Using FPInterface to Estimate Available Forest-Origin Biomass in British Columbia: Arrow, Boundary, and Kootenay Lake TSA

March 2019

Kevin Blackburn, Technician, Fibre Supply

Non-restricted Distribution

fpinnovations.ca

FPInnovations is a not-for-profit world-leading R&D institute that specializes in the creation of scientific solutions in support of the Canadian forest sector's global competitiveness and responds to the priority needs of its industry members and government partners. It is ideally positioned to perform research, innovate, and deliver state-of-the-art solutions for every area of the sector's value chain, from forest operations to consumer and industrial products. FPInnovations' staff numbers more than 525. Its R&D laboratories are located in Québec City, Montréal, and Vancouver, and it has technology transfer offices across Canada. For more information about FPInnovations, visit: www.fpinnovations.ca.

Follow us on:

Technical Report – Report number

ABSTRACT

Based on inventory information and a 10-year harvest queue, estimates of the amount of biomass available from forest harvest residues were estimated in $10 increments of delivered cost. For the study area (Arrow, Boundary, and Kootenay Lake TSA), a total of 154 000 ODT/year was projected to be available, while only 16 000 ODT/year were expected to be available at the economic price of $60/ODT.

ACKNOWLEDGEMENTS

This project was financially supported by Selkirk College, the Natural Science and Engineering Research Council of Canada and by the Province of British Columbia.

REVIEWERS

Charles Friesen, Researcher, Fibre Supply

CONTACT

Kevin Blackburn
Technician
Fibre Supply
604-222-5717
kevin.blackburn@fpinnovations.ca

EXECUTIVE SUMMARY

FPInnovations estimated the amount of forest-origin harvest residue biomass available from the study area (Arrow, Boundary, and Kootenay Lake TSA), largely following the process previously established for several British Columbia TSAs using FPInterface between 2010 and 2017. The biomass inventory was based on 10-year harvest data and road network plans for Crown land that were provided by the B.C. Ministry of Forests, Lands and Natural Resource Operations, and excluded Woodlot Licences, Tree Farm Licences, Community Forest Agreements, and First Nations tenures.

The biomass yield predicted from harvest residues for the study area was 26.6 oven-dried tonnes per hectare (ODT/ha). The biomass ratio (the ratio of recovered biomass to recovered merchantable roundwood) was estimated at 20.2%. Over the next 10 years, a total of 1.54 million ODT of available biomass was predicted to be generated by harvest in the study area, or approximately 154 000 ODT/year. Of this, approximately 157 000 ODT in total, or 16 000 ODT/year, were expected to be available at the economic price of $60/ODT. Approximately 70% of the total predicted volume was expected to be available at $90/ODT: a total of 1.07 million ODT, or 107 000 ODT/year.

Biomass availability at $70/ODT, 382 000 ODT, is over double the amount calculated at $60/ODT. If increases in efficiency or decreases in cost can be realized, there could be a large increase in available biomass.

Most of the biomass that is considered economically available (≤ $60/ODT) is closer to the district's delivery points. Kelowna, Revelstoke, Grand Forks, Midway, Castlegar, Cranbrook, and Wynndel were used as delivery points. The amount of economically available biomass decreased through time from approximately 17 000 ODT/year in years 1 to 5 to 14 500 ODT/year in years 6 to 10. This decrease may be due to increased distances between planned harvest areas and the delivery locations in later periods.

Table of contents

List of figures

List of tables

1 INTRODUCTION

FPInnovations estimated the amount of forest-origin harvest residue biomass from an area encompassing Arrow, Boundary, and Kootenay Lake TSA (hereafter referred to as "the study area"). The study area largely followed the process previously established for several British Columbia TSA reports using FPInterface between 2010 and 2017. The biomass inventory was based on 10-year harvest data and road network plans for Crown land that were provided by the B.C. Ministry of Forests, Lands and Natural Resource Operations, and Rural Development (FLNRORD), and excluded Woodlot Licences, Tree Farm Licences (TFLs), Community Forest Agreements (CFAs), and First Nations tenures. Detailed introductory statements that apply to this project and the greater project as a whole are provided in Friesen & Goodison (2018).

2 OBJECTIVE

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

Specific deliverables were:

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 prices. A value of $60 for one oven-dried tonne (ODT) is regarded as the market value for biomass, in accordance with the analyses that were previously conducted.

3 METHODS

Overall process

The basic methodology for determining biomass supply in western Canada was established during analysis of the Quesnel (Friesen & Goodison, 2018) and Williams Lake TSAs.

This analysis focused on the study area and was based on polygon data (tree characteristics) and a road data set that were supplied by FLNRO. It did not include any nearby Woodlot Licences, TFLs, CFAs, or First Nations tenures. Including some of these areas could alter the available supply of biomass.

Additionally, stands with small diameter trees that are not considered merchantable were not included in the analysis. The analysis focused on recovering harvest residues from merchantable stands. Purpose-harvesting unmerchantable stands 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.

Figure 1 shows the steps taken to build the final inventory of economically available biomass for the Quesnel TSA. A similar process was used for the study area.

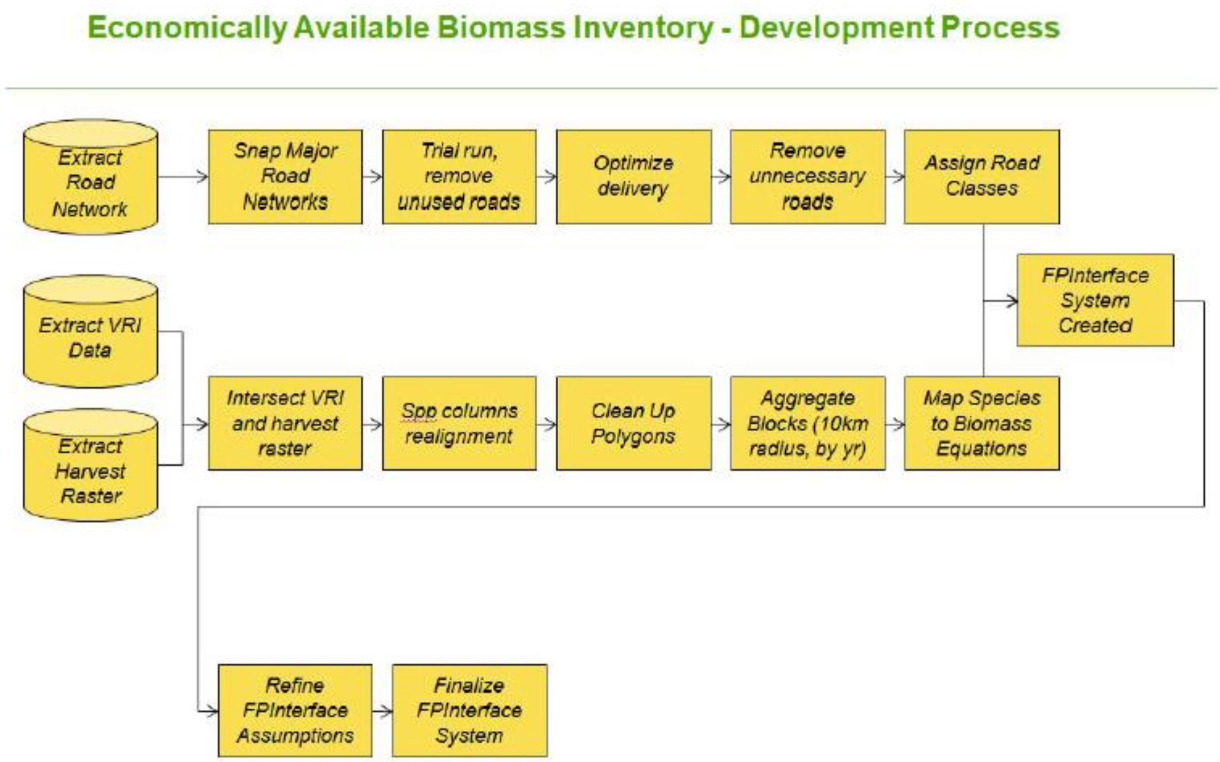

Figure 1. The steps taken to build the final inventory of economically available biomass.

Data acquisition

Data layers for the study area were acquired from FLNRORD (excluding woodlots, TFLs, CFAs, and any First Nations tenures), and included Vegetation Resource Inventory (VRI) polygons with attributes, and road linework with attributes. The data layers were acquired from the three timber supply areas (TSA) within the study area. Arrow and Boundary TSA data layers included 20-year harvest queues while Kootenay Lake TSA included a 10-year harvest queue. The data layers were merged and only the first 10 years were used for the analysis due to Kootenay Lake TSA's shorter harvest queue. The 10-year polygon data was partitioned into 2 consecutive 5-year harvest periods. The total 10-year harvest queue is a point-in-time snapshot. It indicates which polygons are expected to be harvested in the next 10 years. No attempt was made to model possible growth or mortality during the 10-year period. Any projections of growth or mortality are already accounted for in the harvestable proportion contained in the polygon data.

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 queue built into it, indicating which polygons are to be cut in which time period. To calculate biomass amounts, FPInterface requires tree size data (volume per stem) and either stand density (stems per hectare) or volume per hectare 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 calculation, 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 queue layers. Aggregation rules dictated that blocks were grouped if they had an identical harvest year and were within a 5-km grid.

FPInterface calculates cost in part by finding a transportation route from product origin in a polygon (block) to the mill or delivery site. The program 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 suboptimal 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.

Biomass equations

To perform the analysis, tree species in the VRI were tied to single-tree biomass equations in FPInterface. For the Quesnel TSA analysis in 2010–11, these equations were based on "Canadian national tree above ground biomass equations" by Lambert et al. (2005). Although this equation set includes trees from all across Canada, including western and northern Canada, there were very few samples from B.C. More recently, Ung et al. (2008) have released tree equations for B.C. (accepted by FLNRO); these were incorporated into FPInterface for the Williams Lake TSA analysis and subsequent analyses, including this one.

FPInterface parameters

Tree species associations

Tree species associations were made as shown in Table 1.

Table 1. Species associations

FPInterface species	System label	Named	Original data set
Spruce, white	SX	white spruce	S, SX
Aspen, trembling	AT	trembling aspen	AT, ACB
Cedar, western red	CW	western red cedar	CW
Fir, subalpine	BL	subalpine fir	BA, BL, B,
Fir, grand	BG	grand fir	BG
Birch, white	EP	white birch	EP
Douglas-fir (interior)	FDI	Douglas-fir	FDI
Hemlock, western	HW	western hemlock	HW
Larch, western	LW	western larch	LW
Larch, eastern (tamarack)	LT	tamarack	LT
Pine, lodgepole	PL	lodgepole pine	PL, PLI, PA
Pine, western white	PW	western white pine	PW
Spruce, Engelmann	SE	Engelmann spruce	SE

Cottonwood, black	ACT	black cottonwood	ACT, AC
Pine, ponderosa	PY	yellow pine	PY

Road classes

Unlike the Quesnel TSA data set, the Selkirk road data set contained no road classes. 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 as outlined in Table 2.

Table 2. Road class associations

FPInterface road class	Volume (m^3)		Road speed (km/h)		
	Minimum	Maximum	Posted speed	Empty haul[a]	Loaded haul[b]
Paved	10 000 001	50 000 000	90	86	77
Class 1 (off highway)	0	0	70	67	60
Class 1	2 000 001	10 000 000	70	67	60
Class 2	1 000 001	2 000 000	50	48	43
Class 3	500 001	1 000 000	40	38	34
Class 4	5 001	500 000	20	19	17
Class 4 (operational)	0	0	20	19	17
Class 5 (winter)	0	5 000	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, and some can use marked fuel. A price of $1.25/L was assigned, which is slightly higher than current rates for diesel but approximates a medium-term average.

FPInterface'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.

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

Comminution cost

The working time for B.C. conditions was based on previous base case studies and consists of one 12-hour shift per day, 200 days/year. Grinder utilization was set at 60%, and fuel used per productive machine hour (PMH) for the grinder was the standard 135 L/PMH. These are the standard base case parameters used in past FPInnovations studies, which enabled comparisons to those studies. In this study, these parameters produced a grinding cost of $26.82/ODT.

Topping diameter

Although B.C. regulations require a topping diameter of 10 cm for most merchantable species, this analysis used 12.5 cm to reflect more common industrial practise. Topping diameter can have a significant effect on the volume of a tree that is available for biomass use.

Parameters as entered into FPInterface

Table 3 shows some of the parameters that were entered into FPInterface for the base case, which produced a grinding cost of $26.82/ODT.

Table 3. FPInterface parameters

Run descriptor	Value
run name	SelkirkRunV1
output name	Biomass – SelkirkRunV1
block system	bio_5fn_merged_2P.shp
road system	Roads_28nov2018_250m_split.shp
transfer yard(s)	Kelowna, Revelstoke, Castlegar, Midway, Grand Forks, Wynndel
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	Kelowna, Revelstoke, Castlegar, Midway, Grand Forks, Wynndel
topping diameter	12.5 cm
truck used for logs	3-axle
truck used for chips	Tridem B-train

harvesting fuel price/litre (x4)	$1.25
harvesting shifts/day (x4)	1
harvesting hours/shift (x4)	12
harvesting days/year (x4)	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
loader type	loader with log grapples
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

Delivery locations

All harvest residues from in-woods operations (not from mills) were directed to large industrial areas in the study area. In this model, Kelowna, Revelstoke, Grand Forks, Midway, Castlegar, Cranbrook, and Wynndel were used as delivery locations. These locations were selected due to their large populations or wood mills. Initial comminution was set to take place at roadside, and costs are calculated for biomass delivered to the closest delivery locations.

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; biomass that was likely to remain at the stump or that was 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 based on the numbers from the 10-year harvest of the base case with normal grinder utilization of 60% and fuel usage of 135 L/PMH.

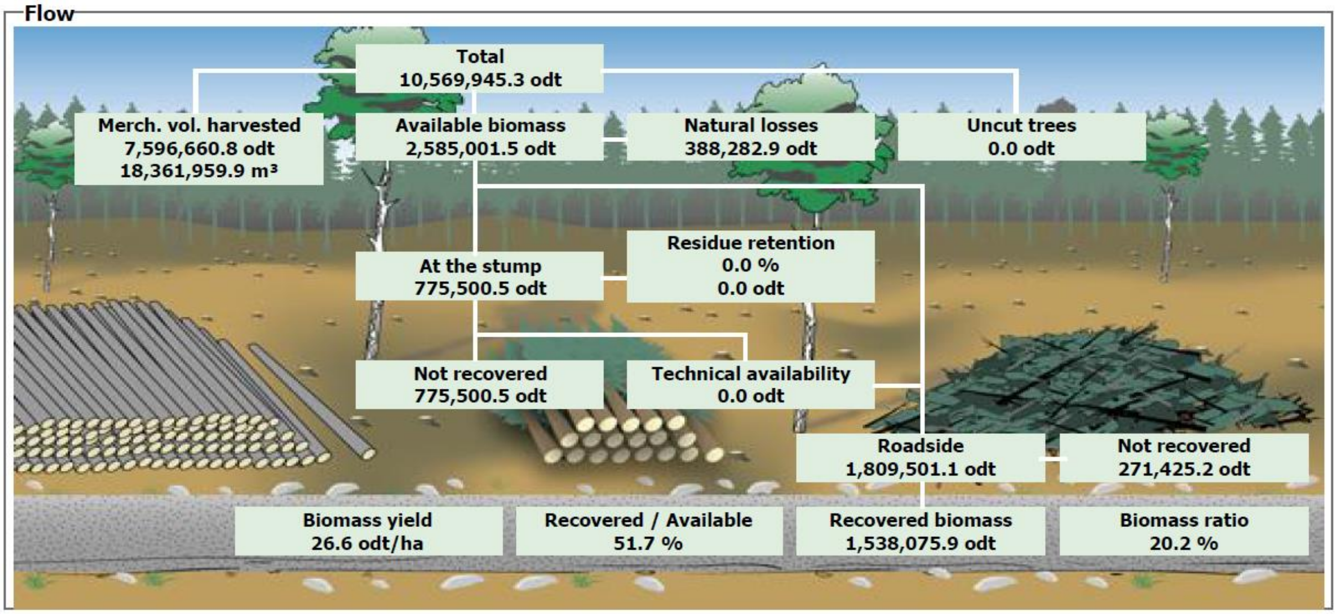

Figure 2. Recoverable biomass in the study area, delivered to closest delivery points.

4 RESULTS AND DISCUSSION

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 study area, based on inventory information and the road network supplied by FLNRO, indicated an average biomass yield of 26.6 ODT/ha. This was in the form of comminuted hog fuel and was from harvest residues only—tops, branches, and other roadside logging waste. Mill residues were not predicted by the model.

Biomass amounts

In total, it was predicted that 1 538 076 ODT could be recovered from roadside and delivered to the delivery locations over the course of 10 years. The amount of available biomass was relatively consistent throughout both periods. The first 5-year period (years 1–5) had a lower amount of available biomass, possibly due to a lower biomass ratio of 19.7% compared to 20.8% for the second 5-year period (years 6-10). The amount of biomass available each year in the study area was approximately 154 000 ODT/year, at any price. However, the amount of economically available biomass available in each 5-year period varied from 85 000 ODT in the first 5-year period to 72 500 ODT in the second 5-year period. The economically available volume was estimated at 15 700 ODT/year (Table 4).

Table 4. Key amounts of biomass availability in the study area

	Volume at $60/ODT (ODT)[a]	Volume at $90/ODT (ODT)	Total volume ($203/ODT) (ODT)
Over 10-year period	157 140	1 072 156	1 538 075
Per year	15 714	107 216	153 808

[a] ODT: oven-dried tonne

Additionally, the model indicated that about 775 500 ODT of biomass would be left on the cutblock and would not make it to roadside. This includes material that falls off trees naturally and material that breaks off logs and is left on the ground during normal harvesting operations. This large amount of material retained in the forest was equal to 43% of the amount removed for biomass and is much higher than that deemed necessary to replenish the forest floor and prevent nutrient degradation in the soil. Additionally, 271 000 ODT of biomass material that makes it to roadside was 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.

Biomass ratio

The biomass ratio is the ratio of recovered biomass to recovered merchantable roundwood. The ratio for the base case was 20.2% (Table 5).

Table 5. Calculation of the biomass ratio

Biomass ratio (ODT)[a]	
Recovered biomass	1 538 075
Recovered roundwood	7 596 661
Biomass ratio (%)	20.2

[a] ODT: oven-dried tonne

Knowing the biomass ratio for an area can be useful for roughly predicting the amount of available harvest residue if the amount of merchantable timber harvest is known.

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 to be 157 140 ODT or about 16 000 ODT/year. The complete results in $10 increments for the entire 10-year period are presented in Table 6 and Figure 3.

Table 6. Cost availability of biomass in the study area

Normal grinder utilization at $60/ODT[ab]		
Cost ($/ODT)	Total (ODT)	Annual (ODT)
10	–	–
20	–	–
30	–	–
40	–	–
50	778.3	77.8
60	157140.0	15714.0
70	382238.9	38223.9
80	735522.7	73552.3
90	1072155.7	107215.6
100	1242878.4	124287.8
110	1354065.4	135406.5
120	1461756.0	146175.6
130	1496693.9	149669.4
140	1512123.5	151212.4
150	1522948.6	152294.9
160	1534549.1	153454.9
170	1536024.6	153602.5
180	1537353.0	153735.3
190	1537361.5	153736.2
200	1538068.7	153806.9
210	1538075.9	153807.6

[a] Presumed market rate.
[b] ODT: oven-dried tonne

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/ODT.

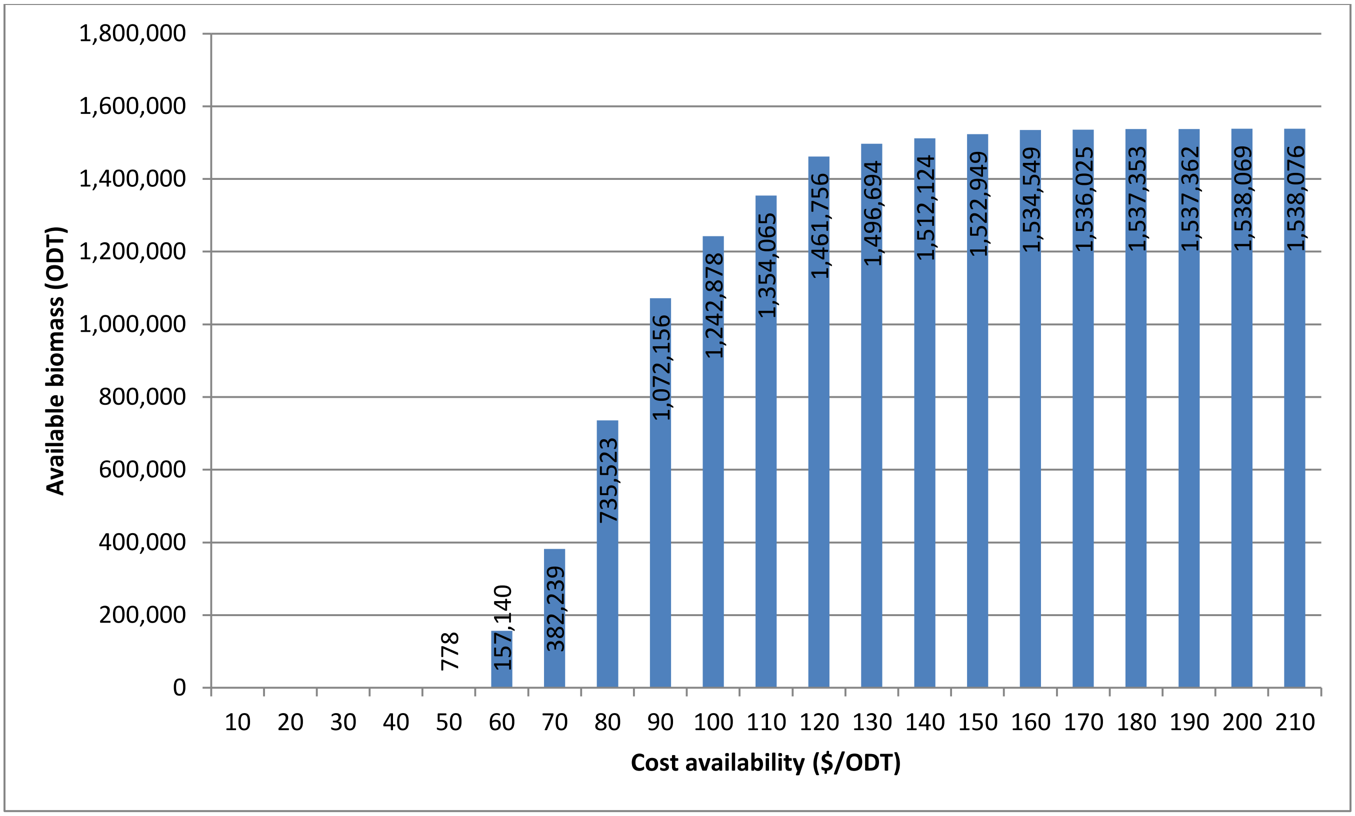

Figure 3. Cost availability of biomass in the study area, over 10 years (ODT: oven-dried tonne)

Mapping

FPInterface shows the distribution of costs by cutblock, using a colour scale that ranges from lime green (blocks with the lowest delivered biomass costs) to red (blocks with the most expensive costs); orange shows the transition between the two (Figure 4). The delivery points are represented by blue triangles. All biomass from the study area was scheduled for delivery to these points. The costs ranged up to $203/ODT for the blocks farthest from the delivery point.

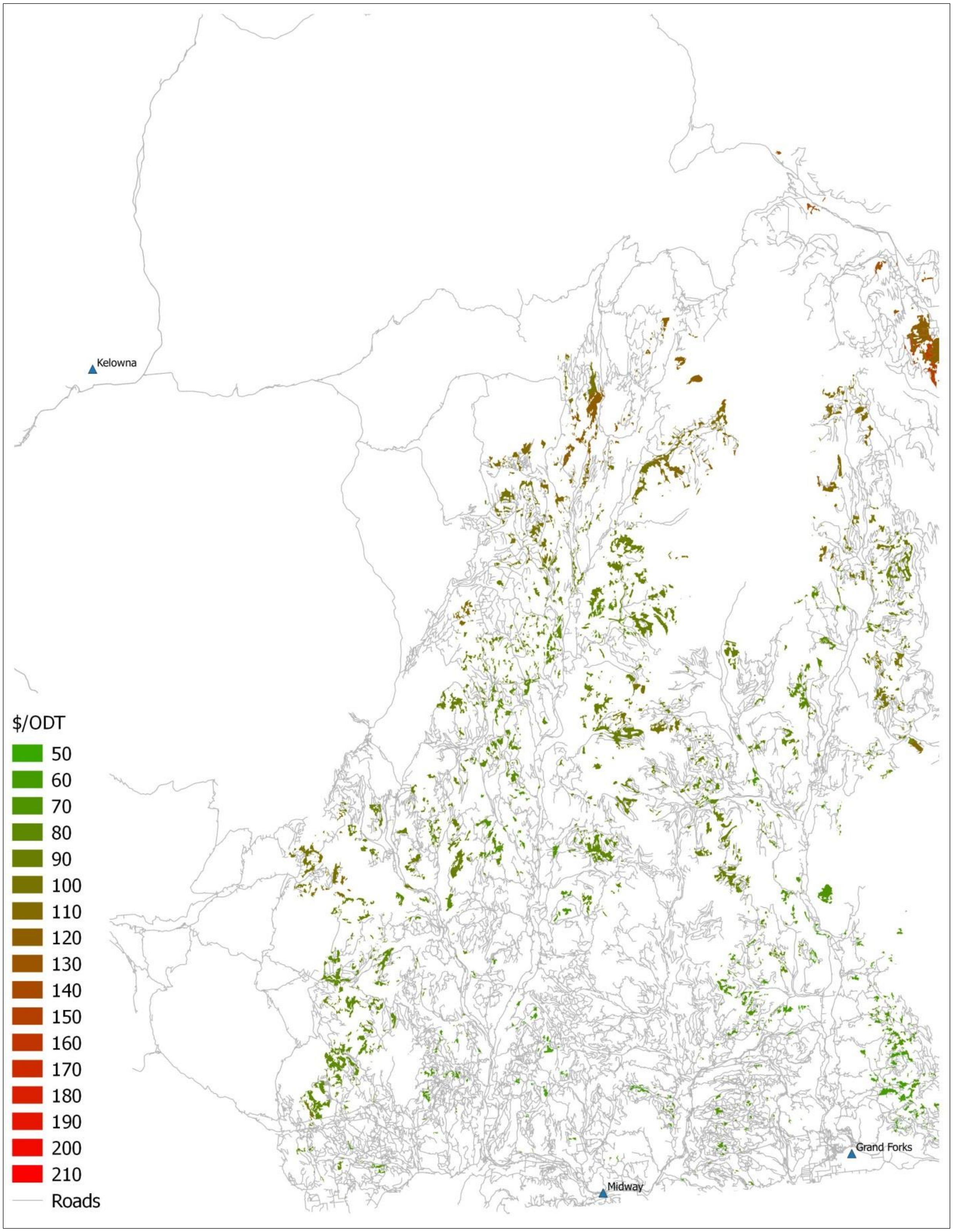

Figure 4. Cost of delivered biomass from point of origin to the delivery points, in increments of $10/oven-dried tonne (Kelowna, Midway, Grand Forks).

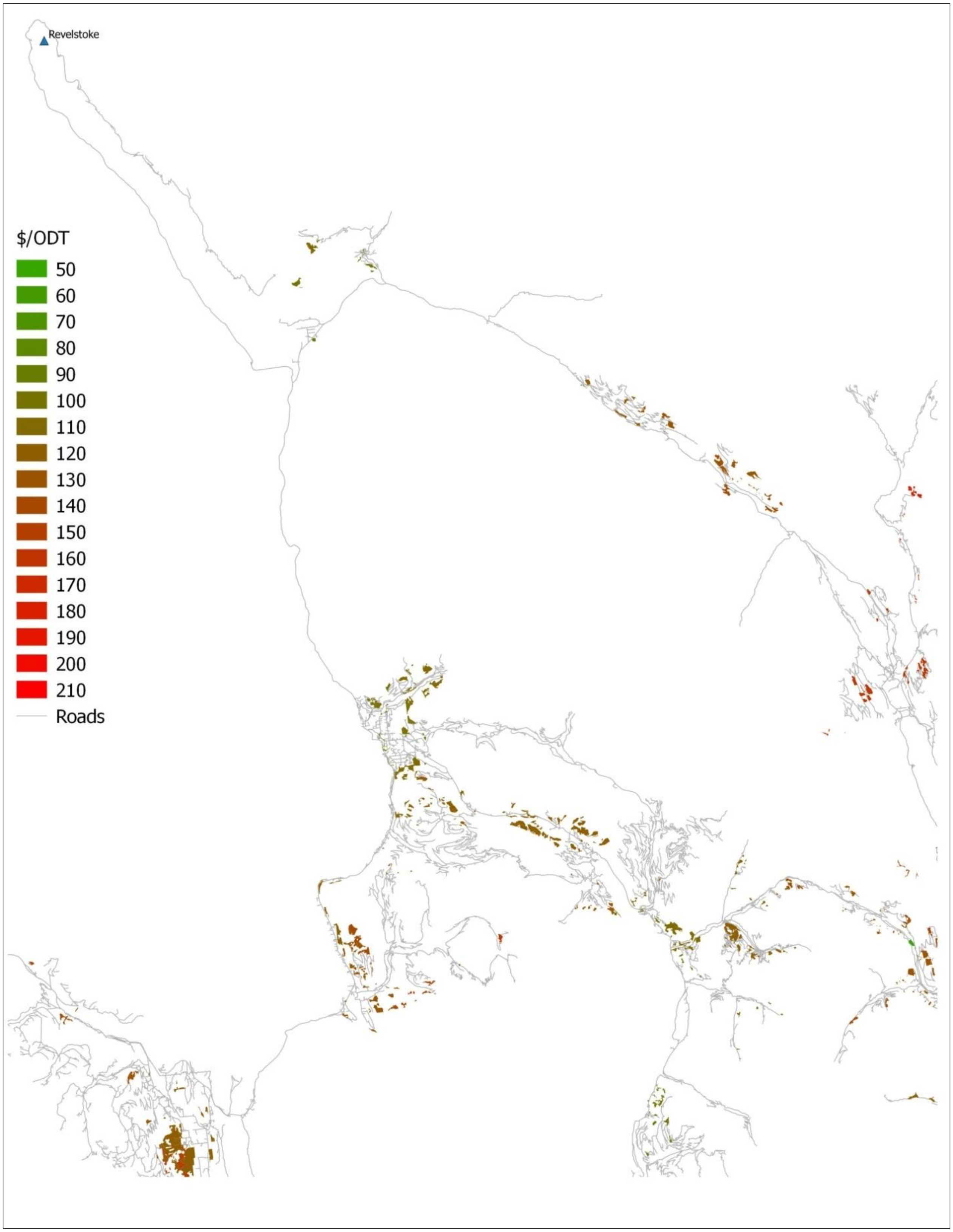

Figure 5. Cost of delivered biomass from point of origin to the delivery points, in increments of $10/oven-dried tonne (Revelstoke).

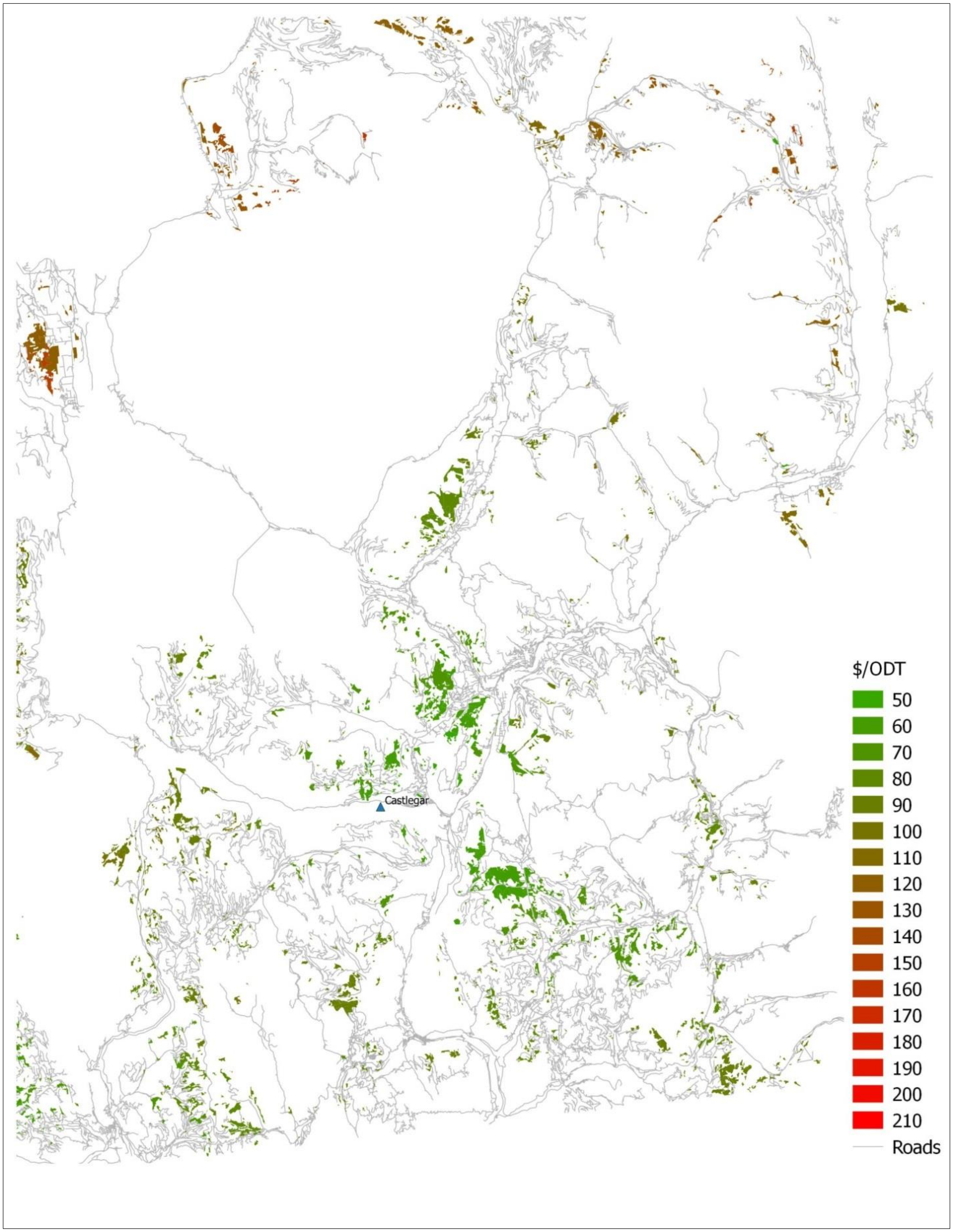

Figure 6. Cost of delivered biomass from point of origin to the delivery points, in increments of $10/oven-dried tonne (Castlegar).

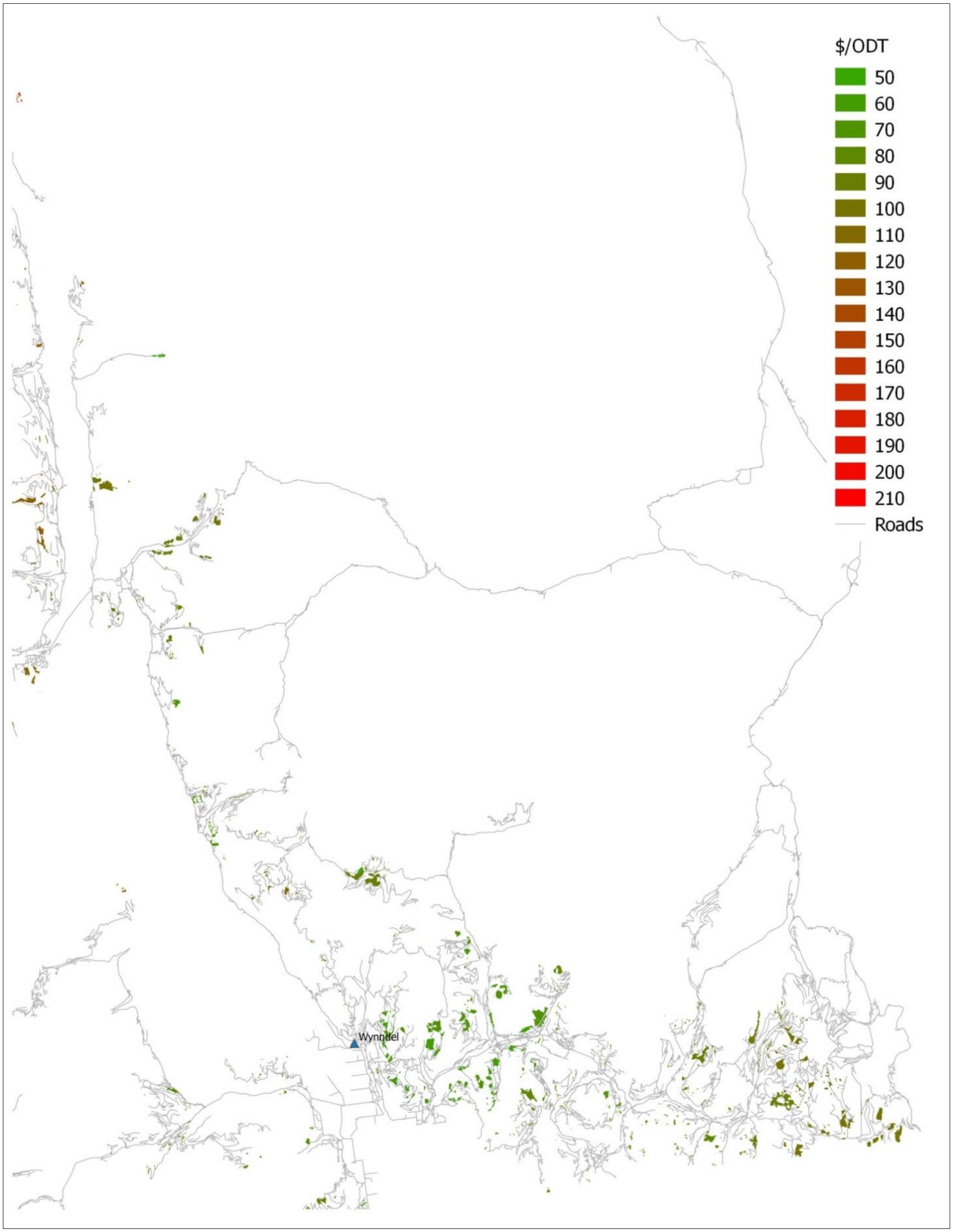

Figure 7. Cost of delivered biomass from point of origin to the delivery points, in increments of $10/oven-dried tonne (Wynndel).

Figure 8 shows the road network to the cutblocks and delivery points. Different classes of roads are shown in different colours. Road class is determined by the amount of harvest that passes over the road. Each road class has a unique set of speed associations for loaded and empty trucks; these are used to determine the cycle times needed to calculate the delivery cost for biomass (Table 2). Most of the roads with the slowest speeds are shown in grey; red and blue show roads with the fastest speeds.

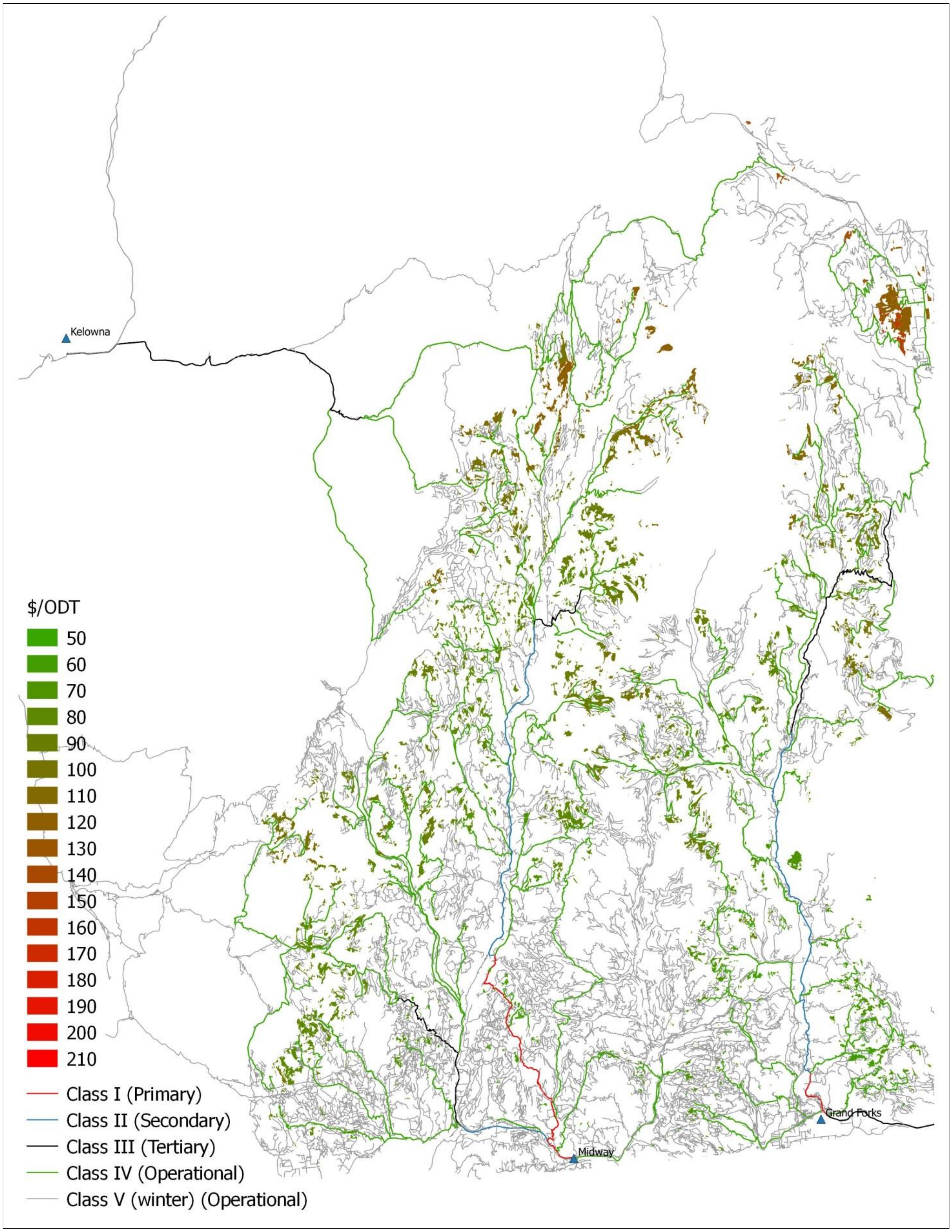

Figure 8. Blocks with road access in the study area (Kelowna, Midway, Grand Forks).

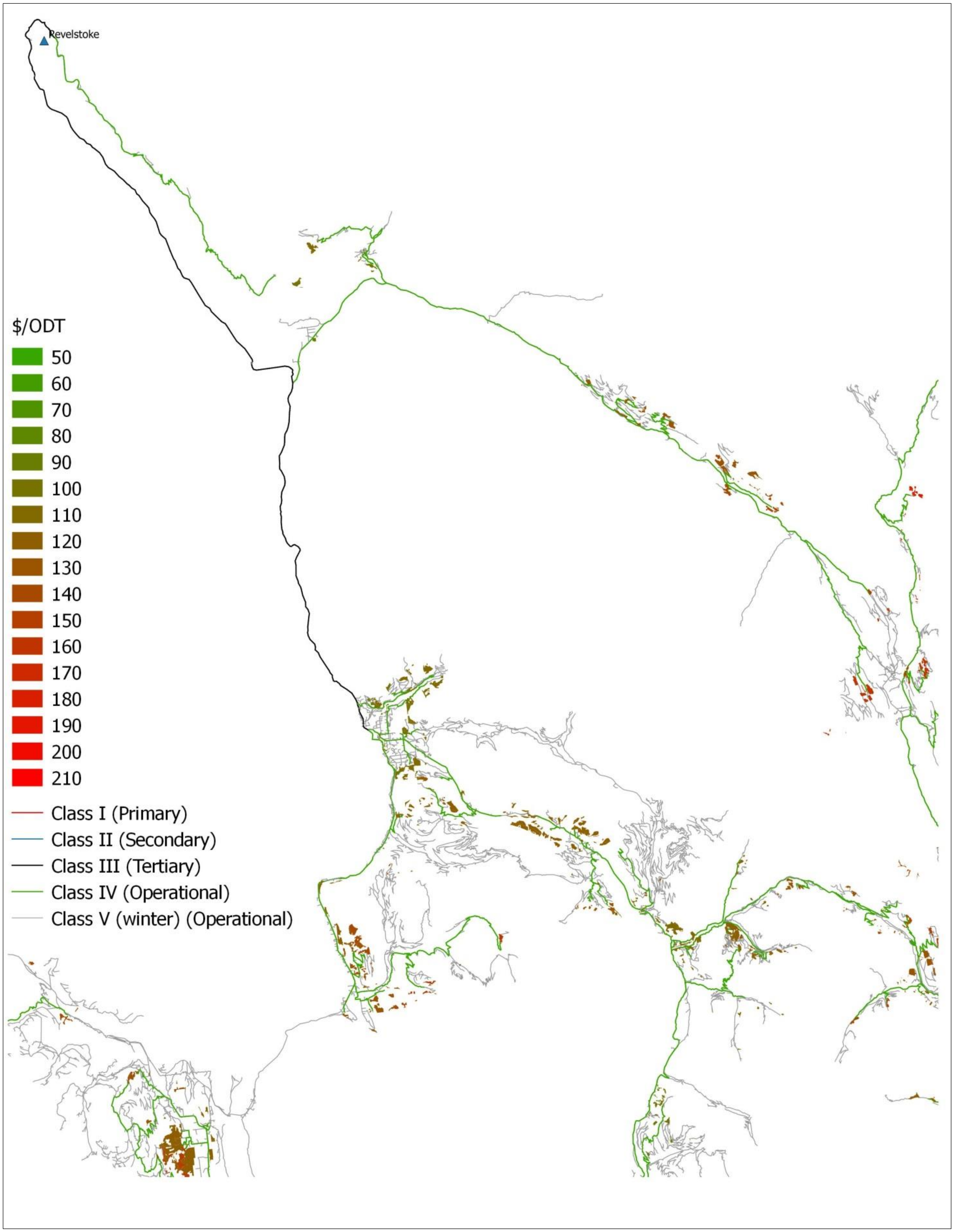

Figure 9. Blocks with road access in the study area (Revelstoke).

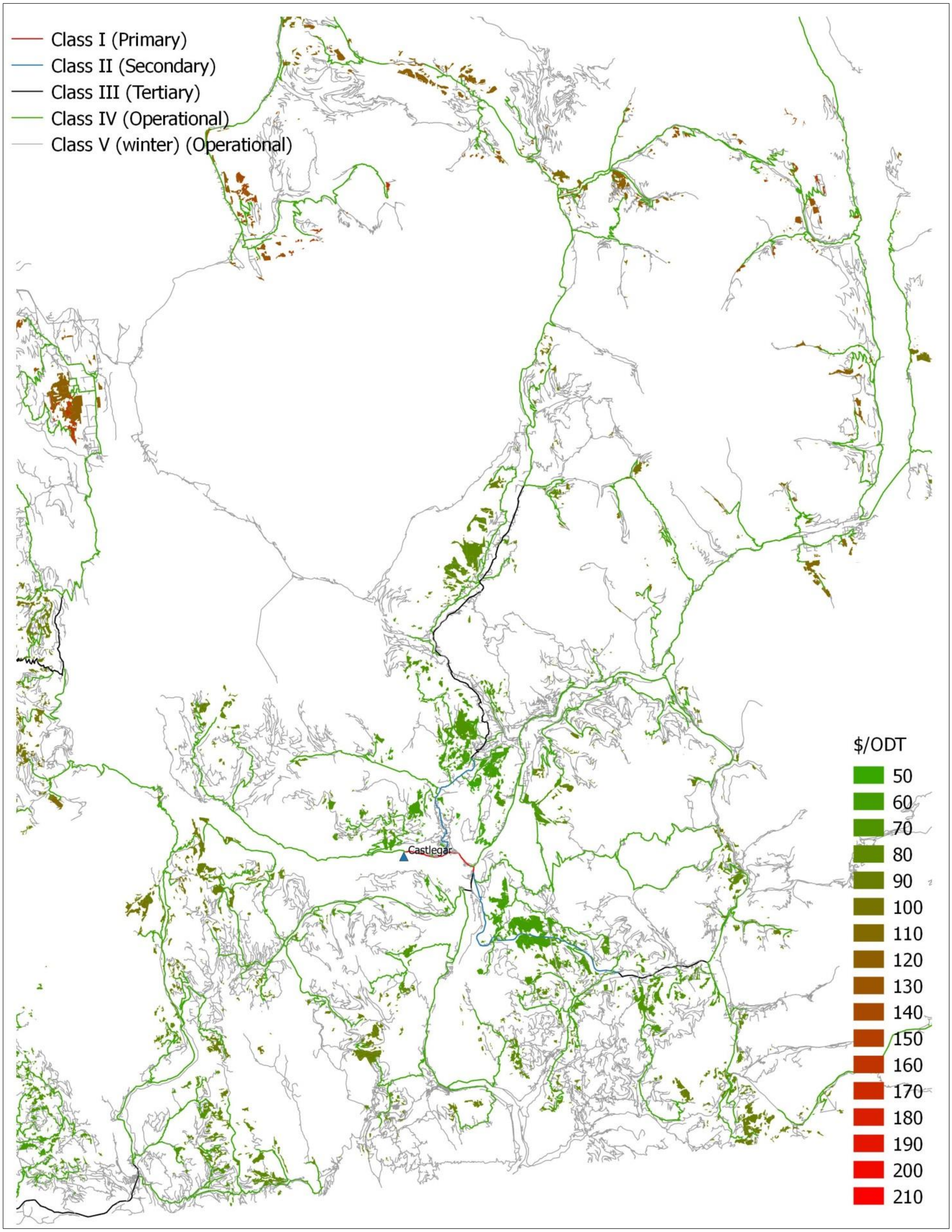

Figure 10. Blocks with road access in the study area (Castlegar).

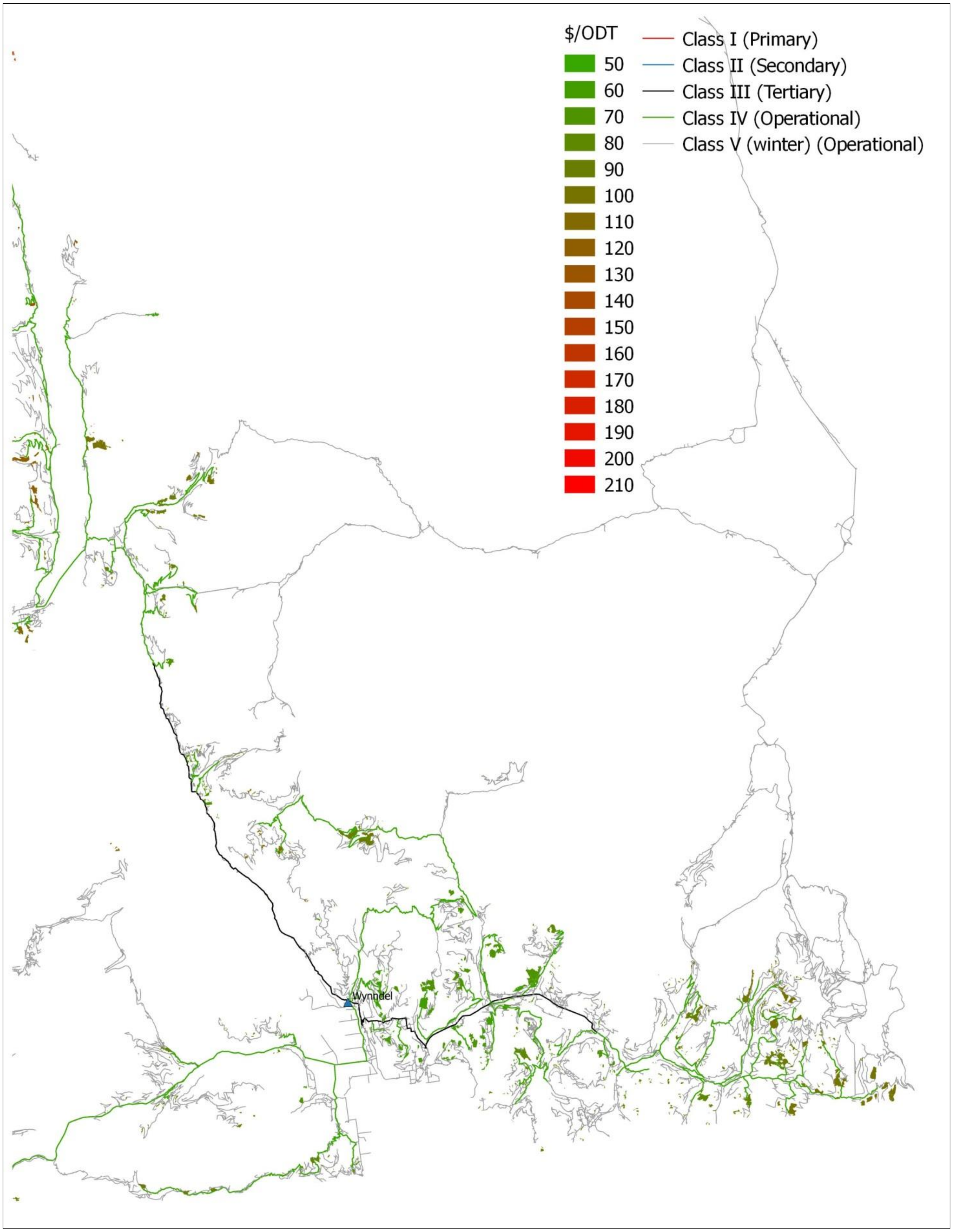

Figure 11. Blocks with road access in the study area (Wynndel).

__Temporal distribution of harvest__

The harvest data included a time period assigned to each cutblock. There are two periods, each of which represents a 5-year period. The harvest projection showed a relatively steady supply of available biomass between each harvest period (Figure 12).

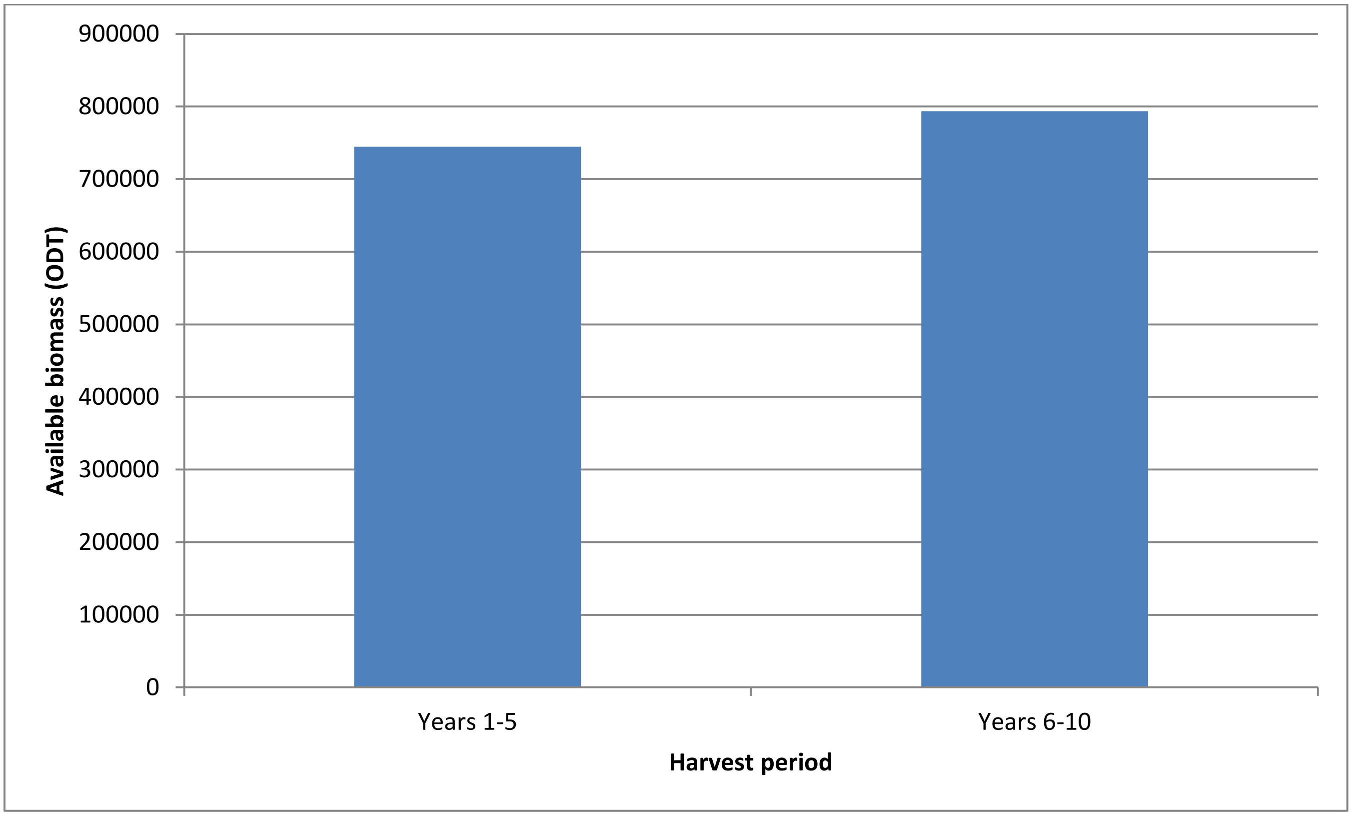

Figure 12. Availability of biomass in the study area, by 5-year harvest period.

The economic harvest available (amount of biomass at $60/ODT) in each 5-year period (Figure 13) showed a disproportionate decline (compared to Figure 6) in the second harvest period. This indicates that the harvest blocks tend to be farther from the delivery locations, increasing transportation costs.

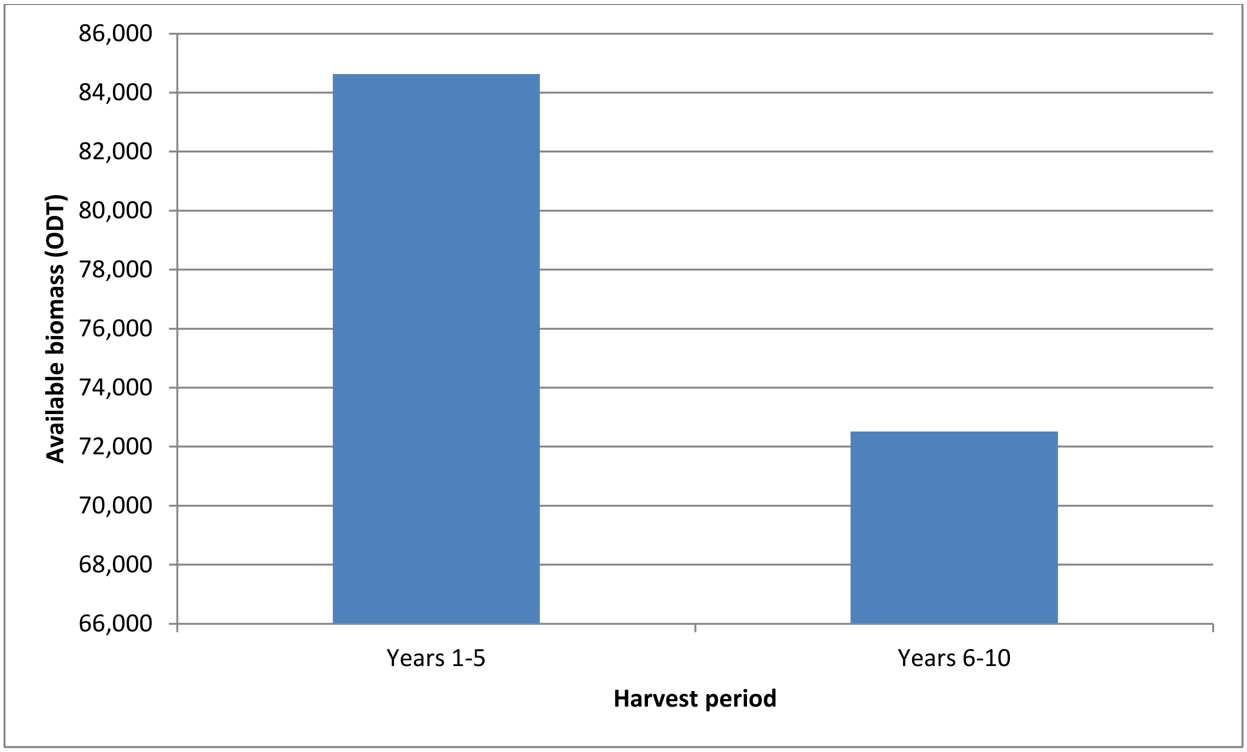

Figure 13. Availability of economic biomass in the study area, by 5-year harvest period, at ≤ $60/oven-dried tonne.

The cost availability of biomass is shown by period and $10 increments in Table 7.

Table 7. Cost availability of biomass in the study area, by 5-year period.

	Period 1 (years1–5)		Period 2 (years 6–10)	
Cost ($/ODT)[a]	Total (ODT)	Annual (ODT)	Total (ODT)	Annual (ODT)
10	–	–	–	–
20	–	–	–	–
30	–	–	–	–
40	–	–	–	–
50	132.3	26.5	646	129
60[b]	84 624	16 925	72 516	14 503
70	198 607	39 721	183 632	36 726
80	358 943	71 789	376 579	75 316
90	536 134	107 227	536 021	107 204
100	613 989	122 798	628 890	125 778
110	663 608	132 722	690 457	138 091
120	720 571	144 114	741 185	148 237
130	731 691	146 338	765 003	153 001
140	739 481	147 896	772 643	154 529
150	741 787	148 357	781 162	156 232
160	743 770	148 754	790 779	158 156
170	743 770	148 754	792 254	158 451
180	743 770	148 754	793 582	158 716
190	743 779	148 756	-	-
200	744 486	148 897	-	-
210	744 493	148 899	-	-

[a] ODT: oven-dried tonne

[b] Presumed market rate

Results appendix
The runs performed in FPInterface and their results are included in Appendix 1.

5 CONCLUSION

The biomass yield per hectare from harvest residues in the study area is predicted to be 26.6 ODT/ha. Over the next 10 years, a total of 1.54 million ODT of available biomass are predicted to be generated by harvest in the study area, or approximately 154 000 ODT/year. Of this amount, approximately 10% of the total or 157 000 ODT, or 15 700 ODT/year, are expected to be available at the economic price of $60/ODT. While at $90/ODT, 70% of the total or 1.07 million ODT, or 107 000 ODT/year, are expected to be available. The biomass ratio (the ratio of recovered biomass to recovered merchantable roundwood) is estimated at 20.2%.

The amount of available biomass below $70/ODT (382 239 ODT) is more than double the amount available below $60/ODT (157 140 ODT). If increases in efficiency or lowered costs can be realized, there could be an increase in available biomass at economical rates.

Most biomass that is considered to be economically available (≤ $60/ODT) is closest to the delivery points due to lower transportation costs. The amount of economically available biomass decreases considerably after each 5-year period. This may be attributed to an increased distance to planned harvest blocks.

6 REFERENCES

Friesen, C., & Goodison, A. (2018). *Using FPInterface to estimate available forest-origin biomass in British Columbia: Quesnel TSA* (Technical Report No. 7). Vancouver, British Columbia: FPInnovations.

Lambert, M-C., Ung, C-H., & Raulier, R. (2005). Canadian national tree aboveground biomass equations. *Canadian Journal of Forest Research* 35,1996–2018.

Mellgren, P.G. (1980) *Terrain classification for Canadian forestry*. Canadian Pulp and Paper Association.

Ung, C.-H., Bernier, P., & Guo, X.-J. (2008). Canadian national biomass equations: New parameter estimates that include British Columbia data. *Canadian Journal of Forest Research* 35,1123–1132.

7 APPENDIX

Forest supply - SelkirkRunV1.pdf
Forest supply - SelkirkP1.pdf
Forest supply - SelkirkP2.pdf
Biomass - SelkirkRunV1.pdf
Biomass - SelkirkP1.pdf
Biomass - SelkirkP2.pdf

Head Office

Pointe-Claire

570, Saint-Jean Blvd

Pointe-Claire, QC

Canada H9R 3J9

T 514 630-4100

Vancouver

2665 East Mall

Vancouver, BC

Canada V6T 1Z4

T 604 224-3221

Québec

319, rue Franquet

Québec, QC

Canada G1P 4R4

T 418 659-2647

OUR NAME IS INNOVATION