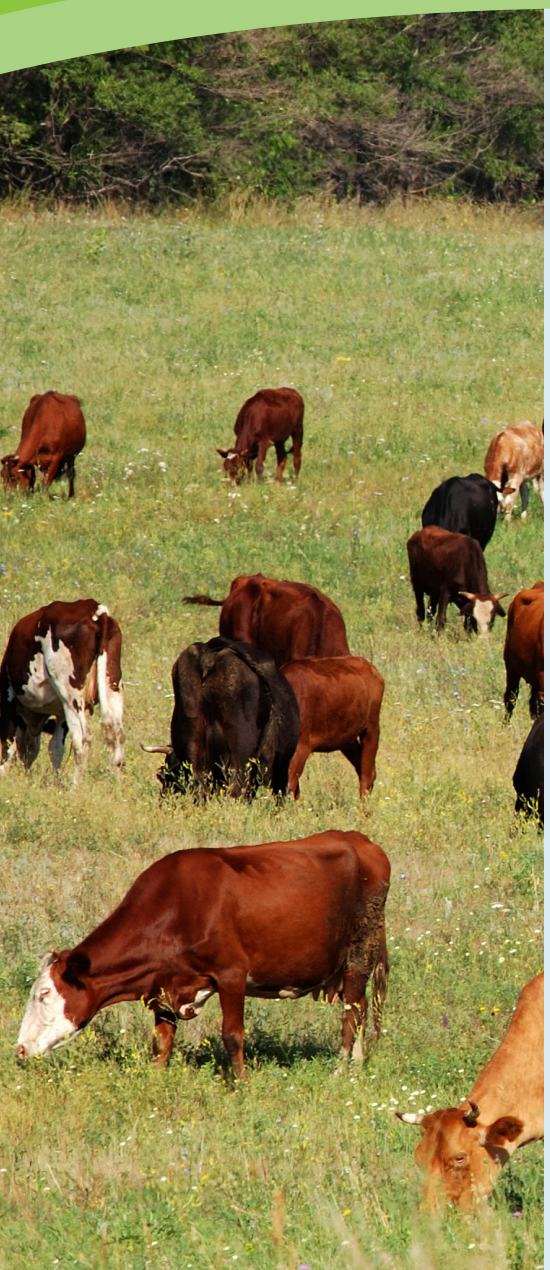
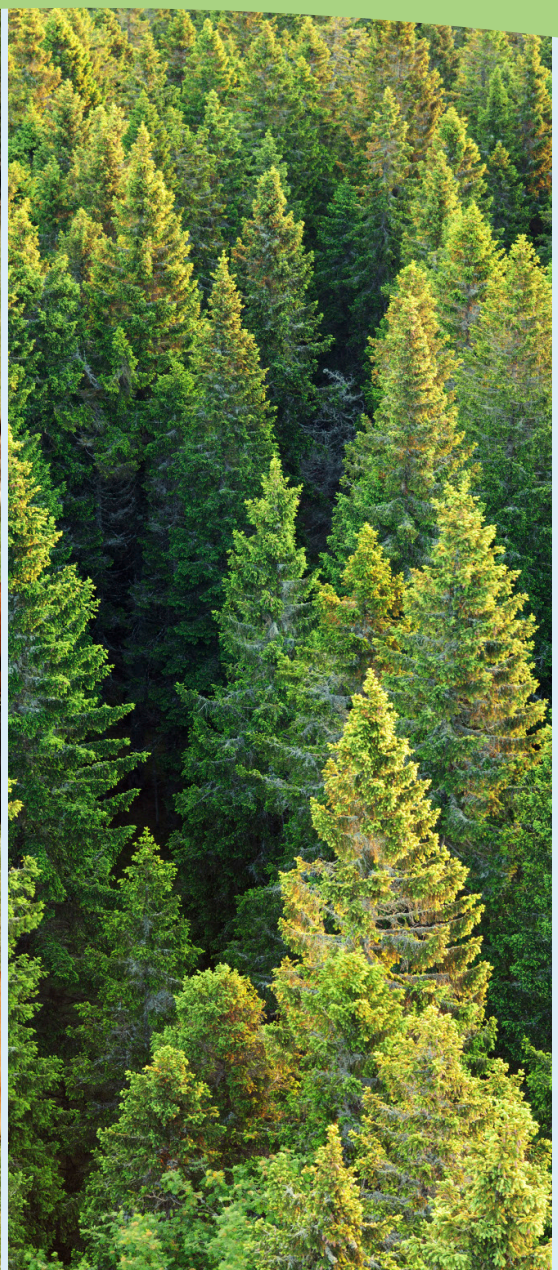
Alberta's Industrial Heartland

ALBERTA'S INDUSTRIAL HEARTLAND

PRE-FEASIBILITY SCAN OF POTENTIAL BIOMASS SUPPLY





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PLEASE NOTE: The resolution of the data and summary results will vary depending on biomass type, consistent with the existing data utilized within BRIMS phase 1. Data used in this analysis is representative of a snap shot in time and varies dependent on biomass type and source of original data. As such, this analysis may not reflect the current or future biomass supply on the landscape. We are utilizing available data as-is, with no field verification or warranty provided. Biomass potential supply numbers provided will be a theoretical estimate and may not be tactically available. Silvacom Ltd. hereby disclaims any liability and shall not be held liable for any damages including, without limitation, direct, indirect or consequential damages including loss of revenue, loss of profit, loss of opportunity or other loss. Any reliance placed on this material is done so strictly at your own risk. This disclaimer applies to all portions of this biomass potential analysis.

EXECUTIVE SUMMARY

Alberta's Industrial Heartland is Canada's largest hydrocarbon processing region with over 40 companies operating within the area. Located within greater Edmonton, and encompassing five municipalities including: the City of Fort Saskatchewan, Lamont County, Strathcona County, Sturgeon County, and the City of Edmonton, the region covers approximately 58,900 ha of land (AIHA 2014).

Alberta's Industrial Heartland is guided by Alberta's Industrial Heartland Association (AIHA), a non-profit organization committed to the sustainable development of the region (AIHA 2014). In support of this mandate, the AIHA is interested in the amount of potential biomass within and surrounding the Heartland region.

Data was leveraged from the Bio Resource Information Management System (BRIMS) framework and used to estimate the total potential biomass within six different buffer areas surrounding the area of interest, covering over 9 million hectares. Three buffer areas were created to estimate the overall biomass within 50kms, 100kms, and 150kms "as the crow flies" and an additional three buffer areas were created using primary and secondary highways to estimate the amount of potential biomass that is currently accessible within 50kms, 100kms, and 150kms of the area of interest.

Theoretically, the total potential biomass within the Industrial Heartland region is estimated to be approximately 599,000 tonnes. As biomass continues to be sourced farther from the region, biomass increases significantly, however when accessibility constraints are taken into consideration this potential is reduced by approximately half (Table 1).

Table 1: Summary Statistics

Analysis Unit	Category[1]	Theoretical Potential Biomass							
		Heartland Region		0-50 Km		51 – 100 Km		101 – 150 Km	
		Tonnes[2]	%	Tonnes	%	Tonnes	%	Tonnes	%
Concentric Rings	Agriculture	409,570	68%	8,527,635	47%	12,873,714	28%	14,679,247	14%
	Woody	189,785	32%	9,351,851	52%	32,510,090	72%	91,023,730	86%
	MSW[3]	0	0%	114,046	1%	68,411	0%	7,474	0%
	Total	**599,355**	**100%**	**17,993,532**	**100%**	**45,452,215**	**100%**	**105,710,451**	**100%**
Transportation Network	Agriculture	409,570	68%	5,897,805	56%	9,314,305	32%	13,274,012	28%
	Woody	189,785	32%	4,602,647	43%	19,701,886	68%	33,732,795	72%
	MSW	0	0%	99,588	1%	82,868	0%	0	0%
	Total	**599,355**	**100%**	**10,600,040**	**100%**	**29,099,059**	**100%**	**47,006,807**	**100%**

[1] Agriculture is summarized on a per annum basis, using 2010 data; Woody material estimates are based on the amount of theoretical potential biomass within the area of interest, and do not account for forest regrowth or other ecological or sustainability constraints. Estimates do not represent an annual supply; MSW is summarized on a per annum basis, as the amount of waste entering the facility using 2012 data

[2] Tonnes are summarizes as per BRIMS (2011) data. Crop seed, crop residue, woody materials, and mill residue are summarized based on oven dried tonnes (ODTs), whereas livestock manure and animal processing waste are summarized as dry tonnes.

[3] Municipal Solid Waste is summarized in *gross tonnes* – no moisture content was assumed

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1. INTRODUCTION

Biomass is a renewable resource comprised of biological material taken from living or recently living organisms (Team Silvacom 2012). There are three general biomass sources that constitute the entire biomass potential of a landscape: forest, agriculture, and organic waste.

Forest biomass includes all secondary products derived from wood. Within BRIMS these include:

- Stem wood: biomass obtained from pre-commercial and commercial thinning, as well as final felling of forests;
- Primary forest residues (i.e. logging residues);
- Secondary forest residues obtained from industry by-products such as sawdust, wood chips, bark, etc.; and
- Trees outside of Alberta's green area (forested area) such as trees in urban areas along sidewalks, and other infrastructural areas.

Agricultural biomass includes biomass derived from energy crops, agricultural residues, and animal waste. Examples of these include:

- Oil containing crops (i.e. sunflower, canola, etc.);
- Starch crops (i.e. corn, wheat, barely, etc.);
- Harvest residues (i.e. straw);
- Manure from livestock; and
- Animal processing waste.

Lastly, organic waste encompasses other potential biomass sources including:

- Biodegradable municipal waste

For more information regarding biomass and its potential, please refer to the Bio Resource Information Management System (BRIMS) framework (2012).[4]

[4] http://silvacom.com/case-studies/brims/

1.1 BACKGROUND

Alberta's Industrial Heartland is Canada's largest hydrocarbon processing region with over 40 companies operating within the area. Located within greater Edmonton, and encompassing five municipalities including: the City of Fort Saskatchewan, Lamont County, Strathcona County, Sturgeon County, and the City of Edmonton, the region covers approximately 58,900 ha of land (AIHA 2014).

Alberta's Industrial Heartland is guided by Alberta's Industrial Heartland Association (AIHA), a non-profit organization committed to the sustainable development of the region (AIHA 2014).

Silvacom Ltd. (Silvacom) was engaged by AIHA to evaluate the biomass resource potential within the Industrial Heartland Region, and its surrounding areas (Figure 1) by:

1. Leveraging existing biomass data within the Bio Resource Information Management System (BRIMS) framework to estimate potential biomass supply in the region and surrounding areas. This analysis includes identifying potential biomass types, amounts (tonnes), location, and distance from the industrial region;
2. Estimating the amount of potential biomass within the Heartland region and concentric 50km, 100km, and 150km rings surrounding the region; and
3. Identifying current accessible potential biomass with a 50km, 100km, and 150km transportation network.

The BRIMS framework is a province wide collection of potential biomass resources and ecosystem services, standardized by township. This initiative was initiated by Alberta Innovates – Bio Solutions (Al Bio), with partners Silvacom and Green Analytics. The framework was designed to develop a data and information management system for biomass companies to assess the relative supply (theoretical, technical, economic and sustainable potential) of biomass available by township across Alberta from agricultural, forestry, and municipal solid waste sources (Team Silvacom 2012). BRIMS phase 1 currently summarizes the theoretical biomass supply.

Al Bio was established in 2010 under the Alberta Research and Innovation Act, and is a member of the Alberta Innovates family, which reports to the Minister of Alberta Enterprise and Advanced Education. Al Bio's mandate is to "…*further research and innovation in the province and make Alberta more competitive in the global economy. Al Bio will meet the research and innovation priorities of the Government by providing leadership and coordination for research and innovation that supports the growth and diversification of Alberta's agriculture, forest, and life sciences sectors".* Specifically Al Bio is dedicated to bio-based research (Alberta Innovates 2014).

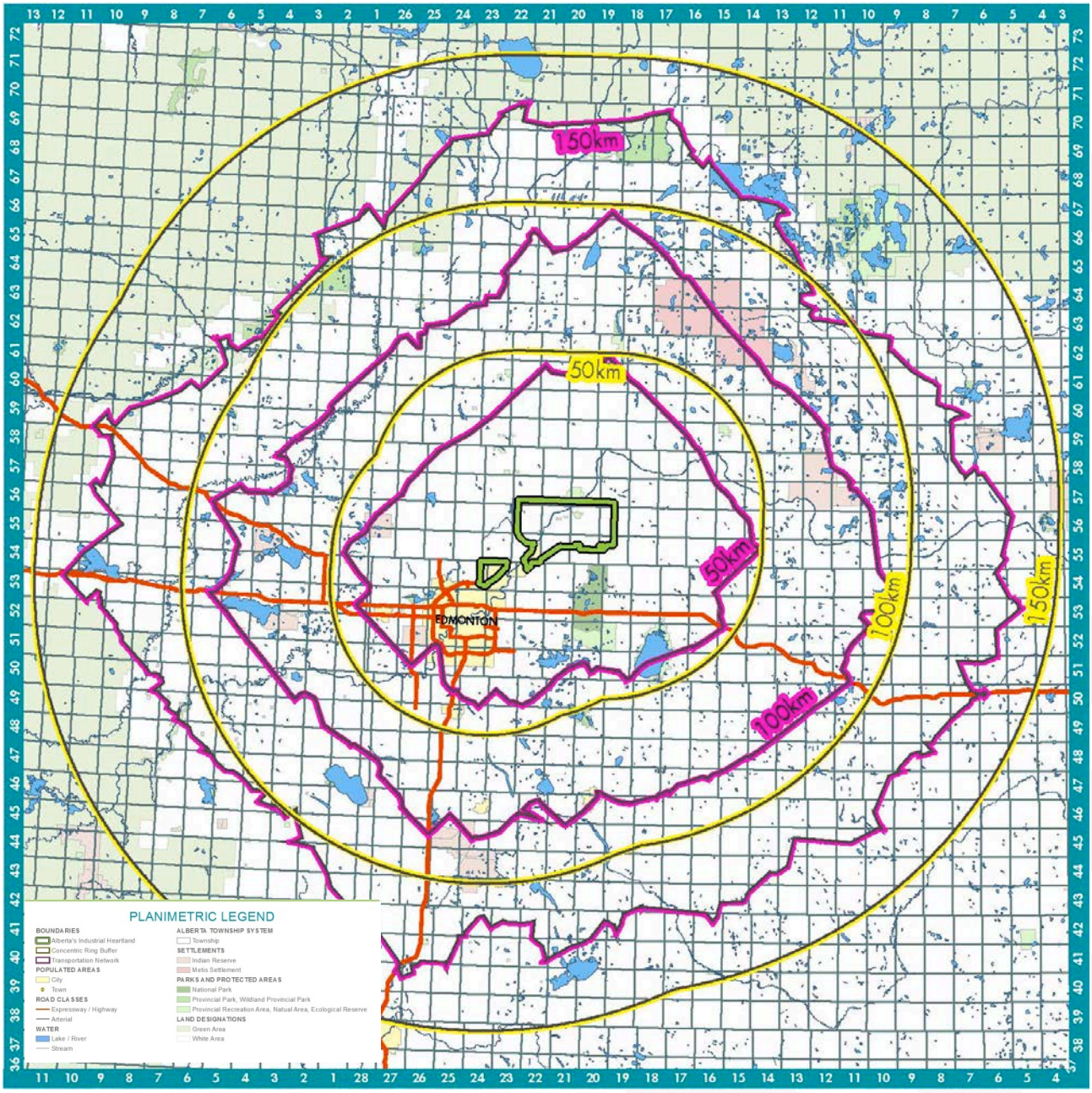
The BRIMS framework is a two phase project. The purpose of phase 1 was to assess the baseline data availability and the associated gaps in an effort to develop a complete biomass inventory for Alberta. Following

this assessment, biomass sources were identified province-wide and recoverable biomass was estimated per township. Phase 1 was completed in 2012. Phase 2 of the framework is on-going, with its end purpose to provide a web-based application to support investment decisions related to the use of biomass in Alberta.

The BRIMS framework fulfils a need in Alberta by providing a centralized location for natural resource, ecosystem services and land-use data. Currently, the framework offers a database of the bio-economy resource assessment, a centralized location to access this information, and a portal to communicate, share, and store all outcomes from the project (LEAP Blog Post 2014).

Data obtained through the BRIMS framework uses the most up-to date information available to calculate biomass potential. This data, along with region-specific information was used to calculate the total biomass potential within the Industrial Heartland region and defined concentric and transportation buffers.

Figure 1: Area of Interest



1.2 PROBLEM DEFINITION

Alberta has an abundant amount of biomass potential and there is a great deal of research and development currently invested in bio-refining, biomaterials, bio-energy, among others. As this industry continues to expand, there will be more and more interest in the market by key players. Industry stakeholders that are interested in expanding into this market will first need to understand the potential biomass resources available to them.

As Canada's largest region dedicated to hydrocarbon processing, investment in the Industrial Heartland region is expected to increase an additional $21 billion as the oil sands industry is anticipated to double over the next 10 years (Salz 2014). The AIHA is dedicated to the sustainable development of the region, and as such are proactively taking steps to diversify their portfolio by promoting investment in biomass based products and energy. As part of this effort, the association is interested in the amount of potential biomass resources in and surrounding the Heartland region.

1.3 APPROACH

Data was leveraged from the Bio Resource Information Management System (BRIMS) framework and used to estimate the total potential biomass within six different buffer areas surrounding the area of interest. Three buffer areas were created to estimate the overall biomass within 50kms, 100kms, and 150kms from the Industrial Heartland. This analysis is termed *concentric rings analysis* as distances are measured directly from the perimeter, "as the crow flies". A second analysis was completed creating an additional three buffer areas that consider transportation routes. This analysis is termed *transportation network analysis* and was created using primary and secondary highways to estimate the amount of potential biomass that is currently accessible within 50kms, 100kms, and 150km of the Industrial Heartland region.

To enhance the BRIMS outputs for the area of interest a number of additional datasets were incorporated to refine potential biomass estimates. Included in this value added process was identifying multiple land cover types (i.e. forested, grassland, pasture, developed, etc.) along with areas where potential biomass resources do exist but are not currently obtainable (i.e. parks and protected areas).

To achieve the project objectives a landbase was first compiled complete with the Industrial Heartland boundary and six surrounding buffer areas. Then, using the compiled landbase, biomass sources and land cover types were identified through the use of the ABMI Land Cover map (2010, Version 1.0) and the ABMI Human Footprint Map (2010, Version 1.1). Lastly, potential biomass (tonnes)[5] was estimated leveraging the BRIMS (2011) framework.

[5] Tonnes are defined as per the BRIMS (2011) framework and can refer to dry tonnes, ODTs, or gross tonnes, dependent on the biomass source.

1.3.1 DATA INPUTS

Layer	Description	Source	Effective Date
BRIMS	The amount of biomass potential (tonnes) per township for the province of Alberta	Alberta Innovates	2011
Alberta Industrial Heartland Boundary	The Industrial Heartland region was digitized using AIHA data	AIHA	2013
Green/White Area	The green and white areas were used to separate biomass potential calculations	AltaLis	2011
50K NTS Base Data (Roads)	Primary and secondary highways were used to estimate the transportation buffers surrounding the Industrial Heartland region	Natural Resources Canada	2013
Parks and Protected Areas	Parks and Protected areas were identified as biomass is not currently accessible within these regions	AltaLis	2012
Indian Reserves and Metis Settlements	Indian Reserves and Metis Settlements were identified as biomass is not currently accessible within these regions	AltaLis	2010
ABMI Land Cover (Version 1.0)	The ABMI Land Cover was used to identify potential biomass sources	ABMI	2010
ABMI Human Footprint Map (Version 1.1)	The ABMI Human Footprint Map was used to identify developed areas	ABMI	2010
Forest Management Areas	FMAs were used to estimate the amount of forest in the green area that is currently allocated	AltaLis	2013
Land Use Framework Planning Regions	The LUF defines regional outcomes (economic, environmental, and social) and provides a broad plan for land and natural resource use (GoA 2013).	AESRD	2011

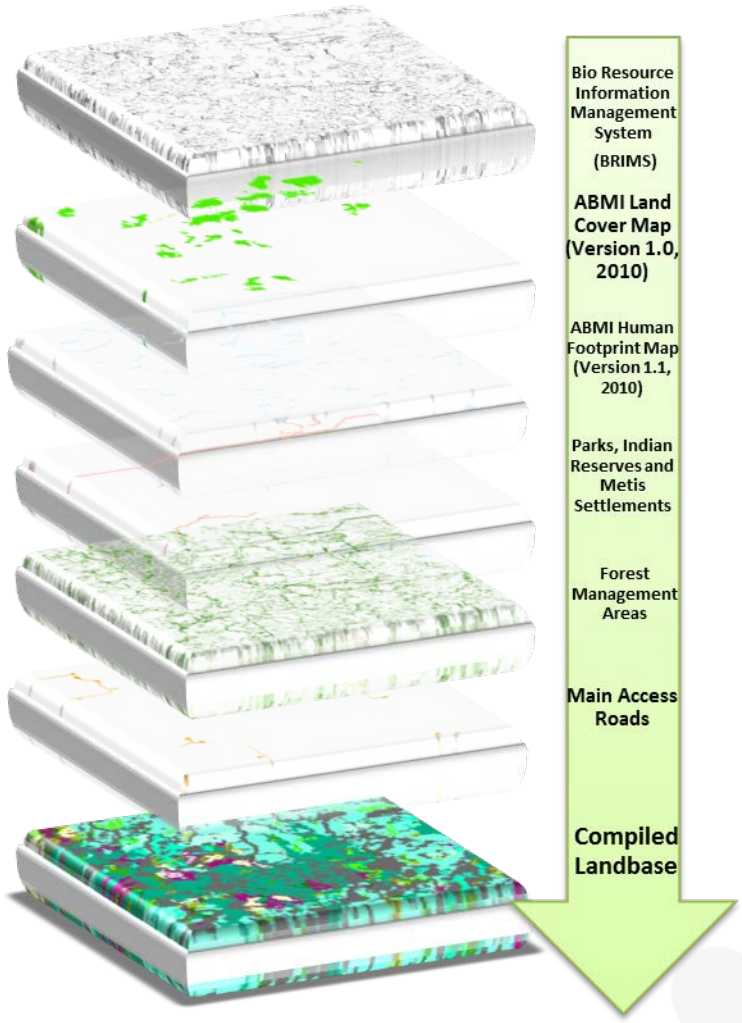
2. METHODOLOGY

All potential biomass resource estimates were leveraged from the BRIMS framework (Alberta Innovates 2011). The BRIMS framework is a province wide database that uses up to date data to estimate the potential biomass resources for the entire province of Alberta. Data was summarized by township.

2.1 LANDBASE CREATION

Multiple data sources were used to identify areas where potential biomass sources exist within and surrounding the Industrial Heartland region (Figure 2). The ABMI Land Cover Map (2010, Version 1.0) overviews forested areas, agriculture areas and developed areas, among others. From this, further anthropogenic footprint was identified from previously productive areas using the ABMI Human Footprint Map (2010, Version 1.1). Parks and protected areas were also identified because biomass may be currently inaccessible within these regions. Parks and protected areas within the white area are identified and biomass is not summarized within this regions. Parks and protected areas within the green area are identified and biomass summaries are included in deletion stands (see Appendix A). Furthermore, current FMA holders were taken into account to forecast areas available for timber harvest within the green area of Alberta. Finally, main access roads were used to estimate the accessibility of potential biomass reserves.

Figure 2: LANDBASE COMPILATION

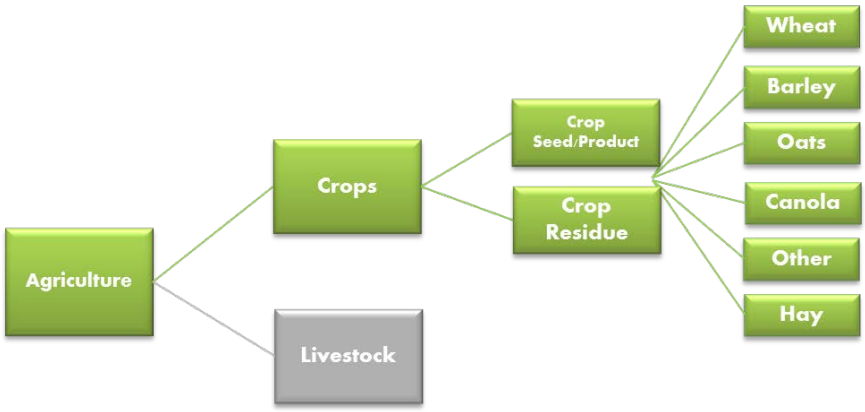


2.2 AGRICULTURE

2.2.1 CROPS

Biomass sourced from agricultural crops can be separated into crop seed/product and crop residue. Crop seed/product represents the total tonnage of crops in the area of interest (oven dried tonnes) and crop residue is an estimate of remaining portions. Currently only materials remaining in the field following harvest are estimated in the BRIMS framework as potential harvest residue sources. Potential biomass was estimated based on the six crops summarized in the BRIMS framework (Figure 3). The biomass estimates per hectare was leveraged into the productive agricultural land outlined in the AIHA landbase. Estimates are based on a per annum perspective, using 2010 data. Estimates will vary from year to year as crop yields and the amount of area in crops varies annually.

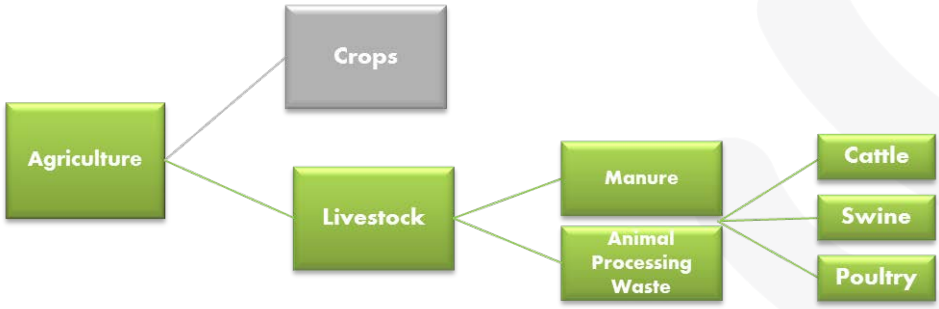
Figure 3: Agricultural Biomass Resources



2.2.2 LIVESTOCK AND POULTRY[6]

Biomass sourced from livestock can be separated into manure and animal processing waste. Biomass estimates for cattle, swine, and poultry were collected per township for both manure and animal processing within the BRIMS framework. This estimate was leveraged into productive agricultural areas within the AIHA landbase. Estimates are based on a per annum perspective, using 2010 data. Estimates will vary year to year, depending on the amount of animals raised per year.

Figure 4: Livestock Biomass Resources



2.3 FORESTED AREA

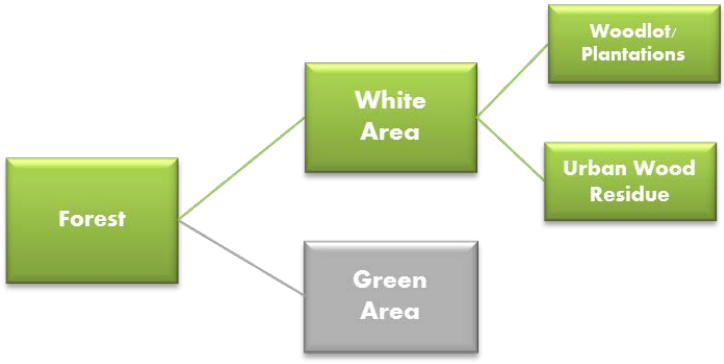
2.3.1 WHITE AREA

The white area in Alberta is comprised of settled lands and covers approximately 39 percent of the province. Primary land uses include: settlements, agriculture, oil and gas development, tourism and recreation, and conservation of natural spaces. Roughly 75 percent of the white area is privately owned (Government of Alberta 2008).

[6] For the purposes of this study poultry is defined as livestock

Forested areas within the white area of the province generally include woodlots and plantations. Potential biomass can be sourced from these woodlots, along with urban wood residue. These two sources are identified as potential biomass sources within the BRIMS framework in the white area. However, currently the BRIMS framework only accounts for potential biomass on woodlots and plantations within the white area. Biomass summaries include all parts of the tree, including top wood, top bark, stem wood, etc. Excluded from this analysis is stump wood and stump bark as this data is not currently available within the BRIMS framework. Estimates are based on the amount of theoretical potential biomass within the area of interest, and do not account for forest regrowth or other ecological or sustainability constraints. Estimates do not represent an annual supply.

Figure 5: Forested Biomass Resources in the White Area



2.3.2 GREEN AREA

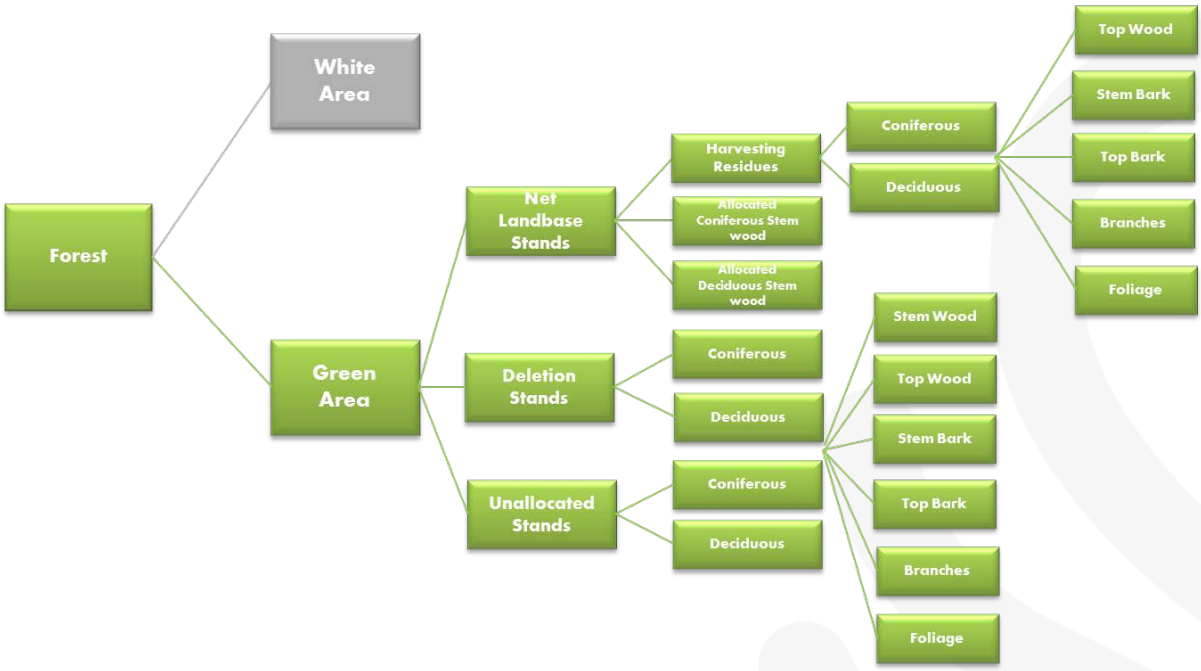
The green area within the province is defined as forested lands and covers approximately 61 percent of the province of Alberta. Primary land uses in this area include timber production, oil and gas development, tourism and recreation and conservation of natural spaces. Nearly all of the green area is publically owned (Alberta Government 2008).

Because the majority of the green area is forested, there are many potential sources of biomass. The BRIMS framework identifies potential biomass sources within the green area as all parts of the tree including not only the stem but also the top wood, top bark, the branches, and the needles or leaves.

The BRIMS framework also separates biomass sources into net landbase stands, landbase deletion stands, and unallocated stands. Net landbase stands are comprised of the operable forested area. Deletion stands contain the area of forests that are inoperable. This includes stands that are within parks are protected areas, within defined water buffers, on steep slopes, low timber productivity or other Forest Management Agreement (FMA) specific operability criteria. For the purposes of this analysis it is assumed that forest area outside of a FMA area is unallocated, although portions of this area may be entirely or partially allocated under a quota or other agreement.

Estimates are based on the amount of theoretical potential biomass within the area of interest, and do not account for forest regrowth or other ecological or sustainability constraints. Estimates do not represent an annual supply.

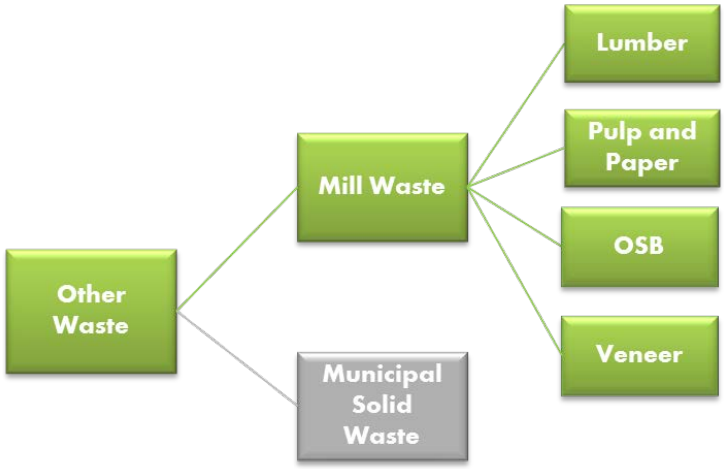
Figure 6: Forested Biomass Resources in the Green Area



2.4 MILL WASTE

Forest product mills were identified within the Industrial Heartland region and surrounding defined buffer areas. The BRIMS framework was then leveraged to estimate potential biomass within the region through sourcing waste from saw mills, veneer mills, OSB mills, and pulp and paper mills. Estimates are based on the amount of residue produced by a forest product mill per annum. This residue may already be allocated to other sources and not tactically available. Estimates will also vary year to year as mill production varies.

Figure 7: Mill Waste Biomass Resources



2.5 MUNICIPAL SOLID WASTE

Landfills located within the Industrial Heartland region and surrounding defined buffer area were identified. Estimates of potential biomass are based on three types of municipal solid waste: construction and demolition (wood components only), organic yard waste, and mixed solid waste (organic components only). Estimates are based on the annual reported incoming waste by landfill.

Figure 8: Solid Waste Biomass Resources

3. RESULTS

The Industrial Heartland region is within greater Edmonton, with concentric rings reaching over 9 million ha and the transportation network reaching just under 6 million ha. As such, the majority of the area of interest is within Alberta's white zone (85%). Due to this, a considerable amount of biomass resources close to the Heartland region are sourced from agriculture, and as the search radius reaches farther from the Industrial Heartland region, additional potential biomass is being sourced from the green area, which is predominately forested. Furthermore, as accessibility constraints are considered, potential biomass is reduced by approximately half (refer to the transportation network results).

The following graphs summarize the results categorically by biomass source. Section 3.4 summarizes the total biomass potential. Potential biomass supply estimates provided are a theoretical estimate and may not be tactically available. Recoverable factors are not taken into account where some potential biomass is likely to remain in the field or the forest floor. Furthermore, some summarized potential biomass is located in areas that may not feasible for recovery and other sources may already be committed to alternative uses.

The resolution of the analysis and results will vary depending on biomass type, consistent with the existing data utilized within BRIMS phase 1 (2011). Tonnes are summarized as *dry tonnes or oven-dried tonnes* consistent with data sources leveraged in the BRIMS framework phase 1, unless otherwise stated.

For a detailed results of the biomass pools, please refer to Appendix A.

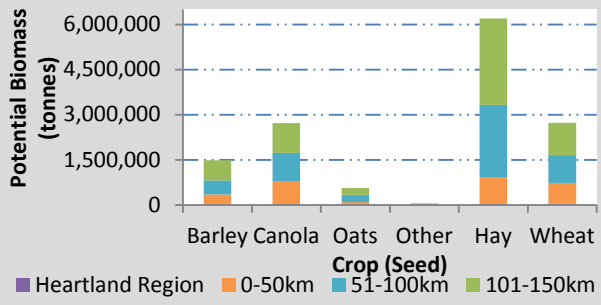
3.1 AGRICULTURE

3.1.1 CROPS[7]

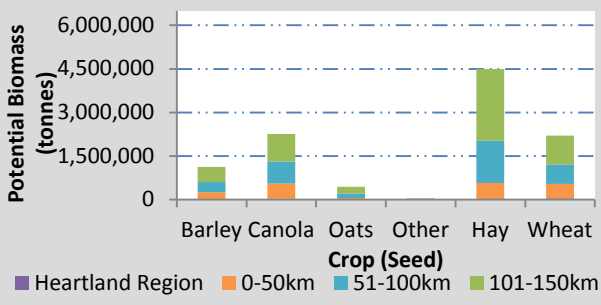
Theoretical Potential Crop Biomass										
Category	Potential Biomass: Concentric Rings									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes[8]	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Crop Seed	125,549	0%	2,796,268	8%	5,014,340	14%	5,830,334	16%	13,766,491	38%
Crop Residue	279,632	1%	5,634,511	16%	7,674,920	21%	8,610,323	24%	22,199,386	62%
Total Crop Potential	**405,181**	**1%**	**8,430,779**	**23%**	**12,689,260**	**35%**	**14,440,657**	**40%**	**35,965,877**	**100%**
Category	Potential Biomass: Transportation Network									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Crop Seed	125,549	0%	1,882,981	7%	3,401,193	12%	5,172,210	18%	10,581,933	37%
Crop Residue	279,632	1%	3,949,342	14%	5,782,551	20%	7,911,029	28%	17,922,554	63%
Total Crop Potential	**405,181**	**1%**	**5,832,323**	**20%**	**9,183,745**	**32%**	**13,083,239**	**46%**	**28,504,487**	**100%**

Agriculture Crop Seed

Concentric Rings

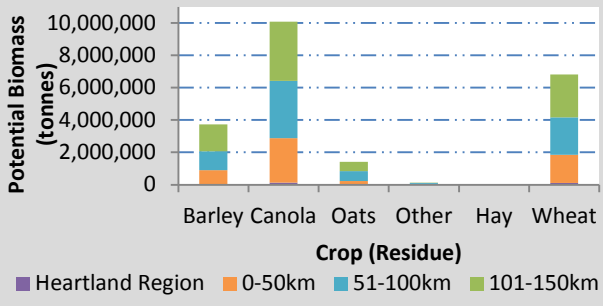


Transportation Network

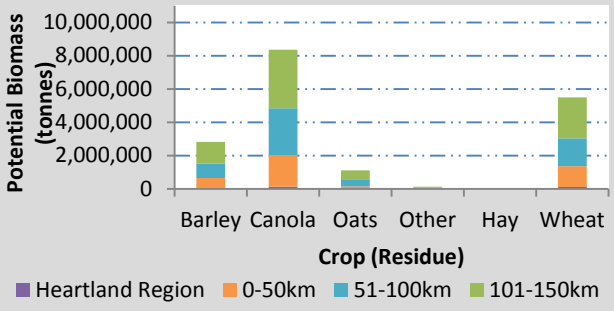


Agriculture Crop Residue

Concentric Rings



Transportation Network



[7] Please refer to the disclaimer on page 5 regarding use of these results.
[8] ODT per year as per the BRIMS (2011) framework

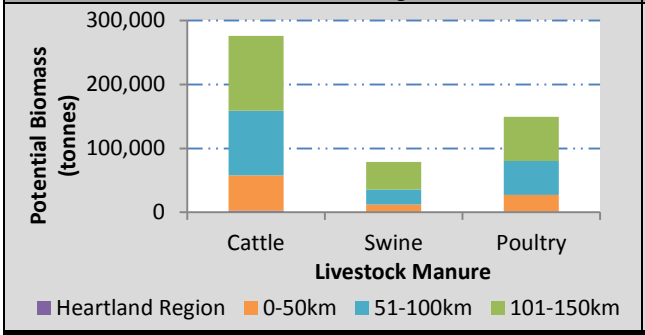
3.1.2 LIVESTOCK AND POULTRY[9]

Theoretical Potential Livestock Biomass

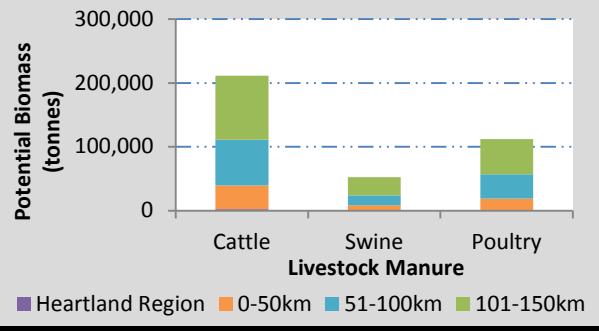
Category	Potential Biomass: Concentric Rings									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes[10]	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Livestock Manure	4,219	1%	93,068	18%	177,423	34%	229,781	44%	504,490	96%
Processing Waste[11]	170	0%	3,788	1%	7,031	1%	8,809	2%	19,799	4%
Total Livestock Potential	**4,389**	**1%**	**96,856**	**18%**	**184,454**	**35%**	**238,590**	**46%**	**524,289**	**100%**
Category	Potential Biomass: Transportation Network									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Livestock Manure	4,219	1%	62,933	16%	125,614	32%	183,599	47%	376,365	96%
Processing Waste	170	0%	2,549	1%	4,947	1%	7,174	2%	14,840	4%
Total Livestock Potential	**4,389**	**1%**	**65,482**	**17%**	**130,561**	**33%**	**190,773**	**49%**	**391,205**	**100%**

Livestock Manure

Concentric Rings

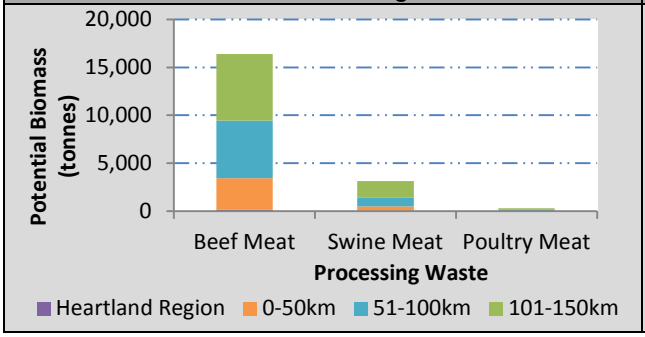


Transportation Network

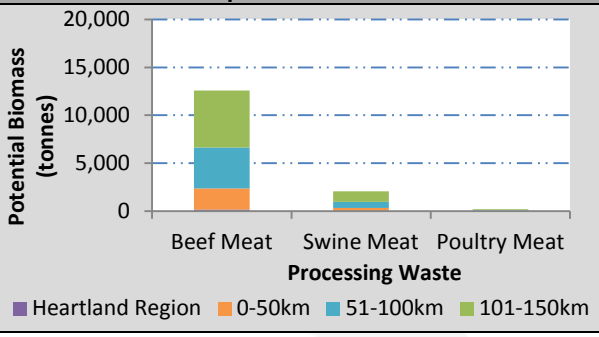


Processing Waste

Concentric Rings



Transportation Network



[9] Please refer to the disclaimer on page 1 regarding use of these results.
[10] Dry tonnes per year as per the BRIMS (2011) framework
[11] Animals may be shipped to processing plants from other regions. The BRIMS (2011) framework does not include an empirical estimate of kilograms of animal processing waste per township. An estimate is computed from the number of animals raised within the region, based on Census Canada data (2010).

3.2 WOODY MATERIALS [12]

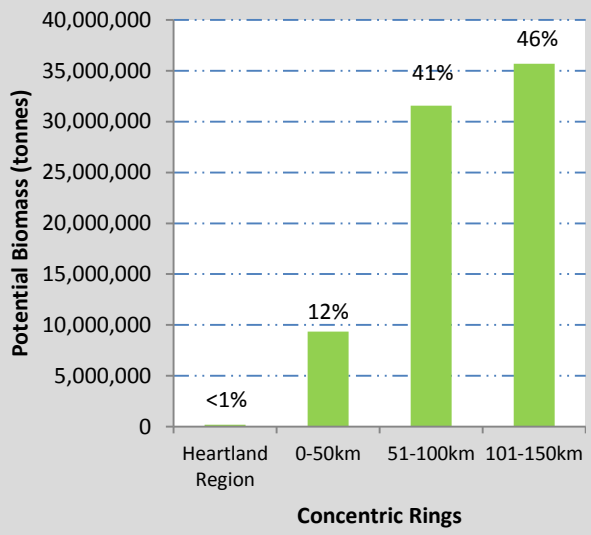
Theoretical Potential Woody Biomass										
Category	Potential Biomass: Concentric Rings									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes[13]	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
White Area	189,785	0%	9,351,851	7%	31,579,984	24%	35,689,178	27%	76,810,798	58%
Green Area	0	0%	0	0%	916,130	1%	55,166,200	41%	56,082,330	42%
Mill Waste	0	0%	0	0%	13,976	0%	168,352	0%	182,328	0%
Total Forestry Potential	**189,785**	**0%**	**9,351,851**	**7%**	**32,510,090**	**24%**	**91,023,730**	**68%**	**133,075,456**	**100%**
Category	Potential Biomass: Transportation Network									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
White Area	189,785	0%	4,602,647	8%	19,687,910	34%	30,040,034	52%	54,520,376	94%
Green Area	0	0%	0	0%	0	0%	3,607,128	6%	3,607,128	6%
Mill Waste	0	0%	0	0%	13,976	0%	85,633	0%	99,609	0%
Total Forestry Potential	**189,785**	**0%**	**4,602,647**	**8%**	**19,701,886**	**34%**	**33,732,795**	**58%**	**58,227,113**	**100%**

[12] Please refer to the disclaimer on page 1 regarding use of these results.
[13] ODT as per the BRIMS (2011) framework. Estimates are based on the amount of theoretical potential biomass within the area of interest, and do not account for forest regrowth or other ecological or sustainability constraints. Estimates do not represent an annual supply.

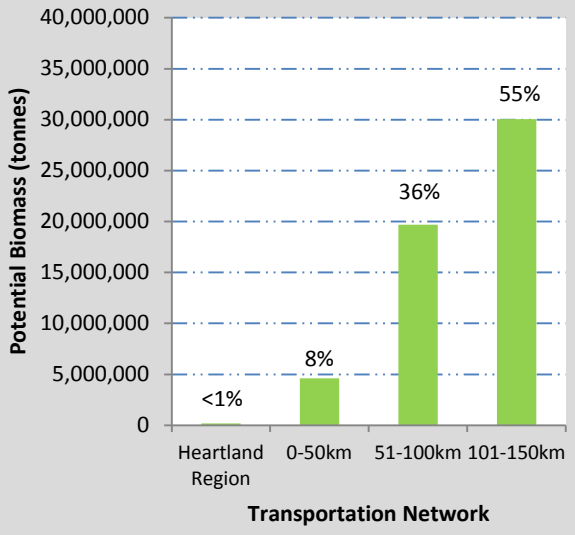
3.2.1 FORESTED WHITE AREA[14]

Forested White Area[15]

Concentric Rings

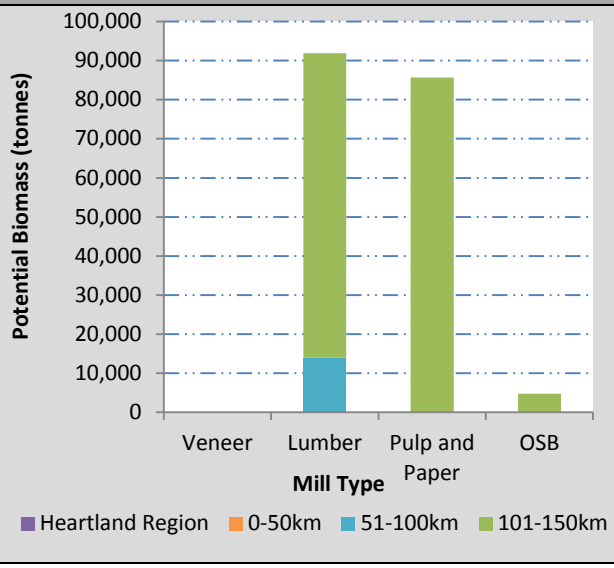


Transportation Network

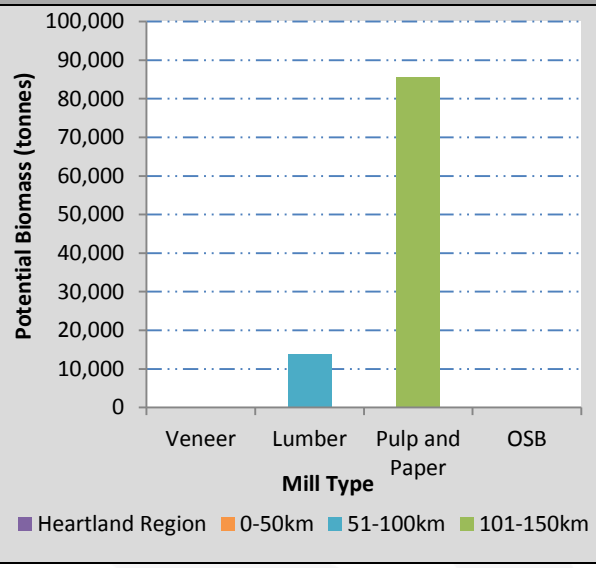


Mill Waste[16]

Concentric Rings



Transportation Network



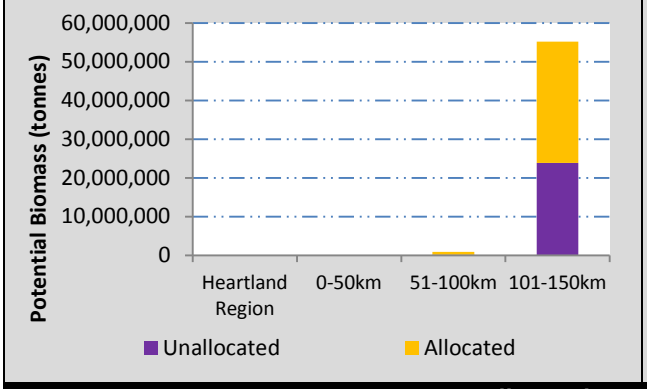
[14] Please refer to the disclaimer on page 1 regarding use of these results.

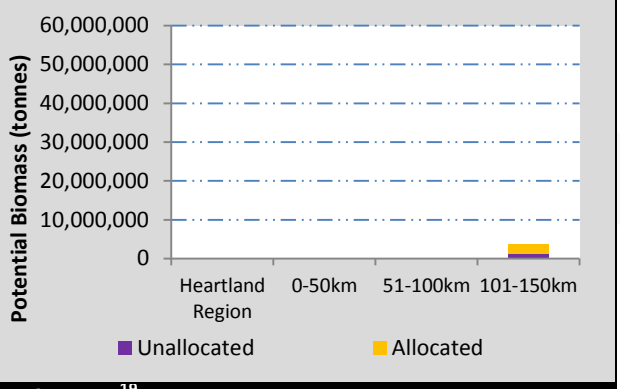
[15] Forested white area biomass potential is determined by average volume estimates published by CANFI. Estimates are a coarse representation of theoretical potential biomass. Stump wood data is not currently available.

[16] Mill waste summarizes the residue surplus from operating mills within the area of interest based on average production (m^3) from 2007-2009. Alpac Forest Products (Boyle) utilizes all harvest residues to generate electricity. Its harvest residues are included in this summary but may not be tactically accessible. There are also other mills within the area of interest of which no production data from 2007-2009 was available. These mills are not included in biomass summary estimates.

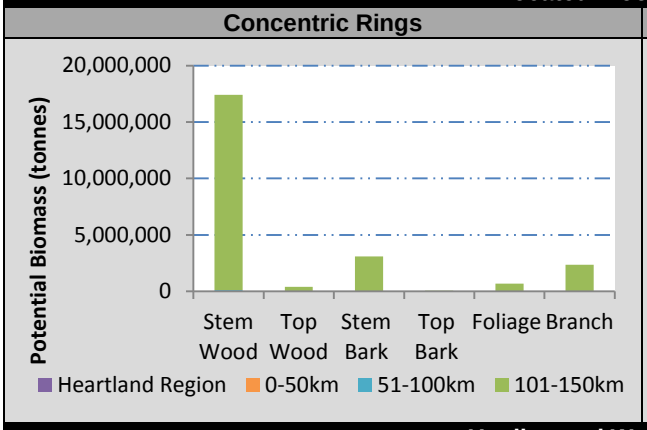
3.2.2 FORESTED GREEN AREA[17]

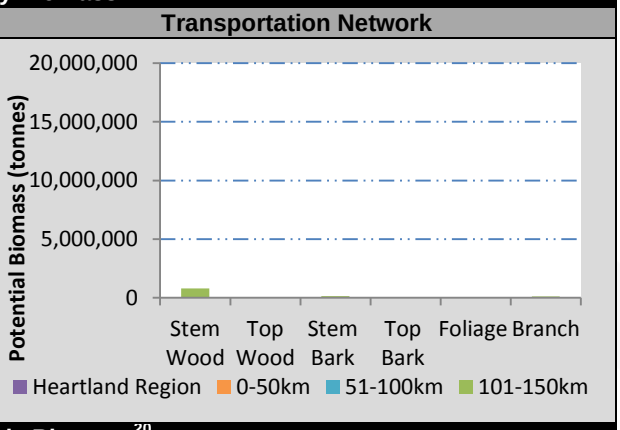
Theoretical Potential Woody Biomass[18]



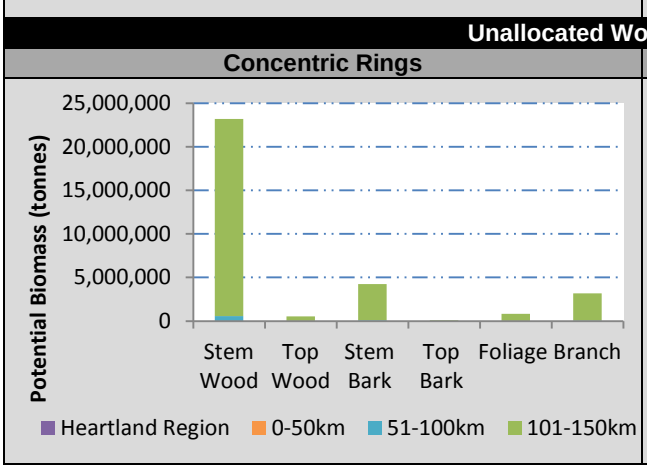


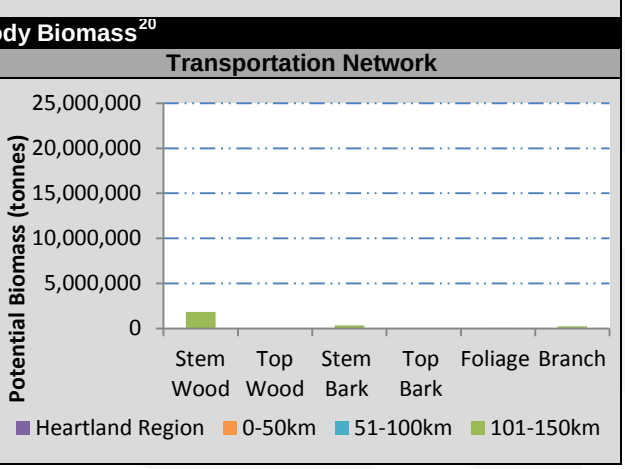
Allocated Woody Biomass[19]





Unallocated Woody Biomass[20]





[17] Please refer to the disclaimer on page 1 regarding use of these results.
[18] Stump wood is not included as a potential biomass source within this analysis
[19] Allocated potential includes all woody material within an FMA
[20] Unallocated potential includes all woody material on forested areas in the green area that do not currently have an FMA holder as well as deletion stands

3.3 MUNICIPAL SOLID WASTE[21]

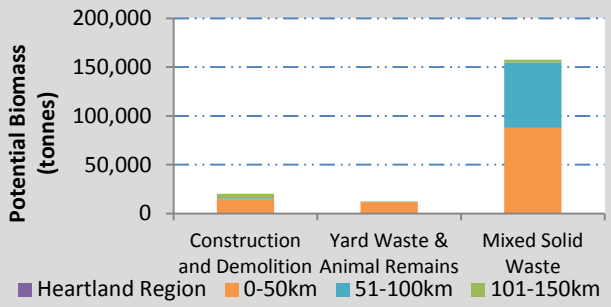
Theoretical Potential MSW Biomass[22]

Category	Potential Biomass: Concentric Rings									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes[23]	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Construction & Demolition	0	0%	14,537	8%	1,022	1%	4,699	2%	20,257	11%
Yard Waste & Animal Remains	0	0%	11,690	6%	380	0%	57	0%	12,128	6%
Mixed Solid Waste	0	0	87,819	46%	67,009	35%	2,718	1%	157,546	83%
Total MSW	**0**	**0%**	**114,046**	**60%**	**68,411**	**36%**	**7,474**	**4%**	**189,930**	**100%**

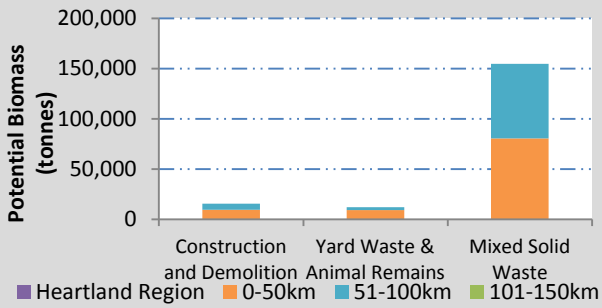
Category	Potential Biomass: Transportation Network									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Construction & Demolition	0	0%	9,701	5%	5,857	3%	0	0%	15,558	9%
Yard Waste & Animal Remains	0	0%	9,338	5%	2,732	1%	0	0%	12,070	7%
Mixed Solid Waste	0	0%	8,0549	44%	74,279	41%	0	0%	154,828	85%
Total MSW	**0**	**0%**	**99,588**	**55%**	**82,868**	**45%**	**0**	**0%**	**182,456**	**100%**

Municipal Solid Waste

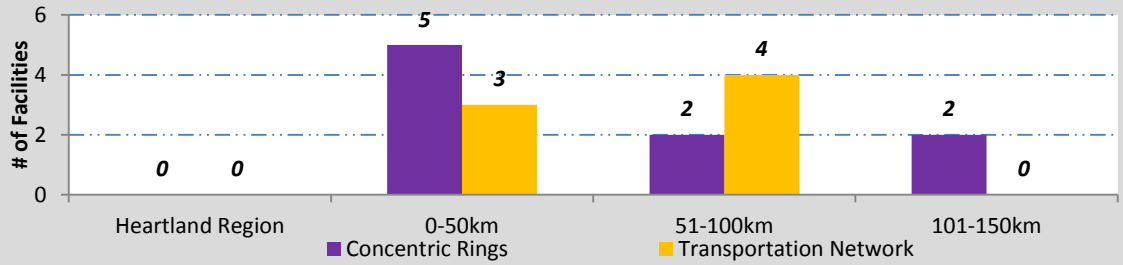
Concentric Rings



Transportation Network



Number of Facilities



[21] Please refer to the disclaimer on page 1 regarding use of these results.
[22] Estimates are based on the amount of incoming waste reported by landfill. These estimates do not include waste that may be diverted to other waste management facilities such as recycling and compost facilities.
[23] Gross tonnes per year – no moisture content was assumed

3.4 TOTAL THEORETICAL BIOMASS POTENTIAL[24]

Theoretical Potential Biomass										
Category	Available Biomass: Concentric Rings									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes[25]	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Agriculture Crop Seed	125,549	0%	2,796,268	1%	5,014,340	2%	5,830,334	3%	13,766,491	6%
Agriculture Crop Residue	279,632	0%	5,634,511	3%	7,674,920	4%	8,610,323	4%	22,199,386	10%
Agriculture Livestock	4,389	0%	96,856	0%	184,454	0%	238,590	0%	524,289	0%
Agriculture Subtotal[26]	***409,570***	***0%***	***8,527,635***	***4%***	***12,873,714***	***6%***	***14,679,247***	***7%***	***36,490,166***	***17%***
Forested White Area[27]	189,785	0%	9,351,851	6%	31,579,984	19%	35,689,178	21%	76,810,798	45%
Forested Green Area[28]	0	0%	0	0%	916,130	0%	55,166,200	26%	56,082,330	26%
Mill Waste[29]	0	0%	0	0%	13,976	0%	82,720	0%	96,696	0%
Woody Subtotal	***189,785***	***0%***	***9,351,851***	***6%***	***32,510,090***	***19%***	***91,023,730***	***54%***	***133,075,457***	***78%***
Municipal Waste[30]	0	0%	114,046	0%	68,411	0%	7,474	0%	189,931	0%
Total Biomass Potential	**599,355**	**0%**	**17,993,532**	**11%**	**45,452,215**	**27%**	**105,710,451**	**62%**	**169,755,554**	**100%**
Category	Available Biomass: Transportation Network									
	Heartland Region		0 to 50km		51 to 100km		101 to 150km		Total Potential	
	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Agriculture Crop Seed	125,549	0%	1,882,981	2%	3,401,193	3%	5,172,210	4%	10,581,933	9%
Agriculture Crop Residue	279,632	0%	3,949,342	3%	5,782,551	5%	7,911,029	7%	17,922,554	15%
Agriculture Livestock	4,389	0%	65,482	0%	130,561	0%	190,773	0%	391,205	0%
Agriculture Subtotal	***409,570***	***0%***	***5,897,805***	***5%***	***9,314,306***	***8%***	***13,274,012***	***11%***	***28,895,693***	***24%***
Forested White Area	189,785	0%	4,602,647	5%	19,687,910	23%	30,040,034	34%	54,520,376	62%
Forested Green Area	0	0%	0	0%	0	0%	3,607,128	3%	3,607,128	3%
Mill Waste	0	0%	0	0%	13,976	0%	0	0%	13,976	0%
Woody Subtotal	***189,785***	***0%***	***4,602,647***	***5%***	***19,701,886***	***23%***	***33,732,795***	***39%***	***58,227,113***	***67%***
Municipal Waste	0	0%	99,588	0%	82,868	0%	0	0%	182,456	0%
Total Biomass Potential	**599,355**	**0%**	**10,600,040**	**12%**	**29,099,059**	**33%**	**47,006,807**	**54%**	**87,305,261**	**100%**

[24] Please refer to the disclaimer on page 1 regarding use of these results.
[25] Tonnes are summarized as per BRIMS (2011) data. Crop seed, crop residue, woody materials, and mill residue are summarized based on oven dried tonnes (ODTs), livestock manure and animal processing waste are summarized as dry tonnes, and MSW is summarized as gross tonnes.
[26] Agriculture biomass estimates are based on a per annum estimate.
[27] Forested white area is based on the amount of theoretical potential biomass within the area of interest and does not account for forest regrowth or other ecological or sustainability constraints. Estimates do not represent an annual supply.
[28] Forested green area is based on the amount of theoretical potential biomass within the area of interest and does not account for forest regrowth or other ecological or sustainability constraints. Estimates do not represent an annual supply.
[29] Mill waste is an annual estimate based on average production values from 2007-2009.
[30] MSW is an annual estimate based on the incoming waste reported by each landfill.

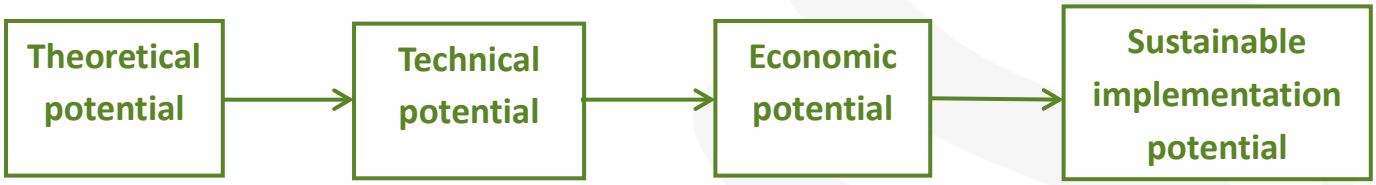
4. NEXT STEPS

Silvacom was engaged by AIHA to evaluate the biomass resource potential within the Industrial Heartland region, and its surrounding areas by leveraging existing biomass data within the BRIMS (2011) framework. Six separate buffer areas were identified surrounding the Heartland region to represent distance to the Heartland region (concentric ring buffers) and accessibility (transportation network).

This analysis has summarized the total theoretical biomass potential in and surrounding the Heartland region. Further investigation can be conducted to refine the scale, scope, and sustainability of biomass potential including:

- Updates to the transportation network using 20K base data;
- Updates to the landbase using ABMI Land Cover (2012) when it becomes publically available;
- Updates to the landbase to include timber dispositions within the green area;
- Continuous and timely updates to biomass summaries as the BRIMS (2011) framework is updated with up to date data and additional biomass resources;
- Sensitivity analysis on agricultural yields from year to year;
- Updating biomass potential scale to identify technical, economic and sustainable implementation potential (Figure 9);
- Biomass conversion from dry tonnes to energy (pj/year); and
- The incorporation of new ideas including flue gas and carbon capture industries.

Figure 9: Biomass Potential Scale



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APPENDIX A: THE BRIMS FRAMEWORK

Theoretical Potential Biomass (tonnes)		AIHA Region	Concentric Rings			Transportation Network		
			0-50km	51-100km	101-150km	0-50km	51-100km	101-150km
Agriculture:		**409,570**	**8,527,635**	**12,873,715**	**14,679,247**	**5,897,805**	**9,314,306**	**13,274,011**
Crops:		***405,181***	***8,430,779***	***12,689,260***	***14,440,657***	***5,832,323***	***9,183,745***	***13,083,239***
Crop Seed:		125,549	2,796,268	5,014,340	5,830,334	1,882,981	3,401,193	5,172,210
	Wheat	46,247	691,980	927,227	1,064,821	500,845	666,608	988,319
	Barley	9,128	349,803	464,677	668,430	249,327	350,563	520,263
	Oats	3,019	92,056	244,211	228,875	55,706	155,168	229,003
	Corn	0	0	0	0	0	0	0
	Canola	36,121	741,246	957,220	991,059	513,884	760,171	949,349
	Flax	0	0	0	0	0	0	0
	Hay	31,034	898,262	2,403,838	2,861,913	549,908	1,453,055	2,463,486
	Other	0	22,921	17,167	15,237	13,311	15,629	21,789
Crop Residue:		279,632	5,634,511	7,674,920	8,610,323	3,949,342	5,782,551	7,911,029
	Wheat	115,617	1,729,950	2,318,067	2,662,052	1,252,114	1,666,521	2,470,798
	Barley	22,819	874,507	1,161,693	1,671,074	623,317	876,407	1,300,656
	Oats	7,548	230,140	610,529	572,188	139,265	387,920	572,508
	Corn	0	0	0	0	0	0	0
	Canola	133,648	2,742,611	3,541,715	3,666,917	1,901,369	2,812,632	3,512,593
	Flax	0	0	0	0	0	0	0
	Hay	0	0	0	0	0	0	0
	Other	0	57,303	42,917	38,091	33,277	39,072	54,474
Processing Residue:		N/A[31]	N/A	N/A	N/A	N/A	N/A	N/A
Livestock:		***4,389***	***96,856***	***184,454***	***238,590***	***65,482***	***130,561***	***190,773***
Manure:		4,219	93,068	177,423	229,781	62,933	125,614	183,599
	Cattle	2,490	55,251	101,337	117,054	37,237	71,683	100,146
	Swine	525	11,846	23,224	43,325	7,874	15,680	28,293
	Poultry	1,204	25,972	52,861	69,401	17,823	38,252	55,160
Animal Processing Waste:		170	3,788	7,031	8,809	2,549	4,947	7,174
	Beef Meat	148	3,282	6,022	6,937	2,211	4,262	5,946
	Swine Meat	21	469	921	1,721	311	621	1,123
	Poultry Meat	2	38	88	151	26	64	105

[31] Not Available

Forest:				***189,785***	***9,351,851***	***32,510,090***	***91,023,730***	***4,602,647***	***19,701,886***	***33,732,795***
	White Area:			189,785	9,351,851	31,579,984	35,689,178	4,602,647	19,687,910	30,040,034
		Woodlot/Plantation:		189,785	9,351,851	31,579,984	35,689,178	4,602,647	19,687,910	30,040,034
		Urban Wood Residue:		N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Green Area:			0	0	916,130	55,166,200	0	0	3,607,128
		Net Landbase Stands:		*0*	*0*	*141,544*	*23,850,945*	*0*	*0*	*1,065,340*
		Allocated Conifer Stemwood:		0	0	53,334	8,807,016	0	0	341,045
		Allocated Deciduous Stemwood:		0	0	50,091	8,493,629	0	0	440,141
		Dead Woody Material:		N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Harvesting Residues:		0	0	38,119	6,550,301	0	0	284,153
		Coniferous:		**0**	**0**	**19,094**	**3,315,024**	**0**	**0**	**113,480**
			Top Wood	0	0	1,230	203,038	0	0	7,863
			Top Bark	0	0	206	31,543	0	0	1,359
			Branches	0	0	6,517	1,161,548	0	0	45,330
			Stem Bark	0	0	8,931	1,368,225	0	0	58,929
			Foliage	0	0	2,210	550,669	0	0	17,959
			Stump Wood	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Stump Bark	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Deciduous:		**0**	**0**	**19,025**	**3,235,277**	**0**	**0**	**170,673**
			Top Wood	0	0	1,155	195,813	0	0	10,147
			Top Bark	0	0	234	39,211	0	0	2,110
			Branches	0	0	6,802	1,179,374	0	0	61,299
			Stem Bark	0	0	10,137	1,700,826	0	0	91,509
			Foliage	0	0	698	120,053	0	0	5,607
			Stump Wood	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Stump Bark	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Landbase Deletion Stands:		*0*	*0*	*302,456*	*23,392,562*	*0*	*0*	*1,845,340*
		Coniferous:		**0**	**0**	**156,923**	**11,119,579**	**0**	**0**	**795,488**
			Top Wood	0	0	2,664	185,742	0	0	13,247
			Top Bark	0	0	446	29,472	0	0	2,295
			Branches	0	0	14,085	1,076,278	0	0	75,972
			Stem Wood	0	0	115,561	8,056,786	0	0	574,594
			Stem Bark	0	0	19,335	1,278,376	0	0	99,552
			Foliage	0	0	4,832	492,925	0	0	29,828
			Stump Wood	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Stump Bark	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Deciduous:		**0**	**0**	**145,533**	**12,272,983**	**0**	**0**	**1,049,852**
			Top Wood	0	0	2,431	204,660	0	0	17,437

	Top Bark	0	0	491	41,364	0	0	3,623
	Branches	0	0	14,296	1,232,942	0	0	105,270
	Stem Wood	0	0	105,438	8,877,360	0	0	756,369
	Stem Bark	0	0	21,305	1,794,208	0	0	157,172
	Foliage	0	0	1,573	122,450	0	0	9,979
	Stump Wood	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Stump Bark	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Unallocated Stands:		*0*	*0*	*472,130*	*7,922,693*	*0*	*0*	*696,449*
Coniferous:		**0**	**0**	**219,404**	**3,395,554**	**0**	**0**	**315,385**
	Top Wood	0	0	3,698	56,405	0	0	5,270
	Top Bark	0	0	584	9,413	0	0	854
	Branches	0	0	20,219	332,659	0	0	29,891
	Stem Wood	0	0	160,384	2,446,626	0	0	228,589
	Stem Bark	0	0	25,350	408,321	0	0	37,024
	Foliage	0	0	9,170	142,130	0	0	13,757
	Stump Wood	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Stump Bark	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deciduous:		**0**	**0**	**252,726**	**4,527,139**	**0**	**0**	**381,064**
	Top Wood	0	0	4,223	75,255	0	0	6,349
	Top Bark	0	0	854	15,498	0	0	1,300
	Branches	0	0	25,165	460,060	0	0	38,094
	Stem Wood	0	0	183,173	3,264,285	0	0	275,404
	Stem Bark	0	0	37,049	672,247	0	0	56,387
	Foliage	0	0	2,262	39,793	0	0	3,529
	Stump Wood	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Stump Bark	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mill Waste		***0***	***0***	***13,976***	***168,352***	***0***	***13,976***	***85,633***
Lumber:		0	0	13,976	77,937	0	13,976	0
Pulp and Paper:		0	0	0	85,633	0	0	85,633
OSB:		0	0	0	4,782	0	0	0
Veneer:		0	0	0	0	0	0	0
Municipalities:		***0***	***114,046***	***68,411***	***7,474***	***99,588***	***82,868***	***0***
Municipal Solid Waste:		0	114,046	68,411	7,474	99,588	82,868	0
	Construction and Demolition:	0	14,537	1,022	4,699	9,701	5,857	0
	Yard Waste & Animal Remains:	0	11,690	380	57	9,338	2,732	0
	Mixed Solid Waste:	0	87,819	67,009	2,718	80,549	74,279	0

APPENDIX B: ADDITIONAL MAPS

APPENDIX C: BRIMS FRAMEWORK POSTER