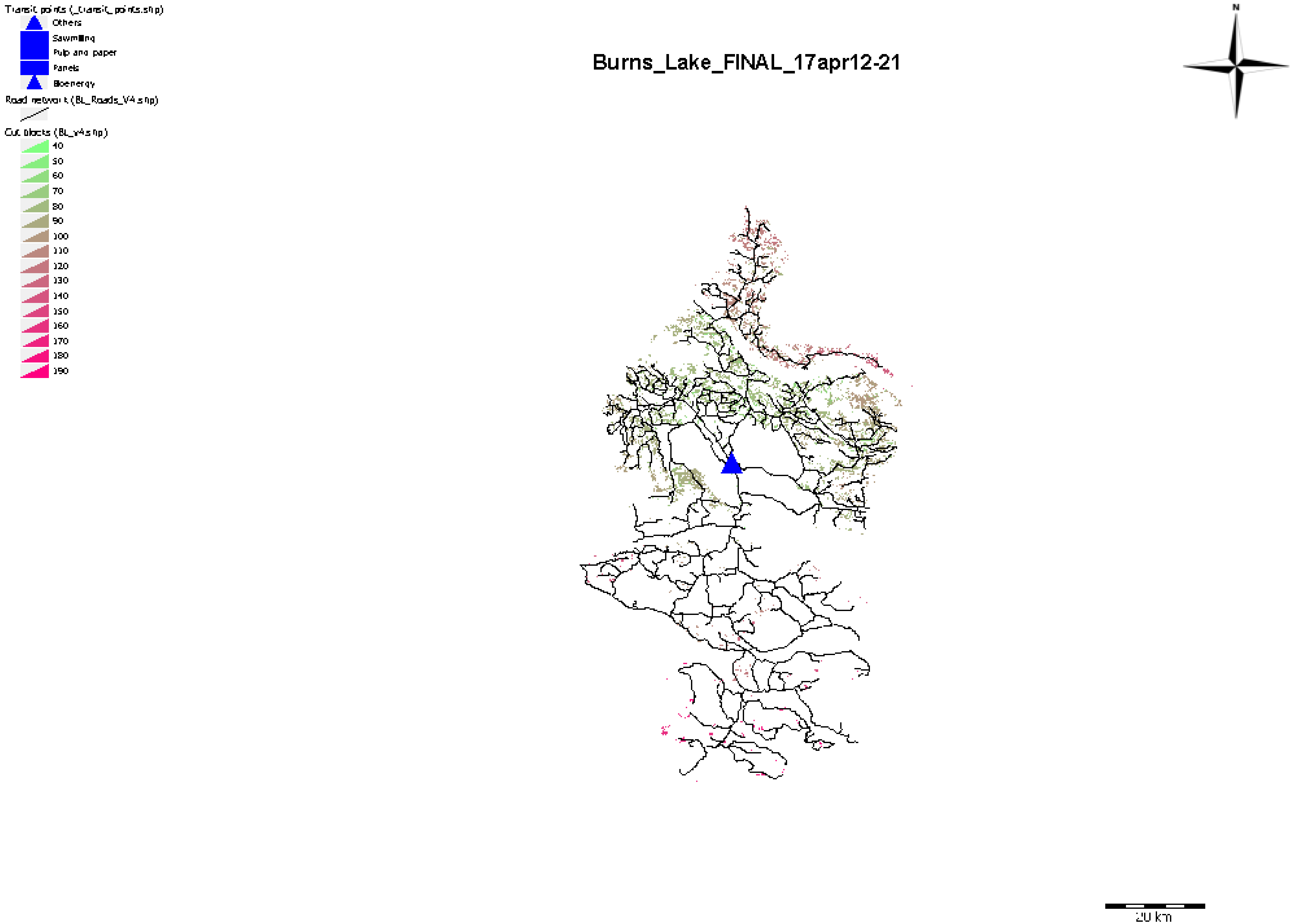
Harvesting	25.24 $/odt
Biomass recovery	31.80 $/odt
Transfer yard	0.00 $/odt
Transportation	35.69 $/odt
Stumpage fees	0.00 $/odt
Road network - Maintenance	0.62 $/odt
Indirect costs	0.00 $/odt
Total	93.34 $/odt

Revenue

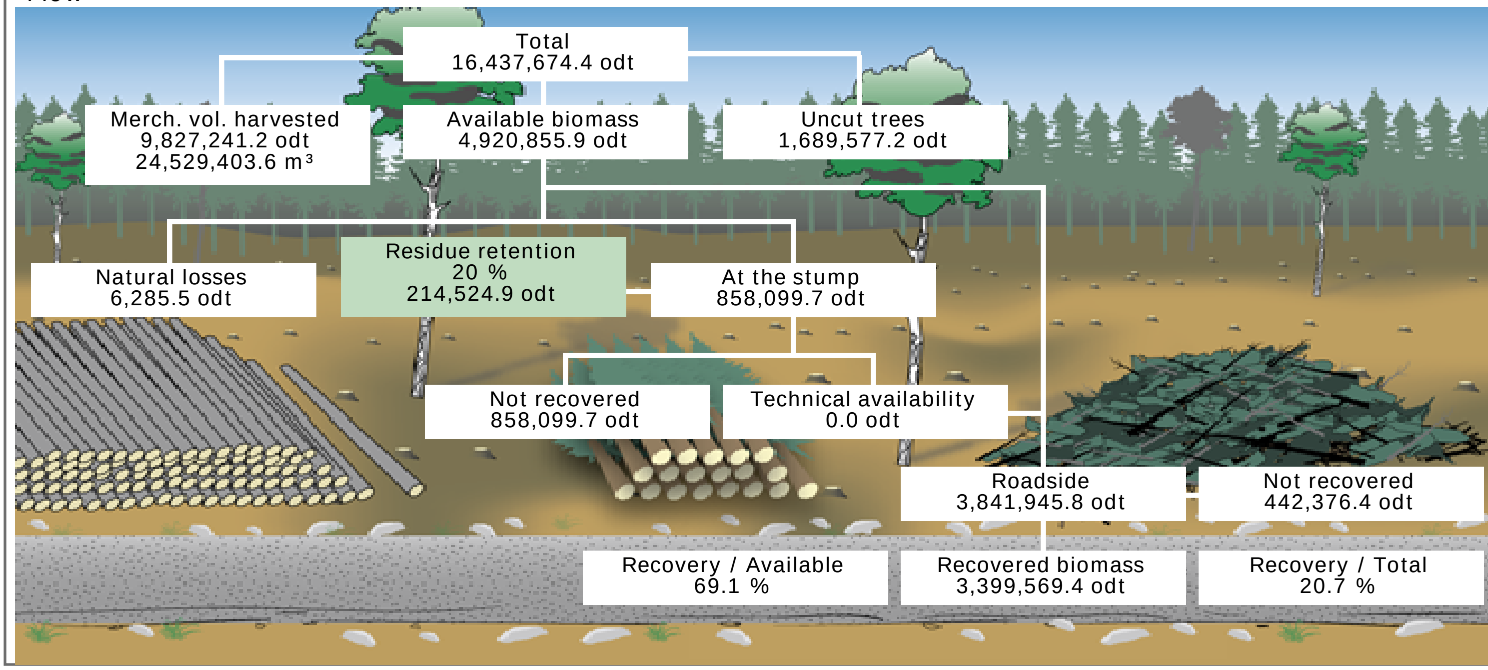
Sale value	0.00 $/odt
Silvicultural discount	0.00 $/odt

Net

Profit	-93.34 $/odt

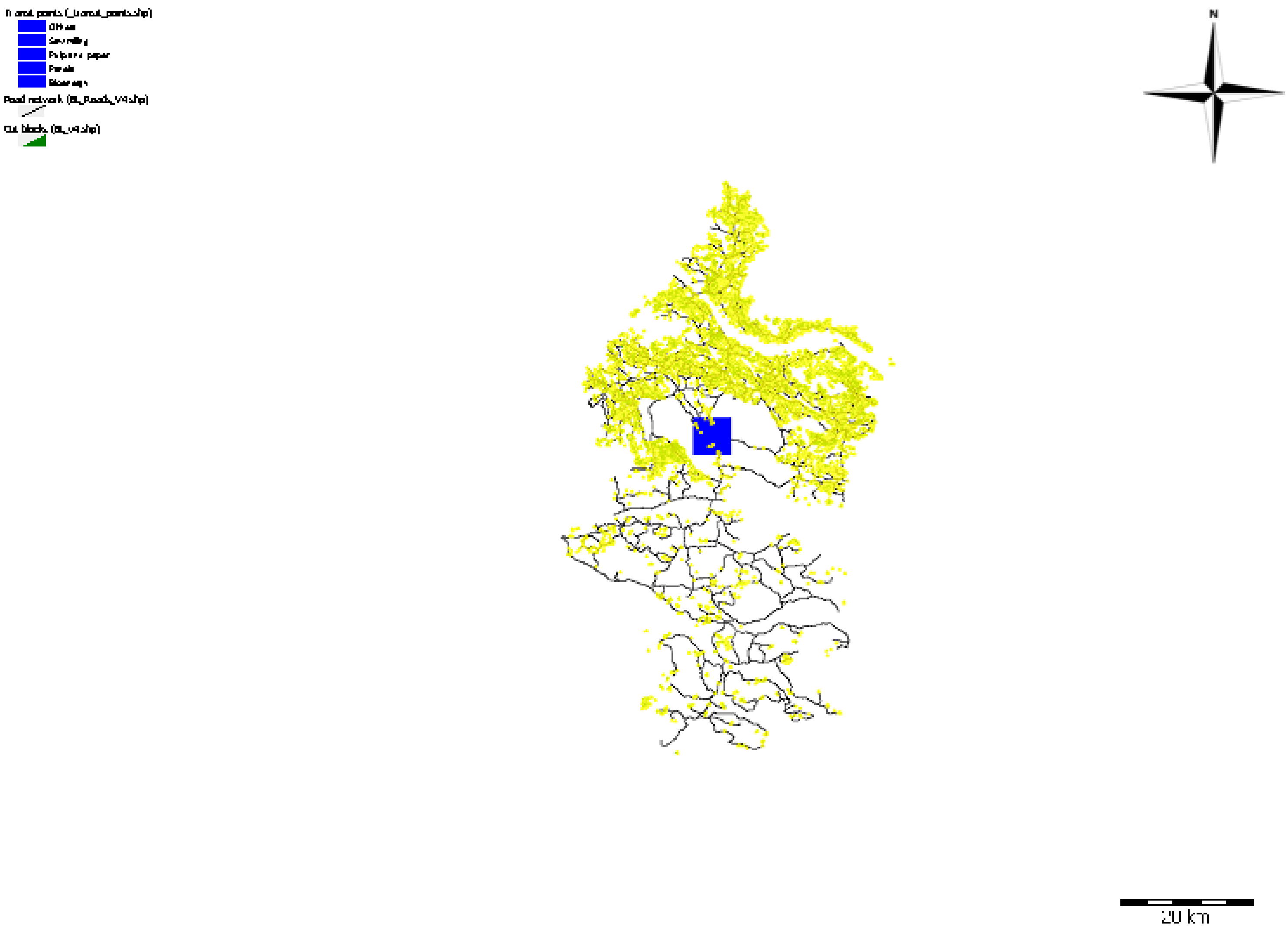

Transit points (_transit_points.shp)
Others
Sawmilling
Pulp and paper
Panels
Bioenergy
Road network (BL_Roads_V4.shp)
Cut blocks (BL_v4.shp)
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Burns_Lake_FINAL_17apr12-21
N
20 km

Flow



Products

Product name	odt	odt/m³	odt/ha
Lodgepole Pine-Biomass	1,272,197.3	20.8944	15.03
Lodgepole Pine (residues)	984,351.4	0.0751	11.63
Spruce (residues)	779,683.1	0.1093	9.21
Lodgepole Pine-Biomass (residues)	210,932.5	0.0751	2.49
Balsam (residues)	105,893.8	0.0898	1.25
Trembling Aspen (residues)	43,378.7	0.0866	0.51
Douglas Fir (residues)	1,879.5	0.1485	0.02
Birch (residues)	1,253.1	0.1688	0.01
	3,399,569.4	0.1370	40.15



881 selected site(s) / 881

Area covered: 84,668 ha / 84,668 ha

Recovery summary

	Volume(odt)	Area(ha)	Number of cut blocks
• Biomass recovery location			
At the stump	0.0	0.0	0
Roadside	3,399,569.4	84,667.9	881
• Recovery season			
Summer	0.0	0.0	0
Winter	3,399,569.4	84,667.9	881
• Residue freshness			
Fresh	3,399,569.4	84,667.9	881
Brown	0.0	0.0	0
Brittle	0.0	0.0	0

Supply summary

Recovered biomass to	Merchantable volume (odt)	Residues (odt)	Total biomass (odt)
10 $/odt	0.0	0.0	0.0
20 $/odt	0.0	0.0	0.0
30 $/odt	0.0	0.0	0.0
40 $/odt	0.0	0.0	0.0
50 $/odt	0.0	108,022.9	108,022.9
60 $/odt	0.0	888,824.3	888,824.3
70 $/odt	0.0	1,478,297.2	1,478,297.2
80 $/odt	0.0	1,658,231.8	1,658,231.8
90 $/odt	0.0	1,897,196.7	1,897,196.7
100 $/odt	0.0	1,983,958.6	1,983,958.6
110 $/odt	3,883.0	2,031,223.3	2,035,106.3
120 $/odt	234,082.6	2,045,154.4	2,279,237.0
130 $/odt	642,128.7	2,060,092.5	2,702,221.2
140 $/odt	975,936.4	2,063,801.6	3,039,738.0
150 $/odt	1,104,186.8	2,082,255.3	3,186,442.0
160 $/odt	1,188,392.0	2,109,985.1	3,298,377.1
170 $/odt	1,240,131.0	2,119,699.9	3,359,830.9
180 $/odt	1,248,352.5	2,127,372.1	3,375,724.6
190 $/odt	1,253,382.6	2,127,372.1	3,380,754.7
200 $/odt	1,254,306.4	2,127,372.1	3,381,678.5
210 $/odt	1,257,736.3	2,127,372.1	3,385,108.4
220 $/odt	1,265,229.3	2,127,372.1	3,392,601.4
230 $/odt	1,270,403.6	2,127,372.1	3,397,775.7
240 $/odt	1,271,444.7	2,127,372.1	3,398,816.8
250 $/odt	1,272,197.3	2,127,372.1	3,399,569.4

Maximum cost	241.12 $/odt	173.82 $/odt

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