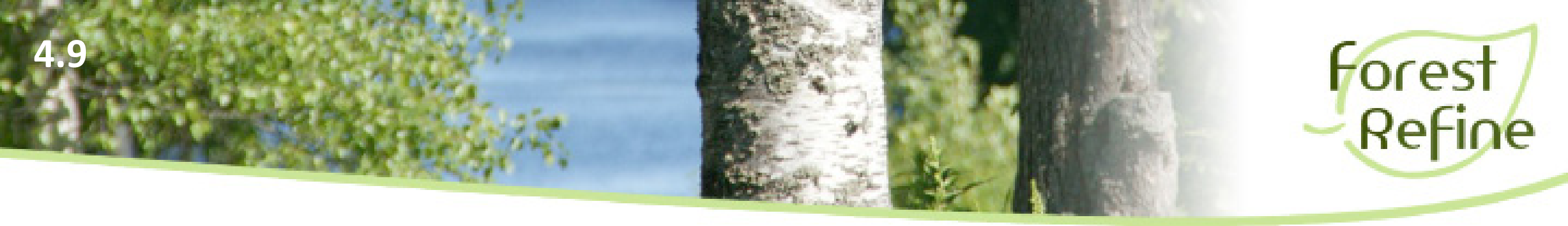

Potentials of Biomass from Pine, Spruce and Birch for Three Locations in The Swedish Part of Botnia-Atlantica Region

The establishment of new biorefineries in the Botnia-Atlantica region depends among other things on the availability of forest biomass in the region and good transport options. In this report, the available potentials of various forest biomass assortments around three potential biorefinery locations (Umeå, Storuman och Örnsköldsvik) are presented. Theoretical procurement areas were created using the existing road network and the biomass potentials within these areas were quantified.

Methods

In this study potentially available quantities of roundwood, bark, branches, leaves and needles as well as tops and stumps with attached root system were estimated for the period 2010-2059 for three localities in the North of Sweden. Two are located on the coast, Umeå and Örnsköldsvik. Both have existing district heating plants that run on biomass as well as large pulp mills and potential locations for development of new types of industries. The third location, Storuman, is located inland and is a potential location for a new forest-based industry or an industrial-scale hub for feedstock handling and upgrading before further transport to remote industries. A procurement area with a 120 km radius was retrieved using the existing road network and the Network Analyst module in ArcGis 10.2. The calculations assumed no competition for biomass from other industries.

The estimations of the available quantities of forest biomass were based on data collected from the Swedish Forest Inventory (SFI) from 2002 to 2006 for the "Skogliga konsekvensanalyser 2008" study (Swedish Forest Agency 2008). This is a hundred year timber production forecast comparing a reference with alternative scenarios. The scenarios are based on different forest management options. The estimations in the current study take into account all the productive forest around the localities of Umeå, Storuman och Örnsköldsvik, including that within formal protected areas (national parks, nature reserves, etc.). The reference scenario that is considered here assumes that Swedish silvicultural practices will not change and annual fellings will still be at a level that is regarded as sustainable, that environmental legislation will not change and that climate change will be light (Swedish Forest Agency 2008).

The volume of roundwood, bark, branches, needles, tops, stumps with attached root system that is forecasted to result after each harvesting operation within the study period, that is in fact a theoretical potential, is reported in oven dry tons per ha (odt/ha) for every tree species i.e. spruce, pine and broadleaves (mostly birch). The biomass functions for estimating volumes of all the tree parts except stumps with attached root system are described in Pettersson (1999). The biomass functions are based on e.g. the tree species, the breast height diameter of the trees, tree height and the production capacity of the site.

Biomass functions for estimating the volume of stumps with attached root system were based on tree species and the breast height diameter of the trees and described in Pettersson and Ståhl (2006). Roundwood is the main product of the harvesting operations while branches, needles and tops (hereafter referred to as harvesting residues) and stumps with attached root system (hereafter referred to as stumps) are regarded as by-products.

The theoretical potential expresses an upper limit of availability of roundwood, bark, harvesting residues and stumps. In order to assess the ecological potential of harvesting residues and stumps a number of restrictions can be applied on the theoretical potential (Athanassiadis et al., 2009). The restriction set is developed in cooperation with the Swedish Forest Agency (SFA, 2008). In this study, harvesting of roundwood was not subjected to any ecological restrictions i.e., the volume that is reported is the theoretical potential for the studied period. On the other hand, the output of harvesting residues and stumps from the harvesting operations was reduced by excluding plots in productive forest areas that are situated in:

1. Sites that are located 25 meters from a lake, sea, waterline or any other ownership category than forest. In this way damage to the water courses is minimized and consideration is taken on social aspects (e.g. risk of damaging sites of cultural heritage, of recreation interest etc).
2. Very wet sites, water table less than 1 meter deep, and peat soils where peat covers more than half of the harvesting area. These sites have low bearing capacity. In this way soil compaction, rutting and rise of the water layer is avoided both in main as well as secondary strip roads.
3. Sites of nature protection.
4. Sites that have a slope of more than 50 percent according to the Swedish terrain classification scheme. In this way erosion is avoided.
5. In addition, no hardwood stumps were considered i.e. to high biodiversity values all hardwood stumps are retained.

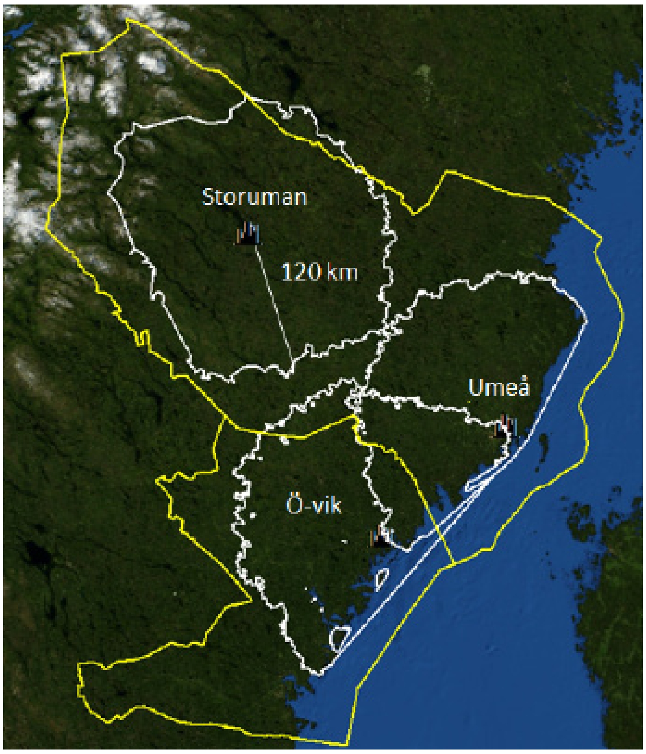

Figure 1. Studied procurement area of the facilities in Umeå, Storuman and Örnsköldsvik. The Botnia-Atlantica region is outlined with a yellow line.

More information on guidelines and recommendations for harvesting of stumps and harvesting residues is provided in SFA (2008b) and SFA (2009).

RESULTS

In Tables 1, 2 and 3 the theoretical potentials (ktonsDS) of assortments from commercial thinnings and final fellings for the period 2010-2059 are reported.

Table 1. Potentials of pine biomass assortments (ktonsDS/year) for facilities located in Umeå, Storuman and Örnsköldsvik

	Period	Roundwood	Bark	Branches	Needles	Stumps	Tops
Umeå							
	2010-2019	702,4	48,3	112,7	37,9	291,8	13,8
	2020-2029	659,5	48,8	112,7	38,1	283,1	14,4
	2030-2039	616,5	44,0	96,9	31,1	264,6	12,2
	2040-2049	568,0	40,8	90,6	28,4	244,3	11,1
	2050-2059	688,8	49,3	108,8	33,6	293,9	13,5
	2060-2069	809,0	57,1	125,0	37,3	340,0	15,3
Storuman							
	2010-2019	454,9	34,9	79,4	34,9	203,0	10,6
	2020-2029	549,3	44,0	96,4	42,1	252,2	13,7
	2030-2039	446,2	32,5	68,3	26,8	199,3	8,9
	2040-2049	437,0	32,1	68,3	26,4	196,8	8,6
	2050-2059	436,2	31,5	66,9	25,4	196,1	8,0
	2060-2069	575,8	41,4	88,7	32,4	253,5	10,2
Örnsköldsvik							
	2010-2019	580,3	42,9	98,9	36,5	246,0	11,9
	2020-2029	674,9	50,6	113,4	40,6	289,9	14,1
	2030-2039	557,5	39,1	83,4	27,7	233,5	10,3
	2040-2049	593,5	42,4	90,3	30,0	252,8	11,5
	2050-2059	753,4	52,4	112,0	35,9	311,9	14,0
	2060-2069	799,6	56,1	119,2	37,8	332,6	15,2

Table 2. Potentials of spruce biomass assortments (ktonsDS/year) for facilities located in Umeå, Storuman and Örnsköldsvik.

	Period	Roundwood	Bark	Branches	Needles	Stumps	Tops
Umeå							
	2010-2019	604,6	69,4	177,1	95,9	291,8	14,6
	2020-2029	440,8	50,9	131,6	71,7	283,1	10,9
	2030-2039	296,6	35,3	89,5	48,6	264,6	7,5
	2040-2049	326,6	38,4	94,9	50,3	244,3	7,9
	2050-2059	341,5	40,2	100,3	53,9	293,9	8,8
	2060-2069	357,8	41,1	100,2	52,9	340,0	8,1
Storuman							
	2010-2019	338,3	43,4	108,1	58,2	212,4	9,3
	2020-2029	330,0	41,6	100,4	52,3	203,9	7,0
	2030-2039	477,9	62,4	142,8	72,1	296,2	10,5
	2040-2049	560,8	72,4	168,3	85,4	347,9	11,4
	2050-2059	408,5	51,2	122,4	63,3	250,1	8,2
	2060-2069	366,0	45,2	107,3	55,3	223,8	6,9
Örnsköldsvik							
	2010-2019	864,2	95,2	241,1	130,4	483,7	21,5
	2020-2029	715,8	80,1	204,0	110,5	405,5	17,2
	2030-2039	517,6	59,6	147,0	77,8	297,6	13,2
	2040-2049	569,5	65,1	158,5	82,3	326,1	13,1
	2050-2059	610,7	67,9	165,9	86,5	343,4	13,3
	2060-2069	556,4	61,1	147,3	76,0	310,7	11,2

Table 3. Potentials of birch biomass assortments (ktonsDS/year) for facilities located in Umeå, Storuman and Örnsköldsvik.

	Period	Roundwood	Bark	Branches	Tops
Umeå					
	2010-2019	119,0	19,5	32,2	3,7
	2020-2029	138,9	22,8	37,1	4,3
	2030-2039	336,	54,7	91,6	8,9
	2040-2049	276,9	44,2	74,8	8,1
	2050-2059	346,9	56,5	93,4	10,2
	2060-2069	420,2	65,4	115,4	10,2
Storuman					
	2010-2019	118,0	20,1	35,3	4,8
	2020-2029	119,4	20,6	34,6	4,8
	2030-2039	263,9	45,2	78,5	8,2
	2040-2049	373,9	64,6	101,4	10,1
	2050-2059	398,6	67,6	108,5	8,7
	2060-2069	330,9	56,0	96,5	8,0
Örnsköldsvik					
	2010-2019	166,7	26,9	45,0	5,0
	2020-2029	216,0	34,7	58,9	6,4
	2030-2039	458,6	72,5	128,7	12,1
	2040-2049	602,4	93,5	168,7	12,1
	2050-2059	586,2	93,6	154,8	13,2
	2060-2069	580,9	90,0	157,3	12,3

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