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Feedstock Availability and Cost in Nova Scotia

By County and Specific Locations

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Table of contents

Executive Summary 6
INTRODUCTION 10
Background 10
Provincial subdivisions 10
Forest landscape 11
Sustainable wood harvest 14
Lahey Report 15
Forest industry 16
Feedstock AVAILABILITY 19
Products 19
Availability 20
Feedstock supply availability 21
Roundwood 21
Harvest residues 27
Mill by-products 30
Feedstock availability by location 33
Site Selection 33
Assumptions 35
Forest feedstock 35
Northern Pulp 35
1-Greenfield 36
Scenario 1. With Northern Pulp operating 37
Scenario 2. Without Northern Pulp 38
2-Kaizer Meadow 39
Scenario 1. With Northern Pulp operating 40
Scenario 2. Without Northern Pulp 41
3-Enfield 42
Scenario 1. With Northern Pulp operating 43
Scenario 2. Without Northern Pulp 44

4-Trenton 45
Scenario 1. With Northern Pulp operating 46
Scenario 2. Without Northern Pulp 47
5-Sheet Harbour 48
Scenario 1. With Northern Pulp operating 49
Scenario 2. Without Northern Pulp 50
6-Port Hawkesbury 51
Scenario 1. With Northern Pulp operating 52
Scenario 2. Without Northern Pulp 53
Feedstock supply cost 54
FPInterface pro forma analysis 54
Markets value analysis 56
What the market is willing to pay 56
Conclusion 58
References 59
Appendix 1 61
Forest industry trends 61
Appendix 2 63
Wood supply 63
Appendix 3 68
Distances to potential bioeconomy locations 68
Appendix 4 70
Forest feedstocks costing pro forma 70

List of figures

Figure 1. Nova Scotia Regions and Counties 11
Figure 2. Forest cover by county in Nova Scotia 12
Figure 3. Nova Scotia productive forest land ownership 13
Figure 4. Historical harvest levels in Nova Scotia 15
Figure 5. Forest fibre utilization rates in Nova Scotia 21
Figure 6. Annual harvest average by county and landowner (2015-2019). 25
Figure 7. Available sustainable wood supply by County and species with Northern Pulp 26
Figure 8. Available sustainable wood supply by County and species without Northern Pulp. 27
Figure 9. Wood flow diagram for softwood stands harvested with CTL (simulated in BiOS). 28
Figure 10. Wood flow diagram for hardwood stands harvested with CTL (simulated in BiOS). 29
Figure 11. Harvest residue availability per county. 30
Figure 12. By-product output by county from sawmills consuming over 1,000 m^3 in 2019. 33
Figure 13. Sites selected for feedstock assessment 34
Figure 14. Road distances from Greenfield. 36
Figure 15. Forest fibre availability surrounding Greenfield with Northern Pulp operating. 37
Figure 16. Forest fibre availability surrounding Greenfield with Northern Pulp closed. 38
Figure 17. Road distances from Kaizer Meadow. 39
Figure 18. Forest fibre availability surrounding Kaizer Meadow with Northern Pulp operating. . 40
Figure 19. Forest fibre availability surrounding Kaizer Meadow with Northern Pulp closed. 41
Figure 20. Road distance from Enfield. 42
Figure 21. Forest fibre availability surrounding Enfield with Northern Pulp operating. 43
Figure 22. Forest fibre availability surrounding Enfield with Northern Pulp closed. 44
Figure 23. Road distances from Trenton. 45
Figure 24. Forest fibre availability surrounding Trenton with Northern Pulp operating. 46
Figure 25. Forest fibre availability surrounding Trenton with Northern Pulp closed. 47
Figure 26. Road distances from Sheet Harbour. 48
Figure 27. Forest fibre availability surrounding Sheet Harbour with Northern Pulp operating. .. 49
Figure 28. Forest fibre availability surrounding Sheet Harbour with Northern Pulp closed 50
Figure 29. Road distances from Port Hawkesbury. 51
Figure 30. Forest fibre availability surrounding Port Hawkesbury with Northern Pulp 52
Figure 31. Forest fibre availability surrounding Port Hawkesbury with Northern Pulp closed. ... 53
Figure A1. Historical harvesting levels by land ownership from 2000-2019 61
Figure A2. Proportion of wood fibre use per business type from 2000 to 2019. 62
Figure A3. Sawmill production levels from 1986 to 2019. 62
Figure A4. Average 5-year harvest by county (m^3). 63
Figure A5. Sawmill wood consumption in 2019 (m^3). 65
Figure A6. Average annual harvest (2015-2019) on Crown lands by region 66
Figure A7. Average annual harvest (2015-2019) on Industrial lands by region. 66
Figure A8. Average annual harvest (2015-2019) on private lands by region. 67

List of tables

Table ES1. Roundwood supply mix with available volumes and supply costs 7
Table ES2. Mill by-product supply mix with available volumes and supply costs 7
Table ES3. Summary of available feedstock (odt) at all sites with Northern Pulp open 9
Table ES4. Summary of available feedstock (odt) at all sites with Northern Pulp closed 9
Table 1. Forest land ownership in Nova Scotia 13
Table 2. Product basket from Nova Scotia's forest 19
Table 3. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (m^3) with Northern Pulp 23
Table 4. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (odt) with Northern Pulp 23
Table 5. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (m^3) without Northern Pulp 24
Table 6. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (odt) without Northern Pulp 24
Table 7. Mill by-products yield factors for sawmills and pulp mills 31
Table 8. 2020 Provincial mill by-product output (odt) 32
Table 9. 2020 Provincial mill by-product consumption (odt) 32
Table 10. Potential sites and nearby assets 34
Table 11. Roundwood transportation costs at distance intervals with weighted truck configurations used in Nova Scotia. 55
Table 12. Supply cost breakdown for roundwood harvested in clearcuts and partial cuts with two different harvest systems. 56
Table 13. Roundwood supply mix with available volumes and supply costs 57
Table 14. Mill by-product supply mix with available volumes and supply costs 57
Table A1. Available harvest volume by county with and without Northern Pulp (odt) 64
Table A2. Provincial secondary forest product volume produced between 2015-2019 (m^3) 65
Table A3. Distance from sawmills to potential forest bioeconomy investment locations 68
Table A4. Parameters changed in FPInterface harvesting model. 70
Table A5. Costs to transport roundwood using different truck configurations ($/$m^3$) 70
Table A6. Parameters changed in FPInterface trucking configurations 70

EXECUTIVE SUMMARY

Nova Scotia's current and future capabilities to support forest bioeconomy investments are presented in this report via an assessment of the current state of provincial fibre supply and cost. This report is an updated version of a similar 2015 report on fibre supply and cost in Nova Scotia. This report includes updated harvest data and market conditions providing a more recent estimate of forest biomass feedstock availability. Feedstock availability, cost, and competitive demand are the three main drivers to determine the viability and best possible locations for new bioeconomy processing plants in Nova Scotia.

The closure of the Northern Pulp mill in early 2020, Nova Scotia's largest consumer of wood chips and by-products, left a diminished market for low-value wood fibre. An oversupply of pulpwood and lack of market has forced harvest contractors to leave pulpwood in the forest, creating a potential supply for new bioventures. Future forest-origin feedstock availability is likely to remain high in the coming years if the Northern Pulp facility remains closed. Currently, sawmills have had to find new opportunities for their mill by-products previously sent to Northern Pulp. These new solutions, while necessary to consume by-products, offer lower returns and are generally short-term in nature. Fortunately, lumber prices are currently at an all-time high, keeping the sawmill industry profitable and diminishing or at least delaying the full effects of Northern Pulp's closure. An analysis of fibre availability by county and by location, with and without Northern Pulp, shows the potential viability of new bioeconomy facilities under these two scenarios. With the Northern Pulp mill in operation, there is a forest-origin pulpwood/fuelwood supply availability of 560 000 oven-dry tonnes (odt) compared to 825 000 odt with the Northern Pulp mill closed. If Northern Pulp remains closed, a surplus of 263 000 odt of mill by-products will be available in the province at current operating rates compared to a 60 000 odt deficit with Northern Pulp open (some chips would need to be imported, as was the case before 2020).

With respect to fibre cost, after Northern Pulp's closure, pulpwood and fuelwood demand decreased but prices in eastern Nova Scotia have only decreased slightly. However, western Nova Scotia has limited markets for softwood pulpwood/fuelwood and as a result these volumes are often left in the woods. Mill residue prices have decreased significantly due to oversupply and low demand. Mill residues such as chips traditionally purchased FOB for $90-$104/odt now sell for $70-$82/odt. Fines (sawdust and shavings) normally purchased for $70/odt now sell for $30/odt and bark which normally sold for $24-$28/odt now sells for between $6-$26/odt. All prices shown assume that roundwood is delivered while mill by-products are FOB (see tables ES1 and ES2 for detailed information).

Table ES1. Comparative roundwood availability and costs, 2015 and 2020

Products	Quality	2015		2020 - Northern Pulp Open		2020 - Northern Pulp Closed	
		Available volumes (odt)[c]	Market prices ($/odt)[a]	Available volumes (odt)[c]	Market prices ($/odt)[a]	Available volumes (odt)[c]	Market prices ($/odt)[a]
Softwood fibre	Pulpwood/ Fuelwood	195 000	95-120/ 80-100	215 000	116-136/ 64-80	360 000	116[b]/80[b]
Hardwood fibre	Pulpwood/ Fuelwood	665 000	95-120/ 80-100	345 000	96-110/ 64-84	465 000	104-110/ 80[b]

[a] Delivered roundwood price. Additional comminution is required at $10-$20/odt
[b] No market in the western region
[c] Available volumes include export volumes

Table ES2. Comparative mill by-product availability and costs, 2015 and 2020

Products	Quality[b]	2015		2020 - Northern Pulp Open		2020 - Northern Pulp Closed	
		Available volumes (odt)	Market prices ($/odt)[c]	Available volumes (odt)	Market prices ($/odt)[c]	Available volumes (odt)	Market prices ($/odt)[c]
Softwood fibre	Wood chips	110 000	65-110	111 000	90-104	436 000	70-82
	Fines[a]	30 000	45-65	35 000	70	35 000	30
	Bark	35 000	30-60	4 000	24-28	39 000	6-20
Hardwood fibre	Wood chips	15 000	70-100	14 000	90-104	21 000	70-82
	Fines	5 000	50-70	3 000	70	3 000	30
	Bark	8 000	35-60	5 000	28	5 000	14-26

[a] Sawdust and shavings
[b] Mill by-product availability for wood chips, fines and bark with sawmills operating at full capacity
[c] FOB prices (add $30/odt for a transportation distance of 100 km)

There are also more uncertainties now. The current mill by-product surplus may only be temporary. The sawmill industry is still adjusting without Northern Pulp operating, and it may find an equilibrium for its surplus of by-products from a reduction in chipping of low-grade wood. Nova Scotia Power has ceased purchasing low-grade pulpwood in favor of chips and bark due to their current low price, while Port Hawkesbury Paper are favouring harvesting high value sawlogs versus pulpwood to leverage a favourable exchange of chips for logs with sawmills.

The Lahey Report, released in 2018, has a mandate to review current forest practices and offer recommendations for improving how Nova Scotia balances long-term environmental, social, and economic interests in managing the provincial forest. The report's recommendations suggest

dividing the Crown forest into three zones managed to provide a specific set of values: a conservation zone with no resource extraction; a high production forest zone supporting timber production; and an ecological matrix comprising most of the land base supporting a mix of ecologically based forestry practices. Clearcutting will be greatly reduced and limited to the high production forest area. We estimate that this approach could reduce the available harvest volume between 170 000 m^3 and 340 000 m^3 (72 000 odt to 144 000 odt). Additionally, it may increase logging costs due to the higher proportion of partial cuts. The proportion of sawlogs in the harvested volume will likely decline with increased partial harvesting which normally aims for stand quality improvements, resulting in a much larger production of low-grade wood. These recommendations have yet to be implemented and their actual impact on wood supply estimates will be clearer once they are fully implemented.

There are also feedstock-related opportunities. Foremost is the potential to increase the capacity of the forest supply chain. Indeed, sawmills in the province are operating at approximately 80% of their capacity, primarily because of limited log & stud supply resulting from a lack of harvesting and transportation capacity. An increase in supply chain capacity would result in an increased fibre supply for the sawmill sector, which in turn would result in an increased supply of by-products equal to about 230 000 odt that could be used as feedstock for new forest bioeconomy ventures.

With respect to data quality, predictions on feedstock availability from forest sources should be fairly accurate because sustainable harvest calculations derived from forest growth and yield information were used. Additionally, current forest fibre and by-product production and consumption, along with mill pricing, were assessed by local “on-the-ground” experts.

Six locations were selected as potential new forest bioeconomy sites (Table ES3 & ES4). They were assessed based on their proximity to available pulpwood/fuelwood and mill residue supplies under two scenarios; with the Northern Pulp mill open or closed.

Greenfield has the lowest supply cost and the most fuelwood available within 50 km in both scenarios due to its location in the western region where there is a lack of market for fuelwood. It also has access to a significant source of mill residues from the nearby Harry Freeman sawmill. As well, Port Hawkesbury has lower average fuelwood cost within 200 km because of an abundant supply located within 50 km. Enfield is also a good option due to its central location and proximity to many sawmills and abundant supply of mill residues within 50 km, despite the little fuelwood available within 100 km compared to the other locations. Trenton’s average costs are low due to promising volumes of fuelwood and mill residues within 100 km, especially in the scenario without Northern Pulp.

Table ES3. Summary of available feedstock (odt) at the six potential sites with the Northern Pulp mill open

Location	Average Fuelwood Cost ($/odt)[a]	Average Mill Residue Cost ($/odt)[a]	50 KM		100 KM		150 KM		200 KM	
			Fuelwood[b]	Mill Residue[c]	Fuelwood[b]	Mill Residue[c]	Fuelwood[b]	Mill Residue[c]	Fuelwood[b]	Mill Residue[c]
Greenfield	104	124	59 200	21 050	120 950	21 750	213 700	65 300	241 400	85 450
Kaizer Meadow	106	127	17 700	800	100 850	24 350	189 150	212 700	226 000	227 800
Enfield	114	114	1 750	60 500	28 900	191 200	122 000	227 800	275 000	227 800
Trenton	106	118	2 600	15 100	102 150	145 500	165 750	191 500	202 100	192 300
Sheet Harbour	111	119	1 600	0	36 600	159 850	106 200	206 000	178 500	206 350
Port Hawkesbury	103	140	35 350	0	126 700	0	170 000	15 100	198 300	160 000

[a] Average weighted cost within 200 km of location (roadside or FOB + transportation). Comminution of fuelwood is required at $10-$20/odt.
[b] Pulpwood or fuelwood logs
[c] Includes wood chips, sawdust, shavings, and bark from sawmills operating at full capacity

Table ES4. Summary of available feedstock (odt) at the six potential sites with the Northern Pulp mill closed

Location	Average Fuelwood Cost ($/odt)[a]	Average Mill Residue Cost ($/odt)[a]	50 KM		100 KM		150 KM		200 KM	
			Fuelwood[b]	Mill Residue[c]	Fuelwood[b]	Mill Residue[c]	Fuelwood[b]	Mill Residue[c]	Fuelwood[b]	Mill Residue[c]
Greenfield	94	106	66 350	108 550	138 000	109 250	256 250	202 850	300 000	247 400
Kaizer Meadow	97	113	24 700	800	133 550	136 300	245 200	477 200	333 550	588 350
Enfield	100	104	14 750	134 950	78 000	368 200	232 600	594 800	395 100	594 800
Trenton	95	101	25 050	117 600	164 450	350 500	276 800	470 950	341 650	471 800
Sheet Harbour	100	106	7 250	0	63 800	271 500	184 650	485 500	302 500	485 850
Port Hawkesbury	94	122	38 500	0	144 200	6 450	205 100	117 600	259 950	365 050

[a] Average weighted cost within 200 km of location (roadside or FOB + transportation). Comminution of fuelwood is required at $10-$20/odt.
[b] Pulpwood or fuelwood logs
[c] Includes wood chips, sawdust, shavings, and bark from sawmills operating at full capacity

INTRODUCTION

Like other regions of Canada, Nova Scotia has seen extensive structural changes within the forest sector over the past few years. With the closure of the Northern Pulp mill in January 2020 and potential future implementation of the Lahey report recommendations, there could be further changes to forest industry assets and disruptions to supply chains within the province. Since the downturn of the forest industry in 2005, the province has been assessing new opportunities that could complement the existing forest products infrastructure.

Stakeholders in the energy and economic development sectors have joined the Nova Scotia Department of Lands and Forestry (NSDLF) in the creation of the Nova Scotia Innovation Hub. The Hub has an office at Innovacorp's 'The Bays' facility located in Dartmouth. It leads research and demonstration activities to encourage dialogue at all levels and to promote the province as a place to do business. FPInnovations has been given the mandate to provide information on feedstock and procurement, market access, and financial opportunities.

Biorefineries, whether they are integrated within the forest industry's existing brownfield sites or greenfield sites, will be required to preserve, or grow forest sector jobs in the province. Earlier bioventures have failed because they did not sufficiently analyze the feedstock supply even though biofibre cost represents a high percentage of operating costs. A thorough understanding of forest fibre availability and costs from all sources is needed before any further investments and to attract capital. The specific objectives of the feedstock assessment project will help answer this need by:

- developing a provincial overview of forest fibre availability per county considering all sources, land ownership, and current demands on the resource
- determining the fibre availability, cost structure and market prices for specified delivery points across the province, with and without an operating Northern Pulp facility
- improving the efficiency of forest fibre supply chains to lower delivered costs

BACKGROUND

Provincial subdivisions

A concern about long-term sustainability of the forest resource in the 1990's resulted in the enactment of the Registration and Statistical Returns Regulations in 2000 (NSDNR, 2008a). Before 2000, NSDNR tabulated annual primary forest products usage from Nova Scotia forests from a voluntary survey (Hudson, 2012). These new regulations now require all buyers and exporters of Nova Scotia primary forest products to register annually and report all wood being harvested from Nova Scotia forests. The primary purpose of the Registry was to tell NSDNR how much roundwood was harvested, as well as what was harvested and where (tenure, county, species,

product). Secondary product movement was not a significant concern when the Registry was formed and thus those products are not accounted for in the Registry (Hudson, 2012). The Registry of Buyers data from 2010 to 2019 were used in this wood supply study.

Since the Registry of Buyers provides the harvested volumes per county, this geographic subdivision was used as the main stratification tool for this wood supply analysis. Nova Scotia is divided into 18 counties and 3 regions (Figure 1).

In 2019, 41 buyers of more than 1000 m^3 were scattered across the province with notable concentrations in the Pictou, Halifax, and Lunenburg counties.

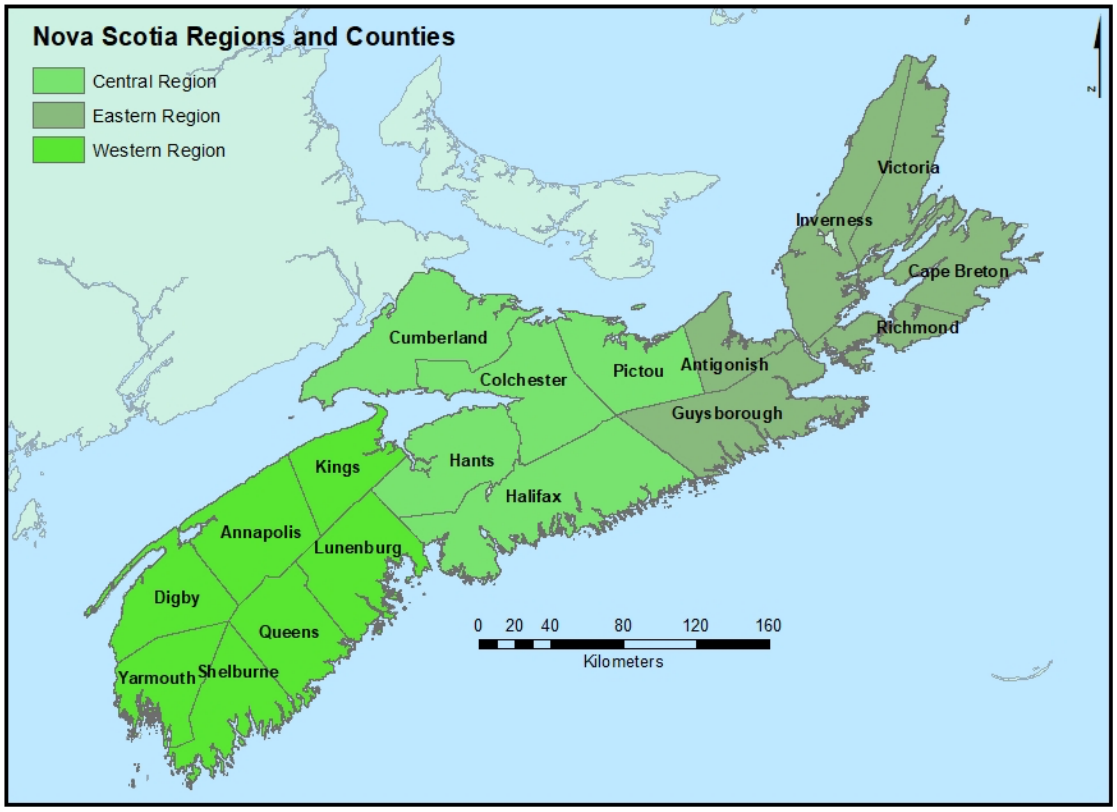


Figure 1. Nova Scotia Regions and Counties

Forest landscape

Nova Scotia is a province rich in forest resources, covering 80% of the area (NSDNR 1999). Three cover types are used to describe the forest landscape, softwood, mixedwood and hardwood dominated stands (Figure 2). Softwood dominated stands represent 48% of the forested area in Nova Scotia, while mixedwood stands make up 29% and hardwood stands the remaining 23%.

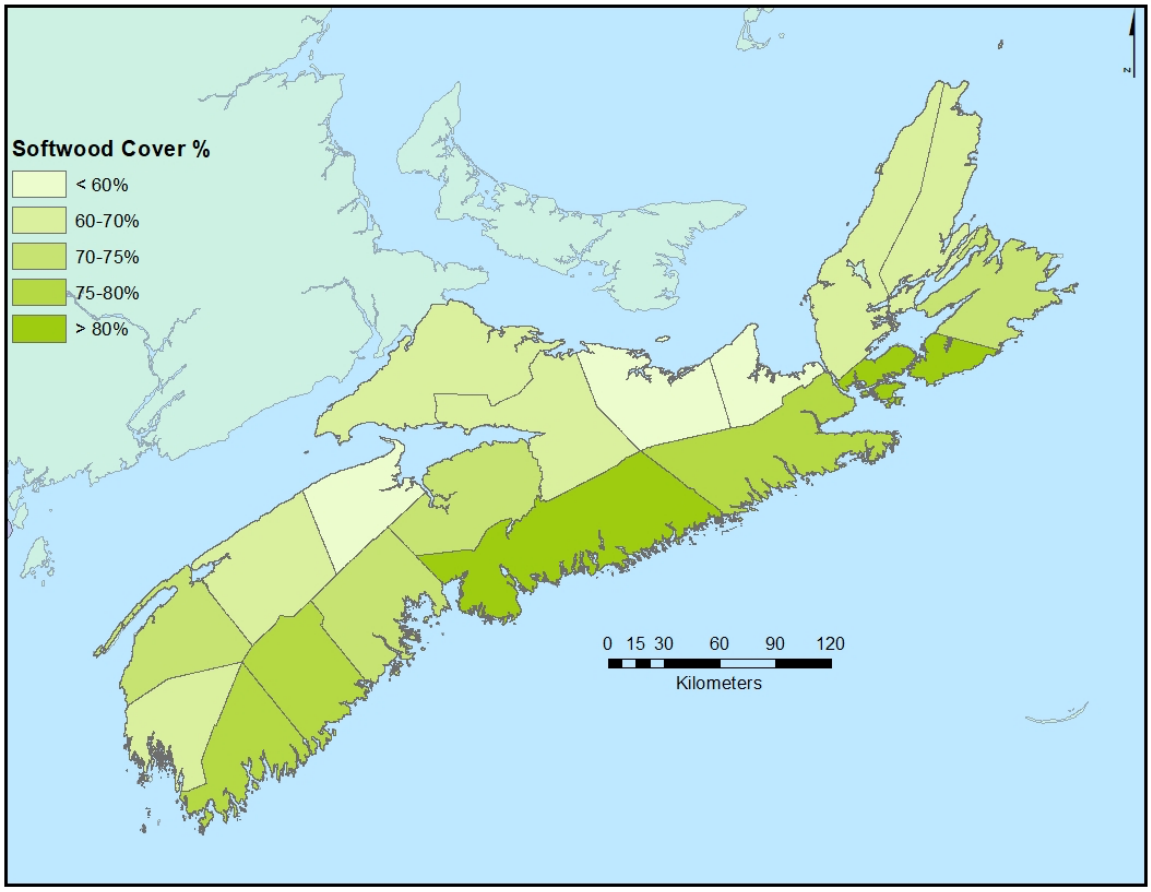


Figure 2. Forest cover by county in Nova Scotia

Unlike other provinces in Canada, except Prince Edward Island, private forest ownership (60%) dominates in Nova Scotia over provincial Crown ownership (37%) and Federal/Aboriginal lands (3%) (Table 1). Nova Scotia's forests are controlled by a large number of stakeholders (over 30 000 private forest owners) that represent half of all productive forests in Nova Scotia, as shown in Figure 3. Therefore, the various landowners and fibre producers' associations are important agencies to deal with when defining fibre supply in Nova Scotia.

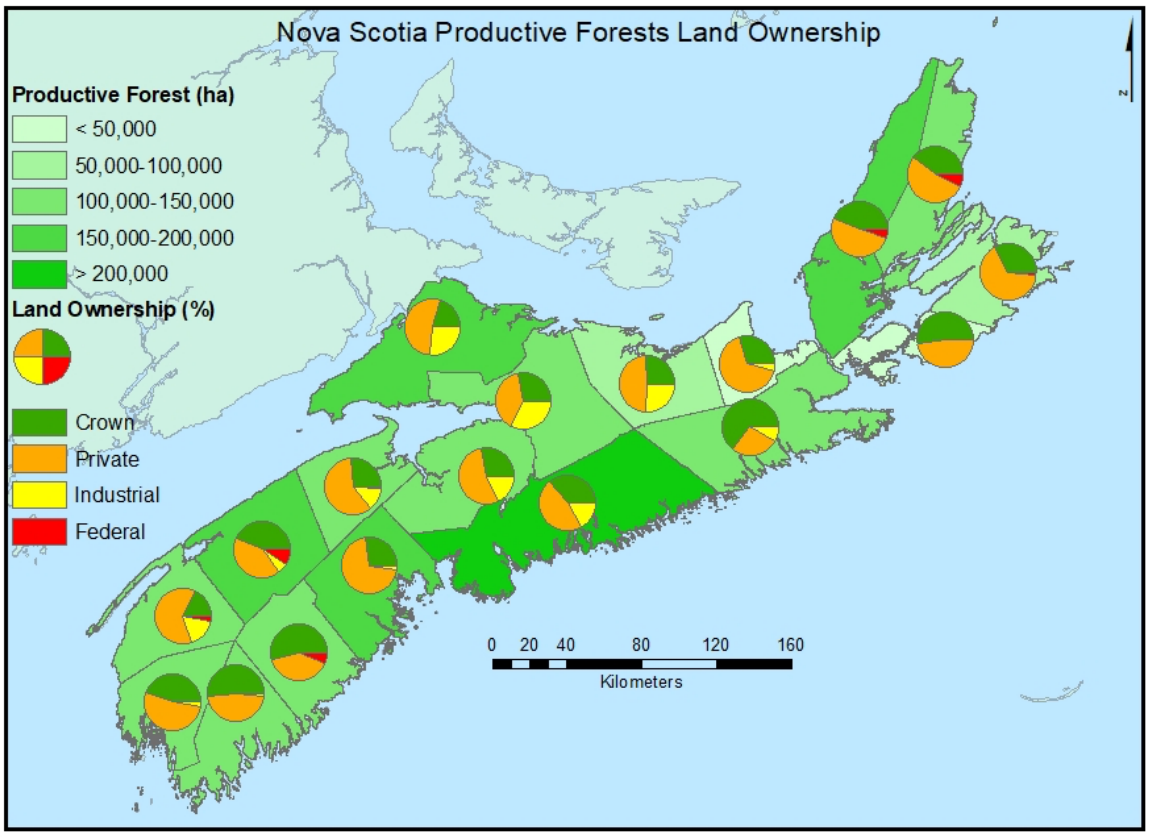


Figure 3. Nova Scotia productive forest land ownership

Table 1. Forest land ownership in Nova Scotia

Forest tenure[a]	Forest type (ha)			Total (ha)	Proportion (%)
	Softwood	Mixedwood	Hardwood		
Crown land under licence	317 061	139 004	158 017	614 082	**14.9%**
Crown land unlicensed[b]	512 097	248 563	158 807	919 466	**22.3%**
Private industrial	250 090	118 259	88 396	456 745	**11.1%**
Private small woodlots	843 495	664 699	515 202	2 023 396	**49.1%**
Federal	43 726	27 449	30 920	102 095	**2.5%**

Forest tenure[a]	Forest type (ha)			Total (ha)	Proportion (%)
	Softwood	Mixedwood	Hardwood		
Aboriginal	2 872	2 847	3 195	8 915	**0.2%**
Total (ha)	**1 969 340**	**1 200 821**	**954 537**	**4 124 698**	**100%**
Proportion (%)	**47.8%**	**29.1%**	**23.1%**	**100%**	**100%**

[a] NS Dept. of Natural Resources, 2015; [b] Crown Land unlicensed are all other crown lands including wilderness protected areas, parks, etc. as well as other harvestable lands.

Sustainable wood harvest

Before 2000, the Annual Allowable Cut (AAC) was calculated at 5.25 million cubic metres (M m^3) (3.75 M m^3 softwood and 1.5 M m^3 hardwood) (Bornais, 2004). The province then moved to potential wood supply estimates (current sustainable harvest) made by land tenure (not by county) in 2004 and stopped publishing an AAC (Figure 4). The current supply estimate is based on the most recent forest stand inventories, stand productivity measurements, and photo interpretation. Supply estimates also consider different silvicultural treatments to maintain the natural structure of the forests. Ecosystem-based management practices are applied to harvesting activities to better reflect natural disturbances (e.g., fires, insect infestations, or diseases). Nova Scotia's forests are frequently disturbed and therefore prone to even-aged structure which is why the data shows most forests are young and even-aged (NSDNR, 2008b).

A report prepared by NSDNR in 2011 presents the results of an analysis carried out to investigate the potential supply impacts of reduced participation by non-industrial private owners than has traditionally been used (15%) for wood supply estimation in Nova Scotia (NSDNR, 2011). Based on this 15% non-participation rate, the potential annual wood supply estimate was 7.5 M m^3 (5.0 M m^3 softwood and 2.5 M m^3 hardwood) (Figure 4). A second report produced in 2011 for NSDNR showed the impacts of a restrictive clear-cut harvest policy (Woodbridge, 2011). The report examined potential wood supply impacts of reducing the annual proportion harvested by clear-cut to 50% (province-wide target). This new harvesting policy was implemented in 2012 to better align silvicultural prescriptions to the province's forest landscape and reduced the annual sustainable harvest to 6.8 M m^3 (4.862 M m^3 softwood and 1.963 M m^3 hardwood). The 2014 provincial timber objective for the next 20 years estimated an annual sustainable harvest of 6.4 M m^3 (4.299 M m^3 softwood and 2.145 M m^3 hardwood).

The 2016 Strategic Forest Analysis (SFA) aimed to develop a balanced strategy that addresses timber harvest, forest wildlife habitat and forest ecosystem objectives. The SFA's recommended scenario results included a 20-year harvest estimate of 5.74 M m^3 (4.152 M m^3 softwood and 1.588 M m^3 hardwood). The SFA also assumed a 15% non-participation rate from private lands.

The average annual wood volume harvested between 2010 and 2019 was 3.6 M m^3 from the following sources:

- Private woodlot owners (62%)
- Industrial forests (freehold) (16%)
- Crown land (21%)

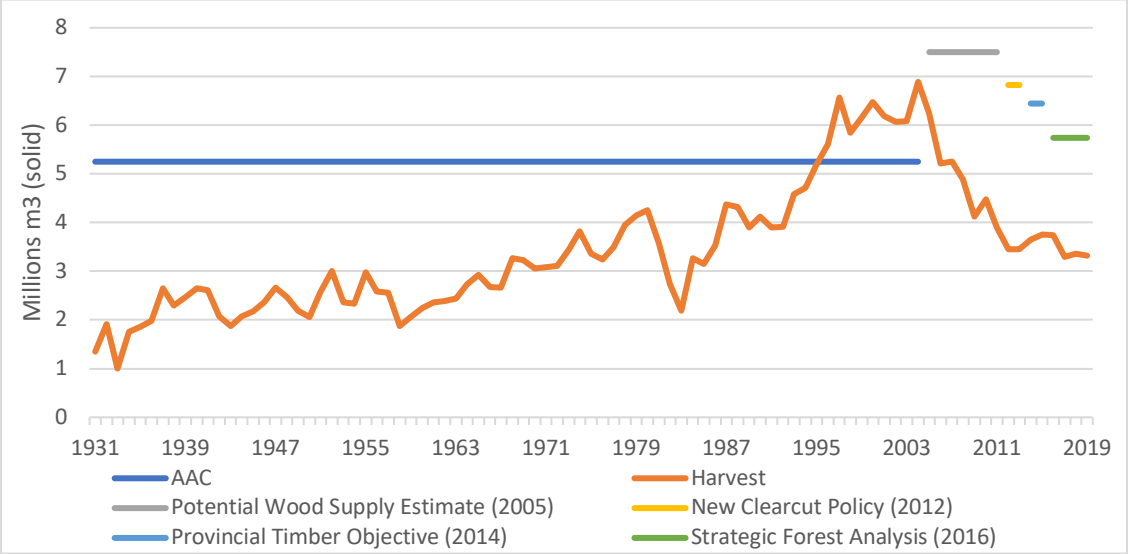


Figure 4. Historical harvest levels in Nova Scotia

Lahey Report

William Lahey was appointed in August 2017 to undertake an independent review of two aspects of forestry in Nova Scotia: forest practices and market access concerns raised by forest landowners particularly in the western region of the province (Lahey 2018).

The Lahey report was mandated to examine current practices, including strengths and weaknesses, and provide recommendations for improving how Nova Scotia balances long-term environmental, social, and economic interests in managing the province's forest (Lahey 2018). The report offers many recommendations for both Crown and private forest lands. However, it suggests that only Crown land recommendations be legislated (Lahey, 2018). The report recommends adopting a triad model approach for the implementation of ecological forestry. This forest management zoning strategy allocates natural areas into one of three zones with specific values to be achieved in each:

- Conservation zone (biodiversity focus, no timber management)
- Ecological Matrix zone (where conservation and timber production objectives are both applied and combined)
- High production forestry (HPF) (timber production focus)

Currently, the NSDLF has committed to implement the triad model approach as documented in their draft version of the *Nova Scotia Silvicultural Guide to the Ecological Matrix* (SGEM) (NSDLF, 2021). The NSDLF has also released a draft discussion paper on the HPF leg of the triad model in February 2020 (NSDLF, 2020).

These documents suggest a major shift in how forestry will be conducted on Crown land. Some wood supply considerations from the SGEM and HPF documents include:

- No clearcutting on Crown land unless it is associated with the HPF leg of the proposed triad
- The HPF portion of the triad will occupy a maximum of 20% of the Crown land area
- Minimum retention levels of 20% to 33% of total basal area with much of the forest at 50% to 66% retention levels
- A reduction of 10-20% of the Crown land short-term (25 years) wood supply as described in the Lahey report (2018)
- The Crown land long-term outlook (30-40 years) may likely be better than today from a wood supply perspective as the condition of the ecological matrix forest improves and high-production plantations arrive to maturity

The short-term reduction of 10-20% would represent a reduction of between 72 000 odt and 144 000 odt from Crown land annually. This reduction is considered conservative given the current direction of the SGEM/HPF drafts. Given the increase in retention levels, wood supply is likely to fall, and wood costs likely to increase in the short-term.

An important consideration is that the harvest areas will grow significantly with an increase in partial cuts to produce the same amount of wood. Partial harvesting treatments that aim for forest quality improvements will see a decline in the proportion of sawlog volume harvested. This will create an overabundance of low-quality wood, especially if Northern Pulp remains closed, that could affect the ability to access sawlog volumes unless the current market challenges for low quality wood can be solved.

These new directives, although still in draft form and subject to change, would present an opportunity for new ventures looking to utilize low quality wood.

Forest industry

The sawmill industry plays a vital role in rural communities with 107 sawmills spread across the province. Most of these (73 out of 107) sawmills are small, family-owned mills that consume less than 1000 m^3 of roundwood per year. Since the 2005 lumber market crash due to the high Canadian dollar and the low number of new houses being built in the US, the number of existing sawmills has been declining rapidly (Appendix 2). Furthermore, out of the 107 existing sawmills in 2019, 18 had no production. The downturn has been especially hard on the small sawmills (< 10 000 m^3 wood consumption per year). The major sawmills consuming more than 70 000 m^3 per year (6 of them) have stayed opened throughout the downturn. The maximum lumber production

for the province was reached in 1999 with 766 million board feet (MBF) and went down to an all-time low of 295 MBF in 2014. More recently, the global COVID-19 pandemic in 2020 threatened to bring on more closures but record high lumber prices due to increased demand have created a sawmilling boom that offset the closure of the Northern Pulp mill in early 2020. When operating, approximately 95% of all sawmill chips and 40% of bark and sawdust produced in the province were purchased by Northern Pulp (Cools, 2021). The long-term effects of Northern Pulp's closure will have on the sawmill industry are yet to be seen, but the excess chips and other by-products normally destined for Northern Pulp were quickly accumulating at many sawmills, eliminating an important source of revenue. Sawmills who sold their by-products to Northern Pulp were forced into less cost-effective arrangements, bringing some of the larger mills to consider suspending operations until more profitable solutions appeared. As much as 15% of sawmill revenues were generated by the sale of wood chips to Northern Pulp (Gardner Pinfold, 2019). This new surplus of mill residues created a downward pressure on prices and created shifts in fibre flows to find a new equilibrium point. For example, Nova Scotia Power's two boilers in Brooklyn and Point Tupper are no longer purchasing roundwood and instead are sourcing their supply from currently cheaper mill residues. Brooklyn Power had stored 30 000 tonnes of softwood roundwood in their yard but do not anticipate using it over the next couple of years. Also, Brooklyn Power are now running at 100% capacity and obtain 50% of their supply from the Harry Freeman sawmill, formerly a supplier of mill residues to Northern Pulp.

The impact of the closure of the Northern Pulp facility has been felt across the supply chain. While sawmillers may have found temporary, albeit less profitable solutions to sell their mill residues, the same cannot be said about pulpwood. Over 80% of the pulpwood purchased by Northern Pulp came from private lands (Cools, 2021). Forest contractors have been hit hard by the mill's closure and report a 30% decrease in revenues one year later. Market prices of sawlogs and grade 2 pulpwood immediately dropped after the mill closure with pulpwood redirected to other consumers in the supply chain but at decreased rates, while sawable logs prices returned to pre-closure levels only after October 2020 (Cools, 2021). The spike in lumber prices seen in the Spring of 2021 will not last and the lack of markets for pulpwood is concerning. Contractors are forced to choose woodlots that contain predominantly high-grade lumber and leave the low-quality pulpwood standing. The lack of markets for low-grade wood presents significant challenges for stand improvement treatments that by design produce greater proportions of low quality wood.

In addition, because of the large quantity of low-cost chips available from sawmills, Port Hawkesbury Paper (PHP) staff have modified their harvesting strategy. While their normal practice is to harvest random length pulpwood to be chipped at the pulp mill, PHP have increased their production of sawlogs in their cut-to-length operations to provide logs to sawmills in exchange for pulp chips. For reference, PHP purchased approximately 87 000 odt of pulp chips in 2020, compared to about 14 000 odt in 2019. While this shift has been beneficial financially for PHP and the sawmills needing to find a home for their pulp chips, the result is a reduced market for low-grade roundwood, which is needed to have a sustainable forest industry. If this does not occur, high grading will become more common, leading to a generalized reduction of stand quality.

The pulp and paper industry in Nova Scotia only consists of one mill in Port Hawkesbury that consumes about 215 000 odt of pulpwood (roundwood) per year. The worldwide drop in demand for newsprint had forced Port Hawkesbury Paper, then called New Page, and Resolute Forest Products to close their respective operations in 2011 and 2012. With provincial help and new ownership via a Vancouver based investment firm, PHP was able to resume operations in October 2012, leaving aside newspaper production and focusing on coated paper products. In early 2020, Northern Pulp was forced to shut down their operation after failing to secure environmental approval to build a new effluent treatment facility (Gorman, 2020). Northern Pulp historically harvested about 260 000 odt of roundwood and purchased approximately 350 000 oven-dry tonnes (odt) of sawmill by-products, even importing from out of province to satisfy its overall demand. While there is a possibility the mill will reopen in the future, a full environmental assessment of a proposed waste treatment plant will push back its earliest reopening to 2023 or later.

The firewood industry is of great importance in Nova Scotia since 75% of homes are in rural areas. The price of heating oil hovers around 1.10 $/L (NRCAN, 2021) and residential electricity rates are about 16 cents/kWh. Natural Resources Canada estimates that about 450 000 m^3 of firewood are harvested per year (NSDLF, 2019). Using a conversion factor of 2.5 m^3/cord, this means that around 180 000 cords of firewood are harvested every year. Using an average household heating use of 4 cords per year, this means that about 45 000 homes or 12% of Nova Scotia homes have a firewood heating system. The firewood/fuelwood market uses on average 88% of hardwoods and 12% of softwoods. These proportions are based on the volumes reported in the Registry of Buyers (average for 2010 to 2019). Since firewood businesses producing less than 1000 m^3 are not required to register, the real proportions might differ slightly. Other roundwood users in the province, representing less than 1% of harvested roundwood, include producers of telephone poles, railways ties, pallet wood and fruit box manufacturers.

Import-export also plays a role in provincial wood flows. From 2010 to 2019, 6% of the roundwood volume harvested in Nova Scotia was exported outside of the province. Hardwoods represent 93% of species exported since 2010, although in the last 5 years, hardwood exports represented 99% of the volume. The hardwood species exported are 99% pulpwood quality with the rest being veneer. Nova Scotia imports minimal amounts of roundwood compared with its harvest, about 2%, with 95% being softwood mainly of pulpwood quality (65%) and the rest for lumber. Hardwood roundwood imported is almost exclusively for lumber (95%). Imports into Nova Scotia have represented an average of 6-11% of the annual harvest since 2010. However, imports will not be considered in the wood supply availability analysis to show only the potential within Nova Scotia to support new bioventures in the province.

FEEDSTOCK AVAILABILITY

Products

Forest-origin feedstocks are accounted for in the provincial *Registry of Buyers* that records information on which types of products were harvested from 2010 to 2019. These data can be used to establish the product mix (average proportions of each product harvested over time). The generic definitions of forest products specifications for Crown lands are used in this report (Hudson, 2012), but product characteristics are often mill specific.

Sawlogs and studwood are the only parts of the trees not considered as potential feedstock for new bioventures. Therefore, potential sources of fibre for new facilities include pulpwood (smaller-diameter, lower-quality logs), fuelwood-quality logs of any size or form, from any species of hardwood or softwood tree having no higher valued potential (e.g., lumber), and mill residues (wood chips, bark, fines) given the current production capacities and historical market demands.

The level at which each type of product has been harvested from 2010 to 2019 is presented by species groups in Table 2. This product mix represents what Nova Scotia forests can produce regardless of land tenure. Future harvest mixes should be in line with these levels. According to current provincial regulations, fibre products from the forest can only come from the stem of trees. Amidst an emerging bioeconomy and supported with environmental studies, fibre utilization policies might change in the future. Therefore, harvest residue volume estimates (branches, tops) will be included in this report. The proportion of pulpwood that can be used as biofuel is difficult to estimate but will depend on the market for pulpwood in a particular region. Low-grade pulpwood could be considered as available for new bioventures in regions with no pulpwood market, as is the case since the Northern Pulp closure. Pulpwood usage has significantly decreased since the closure, the lack of pulpwood demand forcing contractors to leave it in the woods.

Table 2. Historical product mix from Nova Scotia forests

Products	Historical harvest[a]	
	Softwood (%)	Hardwood (%)
Sawlogs and Studs[b]	58	6
Pulpwood	38	38
Firewood/Fuelwood	4	56

[a] Based on 2010 to 2019 Registry of Buyers data.

[b] Not considered as available fibre for the new bioeconomy.

Availability

Since the 2005 downturn in the forest industry, mill residue supply from sawmill is unreliable and the pulpwood market is shrinking. The closure of the Northern Pulp mill has exacerbated a weak pulpwood market, with half of the normal pulpwood harvest without an outlet. Sawmill residues, of which over 350 000 odt were sent to Northern Pulp annually, are now being used for other temporary ventures at a fraction of the original price. Therefore, a large amount of softwood pulpwood and mill residues are, at least temporarily, now available for new ventures. Additionally, only 69% of the potential harvest supply has been harvested since 2012. This level will likely further decrease because of the Northern Pulp closure, generating additional available volume for other opportunities.

The fibre utilization rate is the ratio of the volume harvested to the volume of sustainable harvest, or in this case potential wood supply estimate. Fibre utilization rates are broad indicators of forest sustainability. From 2010 to 2019, the average fibre utilization rates were 14% and 15% below the sustainable harvest for softwoods and hardwoods, respectively (Figure 5).

Traditionally, hardwood and softwood sawlogs are sold to local sawmills for making lumber, flooring, etc. The chips produced from that process are sold to pulp and paper companies. Residues (e.g., bark, imperfections) are sold as hog fuel for boilers. Lower-quality pulpwood logs are used to make paper. Fuelwood is the lowest-grade by-product of normal harvest operations. Despite the increased use of fuelwood, forest companies normally try to manage forest stands based on their highest optimal use, stand diversity, and ecological characteristics (including species composition, water quality and soil quality health, coarse woody debris, and leave patches).

Additional fibre could be made available if provincial regulations, guidelines, and best management practices for Nova Scotia Crown lands allowed the use of other parts of the tree than “stem wood”. Currently, stumps, tops, and branches are not allowed to be removed from the forest. Since traditional harvesting operations target commercial species with high-quality stems, these regulations force forest managers supplying fibre to energy projects to maximize the use of non-commercial species and low-quality stems to meet demand from the facilities.

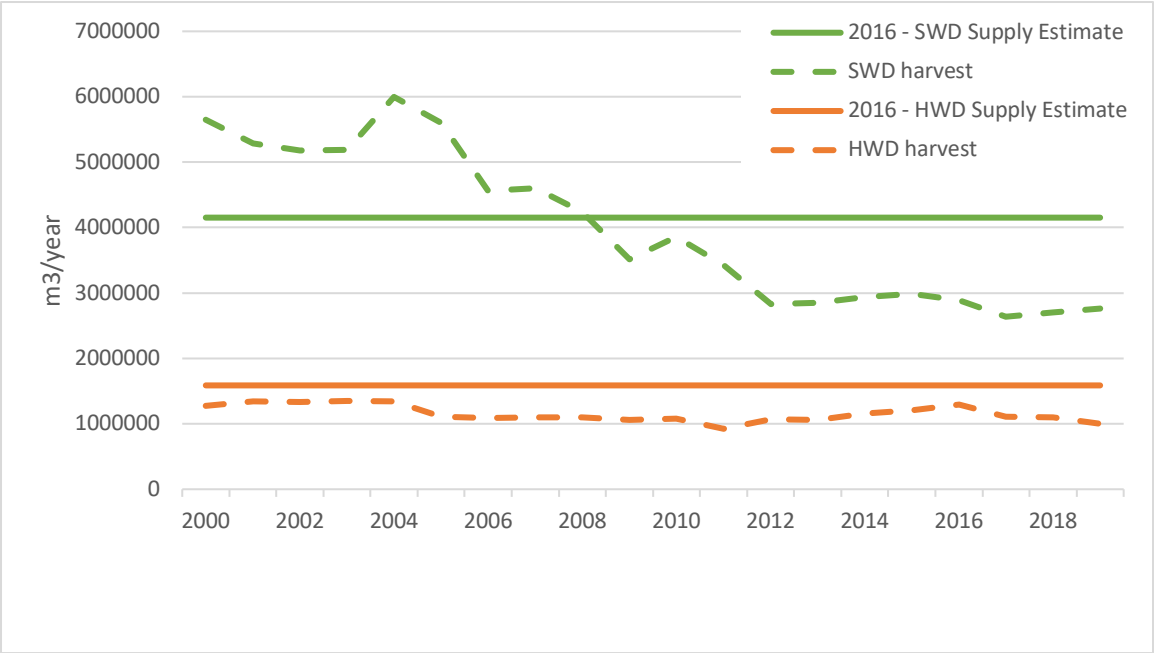


Figure 5. Forest fibre utilization rates in Nova Scotia

FEEDSTOCK SUPPLY AVAILABILITY

Roundwood

The forestry sector traditionally reports wood volumes in cubic meters (m^3) but the bioenergy sector uses oven-dry tonnes (odt). Therefore, in the provincial wood section, volumes will be presented in both units while reporting in odt will be kept for the remainder of the report (Tables 3 and 4).

The sustainable roundwood supply is determined by 2016 calculations made by the Nova Scotia Department of Lands and Forestry (NSDLF) that set the harvest potential for the next 20 years at 4.15 M m^3 of softwood and 1.59 M $m^3$of hardwood. There have been 4 revisions to the supply estimates made by the NSDLF showing a downward trend since 2005. The most recent 2016 estimates are 24% lower compared with the 2005 estimates. The difference between the average annual harvest of the past 5 years and the unused sustainable harvest shows that roughly 1.3 M m^3 of softwood roundwood and 445 000 m^3 of hardwood roundwood are available if the Northern Pulp facility reopens (Table 3 and 4). If Northern Pulp remains closed, availability of unused sustainable harvest increases by 380 000 m^3 and 215 000 m^3 softwood and hardwood pulpwood, respectively, to a total of 1.7 M m^3 softwood roundwood and 660 000 m^3 hardwood roundwood (Table 5 and 6). The bulk of the potential available volume comes from lower demand for softwood from the pulp sector and underutilized intolerant hardwood species. The potential roundwood supply available to biorefineries would be pulpwood and fuelwood quality from the

unused sustainable harvest and from the exports for a total of 569 200 m^3 softwood (216 300 odt) and 628 650 m^3 hardwood (345 750 odt) with Northern Pulp re-opened (Tables 3 and 4) and 949 200 m^3 softwood (360 700 odt) and 843 650 m^3 hardwood (464 000 odt) without the Northern Pulp mill in operation (Table 5 and 6). Pulpwood and fuelwood availability has decreased since 2015 (665 000 odt) due to a lower hardwood sustainable harvest supply (2.1 M m^3 vs 1.59 M m^3, equivalent to a drop of 200 000 odt) and an increased estimated average annual harvest of 300 000 m^3, equivalent to 150 000 odt (Volpé, S. Badcock, R. Duff, R. 2015).

Table 3. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (m^3) with Northern Pulp

Products (m^3)	With Northern Pulp							
	Harvest (used locally)		Harvest (for exports)		Unused Sustainable Harvest		Potential (m^3)[c]	
	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD
Timberwood[a]	1 590 750	91 400	1 650	9 500	785 500	26 700	**787 150**	**36 200**
Pulpwood	1 147 150	456 950	400	182 750	514 650	169 150	**515 050**	**351 900**
Firewood[b]	55 950	594 050	0	27 500	54 150	249 250	**54 150**	**276 750**
Total	2 793 850	1 142 400	2 050	219 750	1 354 300	445 100	**1 356 350**	**664 850**

[a] Not considered as potential feedstock for biorefineries.

[b] Also includes the Fuelwood category.

[c] Potential = Harvest (for export) and Unused Sustainable Harvest

Table 4. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (odt) with Northern Pulp

Products (odt)[a]	With Northern Pulp							
	Harvest (used locally)		Harvest (for exports)		Unused Sustainable Harvest		Potential (odt)[b]	
	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD
Timberwood	604 500	50 250	600	5 200	298 500	14 700	**299 100**	**19 900**
Pulpwood	435 900	251 300	150	100 500	195 550	93 050	**195 700**	**193 550**
Firewood	21 250	326 700	0	15 100	20 600	137 100	**20 600**	**152 200**
Total	1 061 650	628 250	750	120 800	514 650	244 850	**515 400**	**365 650**

[a] Conversion factors (basic density) used for softwood is 380 kg/m^3 and for hardwood is 550 kg/m^3.

[b] Potential = Harvest (for export) and Unused Sustainable Harvest

Table 5. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (m^3) without Northern Pulp

Products (m^3)	Without Northern Pulp							
	Harvest (used locally)		Harvest (for exports)		Unused Sustainable Harvest		Potential (m^3)[c]	
	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD
Timberwood[a]	1 590 750	91 400	1 650	9 500	785 500	26 700	**787 150**	**36 200**
Pulpwood	767 150	241 950	400	182 750	894 650	384 150	**895 050**	**566 900**
Firewood[b]	55 950	594 050	0	27 500	54 150	249 250	**54 150**	**276 750**
Total	2 413 850	927 400	2 050	219 750	1 734 300	660 100	**1 736 350**	**879 850**

[a] Not considered as potential feedstock for biorefineries.

[b] Also includes the Fuelwood category.

[c] Potential = Harvest (for export) and Unused Sustainable Harvest

Table 6. Annual roundwood supply potential for the province of Nova Scotia – 2015 to 2019 average (odt) without Northern Pulp

Products (odt)[a]	Without Northern Pulp							
	Harvest (used locally)		Harvest (for exports)		Unused Sustainable Harvest		Potential (odt)[b]	
	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD
Timberwood	604 500	50 250	600	5 200	298 500	14 700	**299 100**	**19 900**
Pulpwood	291 500	133 050	150	100 500	339 950	211 300	**340 100**	**311 800**
Firewood	21 250	326 700	0	15 100	20 600	137 100	**20 600**	**152 200**
Total	917 250	510 000	750	120 800	659 050	363 100	**659 800**	**483 900**

[a] Conversion factors (basic density) used for softwood is 380 kg/m^3 and for hardwood is 550 kg/m^3.

[b] Potential = Harvest (for export) and Unused Sustainable Harvest

Concerns about the long-term sustainability of the forest in the 1990's resulted in the enactment of the Registration and Statistical Returns Regulations in 2000 (NSDNR, 2008a). Before 2000, NSDNR tabulated annual primary forest products usage from Nova Scotia forests from a voluntary survey. The new regulations required all buyers and exporters of Nova Scotia primary forest products to register annually and report all wood being harvested from Nova Scotia forests. The annual reports from 2000 to 2019 were used in this wood supply analysis.

The provincial harvest for all land ownership types by county is presented in Figure 6. The average provincial harvest for the last 5 years is 3.49 M m^3 and occurs mainly on private woodlots at 63%, followed by Crown land at 25% and industrial lands at 12%.

The difference between the average harvest of the last 5 years and the sustainable wood supply is the available sustainable wood supply for new ventures in the forest sector. With Northern Pulp operating, harvested roundwood equals 1.7 M odt and the sustainable wood supply is set at 2.45 M odt, which means there is currently about 750 000 odt (68% SWD & 32% HWD) of potentially available roundwood in the province (Figure 7). With the Northern Pulp mill not operating, harvest levels decrease to 1.43 M odt, increasing the potential available roundwood to about 1 M odt (65% SWD & 35% HWD) (Figure 8). The increased available roundwood is predominantly located in the Central Region where Northern Pulp's harvest operations took place. Detailed results can be found in Appendix 2.

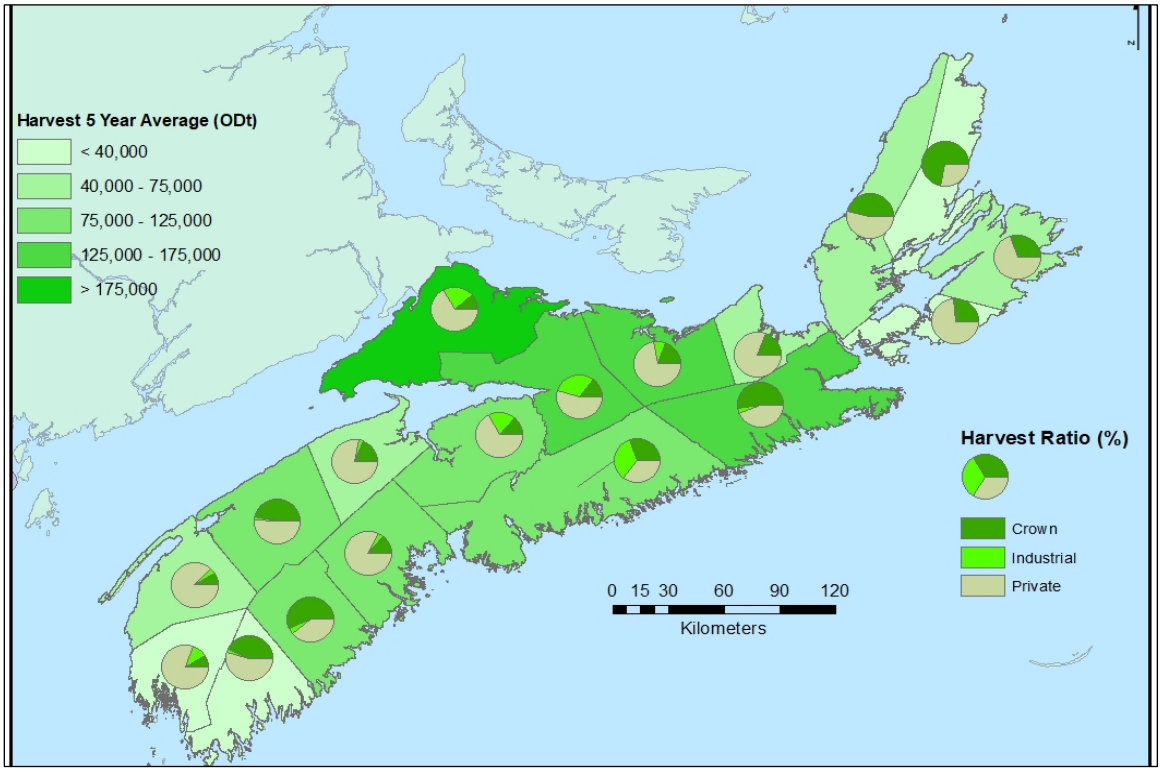


Figure 6. Annual harvest average by county and landowner (2015-2019).

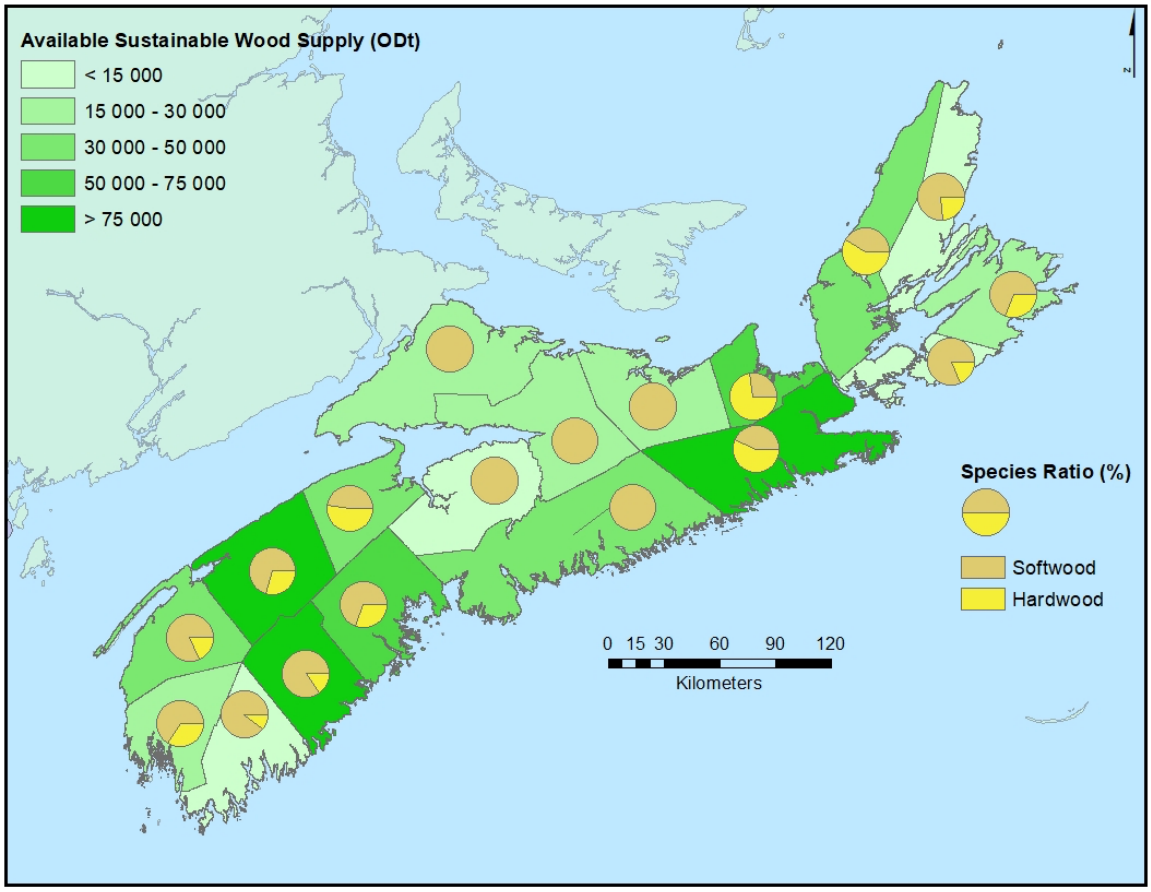


Figure 7. Available sustainable wood supply by County and species group with Northern Pulp operating.

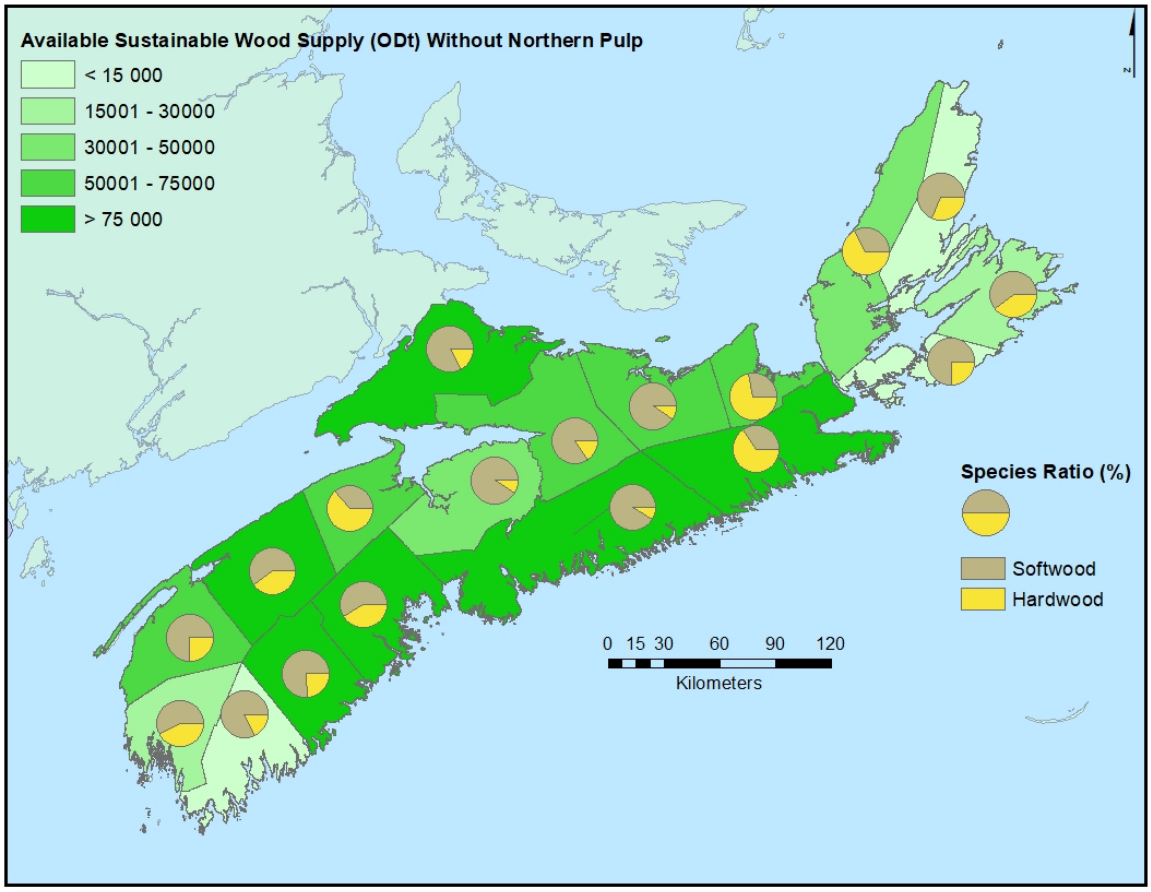
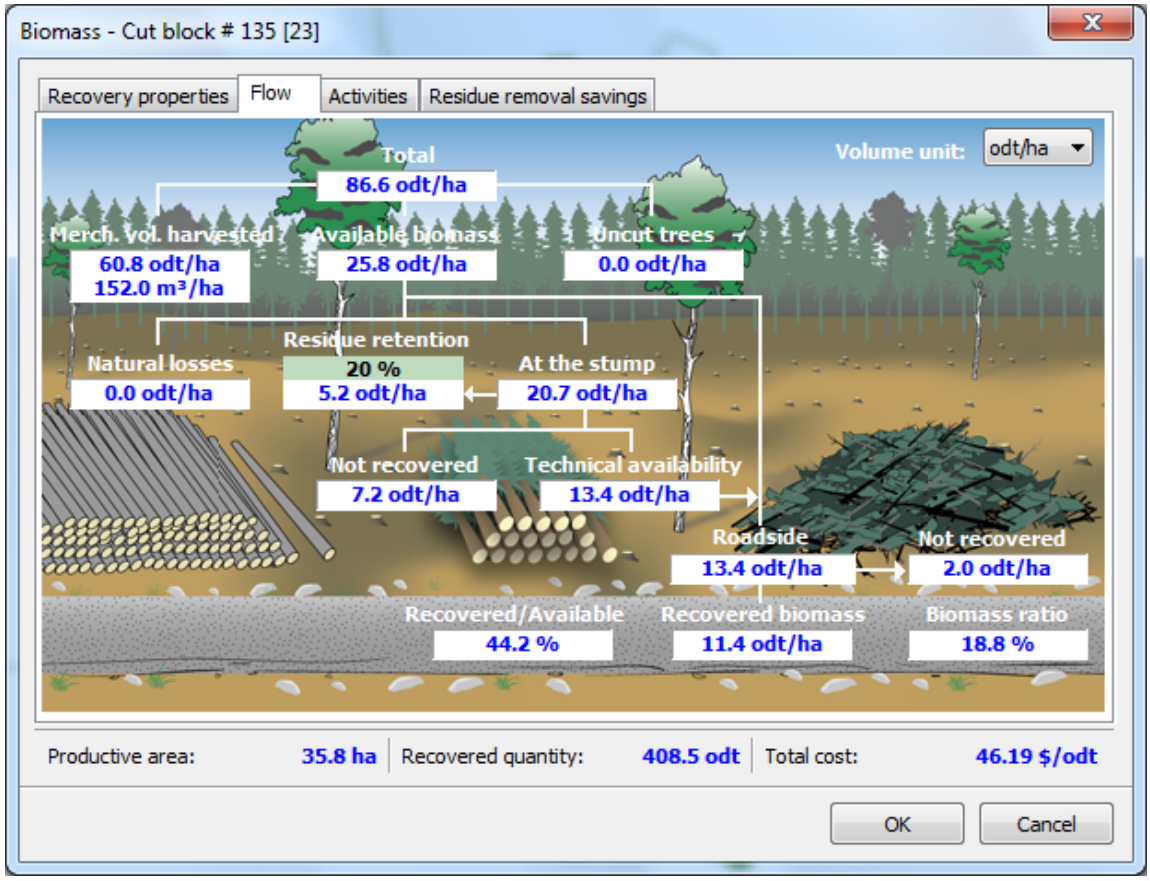


Figure 8. Available sustainable wood supply by County and species group without Northern Pulp.

Harvest residues

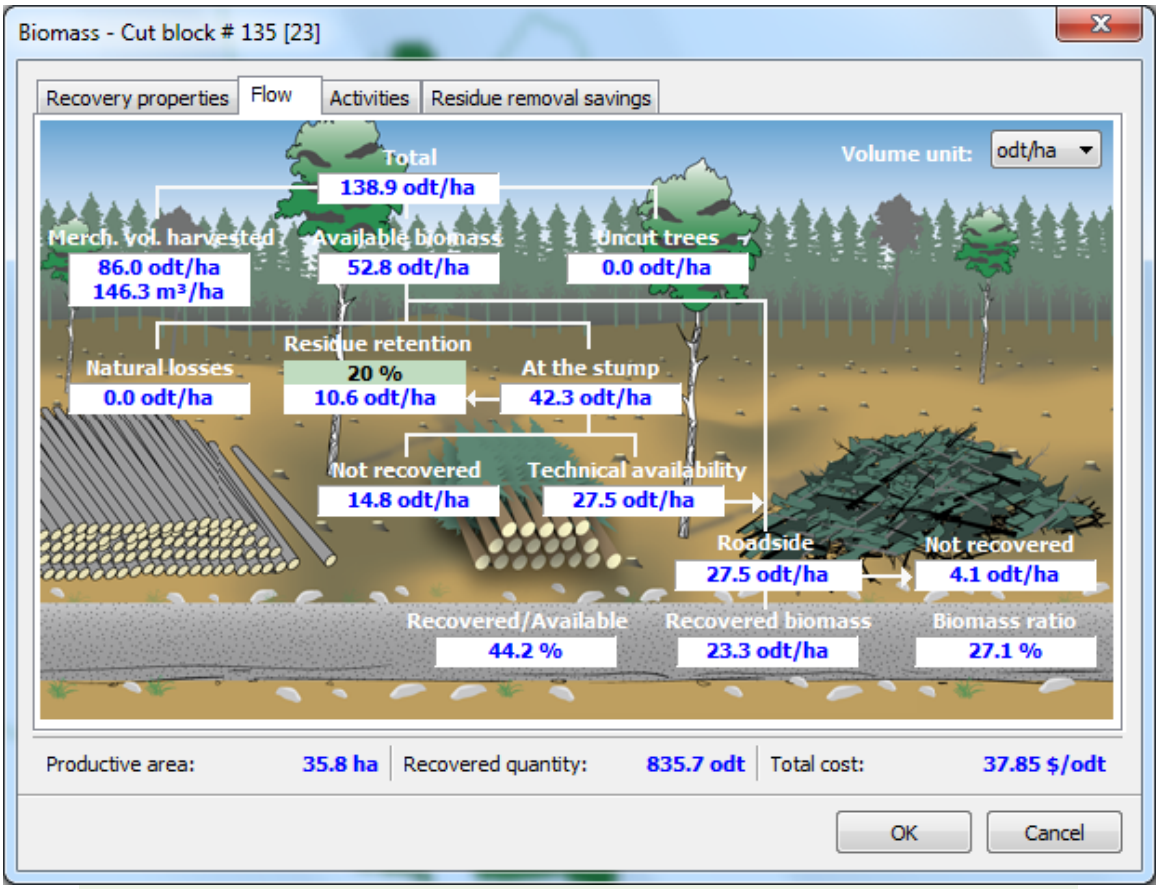
Harvest residues are an important potentially available source of biomass feedstock, but availability needs to be established using operational and economic parameters, and supply should be established on a case-by-case basis (Paré *et al.* 2011). Multiple factors like harvesting systems, stand conditions, season of recovery, and operational, environmental, and economic constraints affect the quantity of forest fibre that can be economically delivered to the end-user (MacDonald 2006; Ralevic 2010). Another important factor affecting harvest residue recovery efficiency is the operator's work methods and experience (Peltola 2011; Nurmi 2007). For the present study, harvest residues will be estimated by County using recovery rates used in the FPInnovations BiOS model for cut-to-length (CTL) harvesting.

CTL harvesting is a popular harvesting method across Eastern Canada. The average recovery rate for harvest residues is 60% when forest fibre is recovered using a CTL harvesting system in softwood dominated stands (Norvez *et al.* 2013, Nurmi 2007, Peltola *et al*. 2011). For this analysis, default recovery rates in BiOS, which are set at 45% for CTL systems, will be used. With this hypothesis, for every cubic meter of softwood roundwood harvested, 0.075 odt of harvest residues can potentially be recovered and delivered to a potential client, while a cubic meter of harvested hardwood will generate 0.16 odt (Figure 9 and 10).



Stand description: Black spruce = 152 m^3/ha; Avg. stem volume = 0.2 m^3 Stems/ha = 760; Topping diameter = 10 cm; Basic density = 437 kg/m^3

Figure 9. Wood flow diagram for softwood stands harvested with CTL (simulated in BiOS).



Stand description: Red maple = 146 m^3/ha; Avg. stem volume = 0.2 m^3 Stems/ha = 730; Topping diameter = 10 cm; Basic density = 600 kg/m^3

Figure 10. Wood flow diagram for hardwood stands harvested with CTL (simulated in BiOS).

Recovery rates were applied to the last 5-year historical average harvest (2015 to 2019) and the most recent sustainable wood supply calculations (2016). Available harvest residues currently being generated with the harvest of merchantable wood represent 180 000 odt and potentially available total volumes of 260 000 odt based on sustainable harvest levels (Figure 11). Volumes are “available” in the sense that they could be extracted from harvest operations if there was demand and regulatory changes. However, this fiber is not currently being generated in a marketable form today. Also, a new product to recover would mean that current operating practices would need to be adapted.

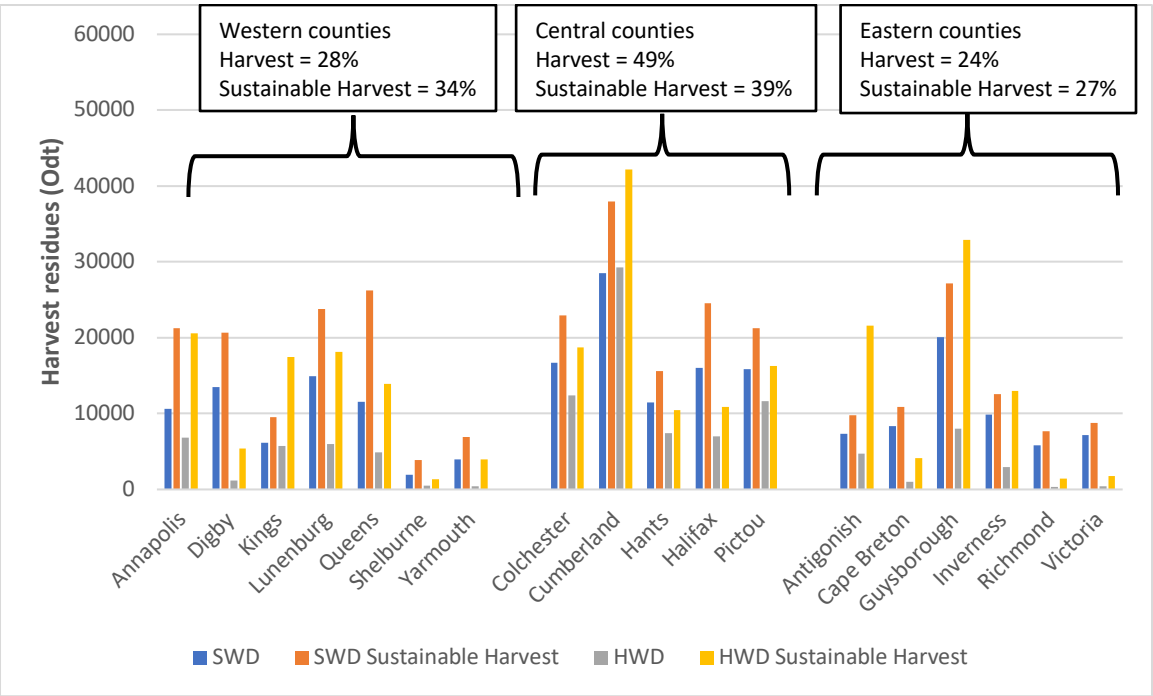


Figure 11. Harvest residue availability per county.

Mill by-products

Mill by-products availability is determined in oven-dry tonnes (odt) by looking at the difference between the output of by-products from the mills running at full capacity and the operating rates for 2020.

Mill by-products for which volumes are estimated include:

(1) Wood chips: means any softwood or hardwood pieces (small and thin) suitable for processing in a pulp mill or for sale to any other user, except as biomass fuel. Sawmills producing pulp quality chips can transfer the silviculture liability to the company acquiring them.

(2) Sawdust: fines, dust-like particles, generated from the processing of roundwood at sawmills during cutting and sawing. Fine sawdust is also a by-product of de-barked roundwood chipping at pulp mills. Fine sawdust is mainly used as feedstock for industrial boilers or for pellet production.

(3) Shavings: thin strips of wood generated from the processing of roundwood at sawmills during edging, trimming, and planing. Shavings are mainly used as animal bedding, feedstock for industrial boilers or for pellet production.

(4) Bark: is generated from de-barking operations at sawmills and pulp mills. Bark is entirely used as fuel for industrial boilers.

Mill by-products from sawmills were estimated using average yield factors for all sawmills across the province and reflect the technological level of sawmills and fiber quality found in the province (Table 7). Those yield factors were estimated by the FPInnovations Wood Products Group using FPInnovations' Optitek software (MacDonald 2015). Factors were determined for representative softwood (380 kg/m^3) and hardwood (550 kg/m^3) sawmills. Yield factors for sawmills reflect the quantity in oven-dry tonnes (odt) of wood chips, sawdust, shavings, and bark produced when processing 1 MFBM of lumber. Pulp mill by-products were also estimated using average yield factors for drum debarkers (Table 7). The bark and some residual fibre attached to the bark will represent about 20% of the mass; the remaining 80% is processed by the chipper. Of this chipped volume, about 2% will be screened out as fines.

Table 7. Mill by-products yield factors for sawmills and pulp mills

By-products yield	Pulp chips		Sawdust		Shaving		Bark	
	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD
Sawmills[a]	odt/Mfbm	odt/Mfbm	odt/Mfbm	odt/Mfbm	odt/Mfbm	odt/Mfbm	odt/Mfbm	odt/Mfbm
	0.807	**0.897**	**0.103**	**0.350**	**0.107**	**0**	**0.273**	**0.499**
Pulp mills[b]	odt/m^3	odt/m^3	odt/m^3	odt/m^3	odt/m^3	odt/m^3	odt/m^3	odt/m^3
	77.6%	77.6%	2.4%	2.4%	0%	0%	20%	20%
	0.295	**0.427**	**0.009**	**0.013**	**0**	**0**	**0.076**	**0.11**

[a] More sawdust is produced when sawing hardwoods because more cuts are required to make high value lumber products and logs are bigger compared to softwood. Sawmills producing hardwood lumber almost never trim sawn timber. They usually sell smaller pieces to a secondary industry like furniture or flooring.

[b] Bark volume generated has some white wood volume attached to it. This mix of bark and white wood generated by the debarker is referred to as hog fuel which is used as feedstock for biomass boilers. The fines are also used to feed boilers.

The production rates of the 24 existing active sawmills consuming over 1000 m^3/year run is about 80% of their capacity. Based on this and the residue production levels of other roundwood-consuming establishments such as pulp mills, pellet plants, and hardboard facilities, the total annual by-product output from the province is estimated at 1 million odt (Table 8). There is a potential for additional by-product output from higher sawmill operating rates and capacity. By utilizing the unused sawlog/studwood portion of the sustainable harvest, an additional 235 000 odt of by-products could be generated with increased lumber production from active sawmills.

Part of the wood fibre consumed by the pulp and paper mill is generated internally from purchased pulpwood roundwood. In fact, one quarter of the SWD pulp chips generated in the province are produced at the Port Hawkesbury Paper mill (Table 8). Operating rates in 2020 showed that the province had a surplus of by-products. Current operating rates yield a surplus of 263 000 odt of by-products annually which includes a 253 000 odt surplus of pulp chips. This imbalance is due to Northern Pulp's mill closure which required over 350 000 odt of by-products from around the province and even out-of-province pulp chips to satisfy its needs. Markets have yet to adjust to this disruption. Tables 8 and 9 provide an overview of the provincial mill by-product fibre flow for 2020.

Table 8. 2020 Provincial mill by-product output (odt)

Mill type	Energy chips[c]		Pulp chips		Sawdust		Shaving		Bark		Total	
	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD
Sawmills[a]	0	0	367 400	12 000	45 600	4 700	47 000	0	123 400	6 700	583 400	23 400
Others[b]	0	0	171 300	141 800	5 300	4 400	0	0	44 100	36 500	220 700	182 700
Total	**0**	**0**	**538 700**	**153 800**	**50 900**	**9 100**	**47 000**	**0**	**167 500**	**43 200**	**804 100**	**206 100**

[a] In 2019, there were 24 active sawmills consuming more than 1000 m^3/year.

[b] Pulp mills, pellet plants, particle board plants, wood chip export.

[c] Comes from full tree (FT) operations, partially from land-clearing operations and from private forest operations.

Table 9. 2020 Provincial mill by-product consumption (odt)

Mill type	Energy chips[c]		Pulp chips		Sawdust		Shaving		Bark		Total[b]	
	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD	SWD	HWD
PHP	0	0	251 800	0	5 200	0	0	0	0	0	257 000	0
NSP 60 MW	49 400	16 500	0	0	0	0	0	0	70 000	12 400	70 000	12 400
Emera 21 MW	1 400	1 400	40 000	1 100	5 000	400	5 000	0	80 000	0	130 000	1 500
Maibec	0	0	0	31 700	0	1 000	0	0	0	8 200	0	40 900
Great Northern Pellets	0	0	4 400	58 900	15 100	1 800	9 000	0	16 100	15 200	44 600	75 900
Shaw	0	0	0	0	14 000	0	21 000	0	0	0	35 000	0
GNTI	0	60 000	0	51 200	0	0	0	0	0	0	0	51 200
Sawmills[a]	0	0	0	0	500	0	14 100	0	6 000	300	20 600	300
Institutional users	2 000	2 000	0	0	0	4 000	0	0	0	4 000	0	8 000
Total	**52 800**	**79 900**	**296 200**	**142 900**	**39 800**	**7 200**	**49 100**	**0**	**172 100**	**40 100**	**557 200**	**190 200**

[a] Based-on quantities of secondary products transferred by sawmills, it is estimated that 1% of sawdust, 30% of shavings, and 5% of bark generated by sawmills are used internally.

[b] Excluding energy chips.

[c] Comes from full tree (FT) operations, partially from land-clearing operations and from private forest operations.

The 5 largest sawmills account for over 90% of sawmill production in Nova Scotia. Therefore, most sawmill by-products are produced in these counties (Figure 12). There are very few sawmills in Eastern Nova Scotia, and none that consumed over 1 000 m^3 in 2019 according to the Registry of Buyers.

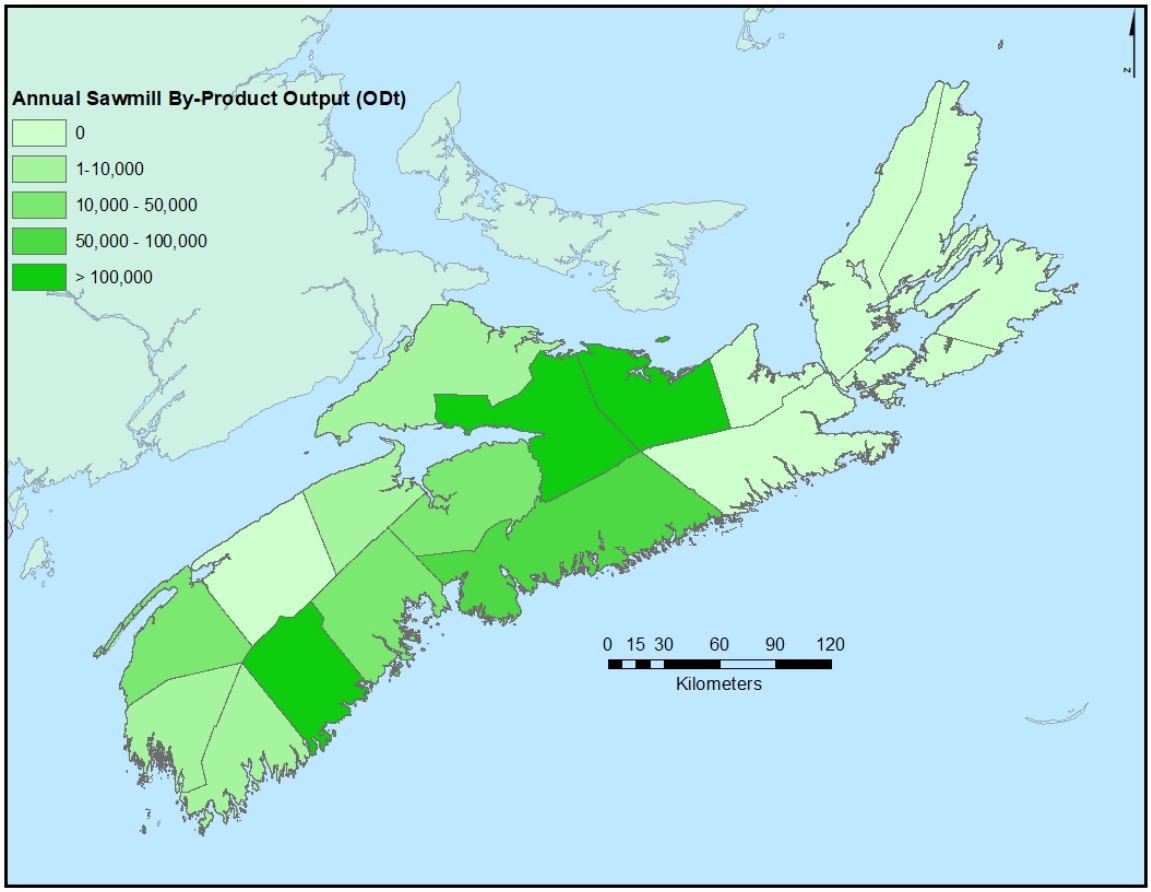


Figure 12. By-product output by county from sawmills consuming over 1,000 m^3 in 2019.

FEEDSTOCK AVAILABILITY BY LOCATION

Site Selection

Feedstock availability was measured for potential new forest bioeconomy sites across Nova Scotia (Figure 13). The six potential sites are all brownfield sites chosen for their proximity to potential fibre sources, such as mill by-products or pulp and paper mills. Each site was selected and assessed in detail for available feedstock located within a 200-km transport distance. The six potential sites are listed in Table 10, from west to east.

Table 10. Potential sites and nearby assets.

Potential Sites	Nearby Strategic Assets
Greenfield	Harry Freeman and Sons Ltd.
Kaizer Meadow	Kaizer Meadow Waste Management Facility Sustane Technologies
Enfield	Elmsdale Lumber Co Ltd. Ledwidge Lumber Co Ltd.
Trenton	Nova Scotia Power 307 MW power station
Sheet Harbour	Great Northern Timber Inc. ship loading terminal
Port Hawkesbury	Port Hawkesbury Paper Nova Scotia Power 60 MW power plant NuStar energy terminal

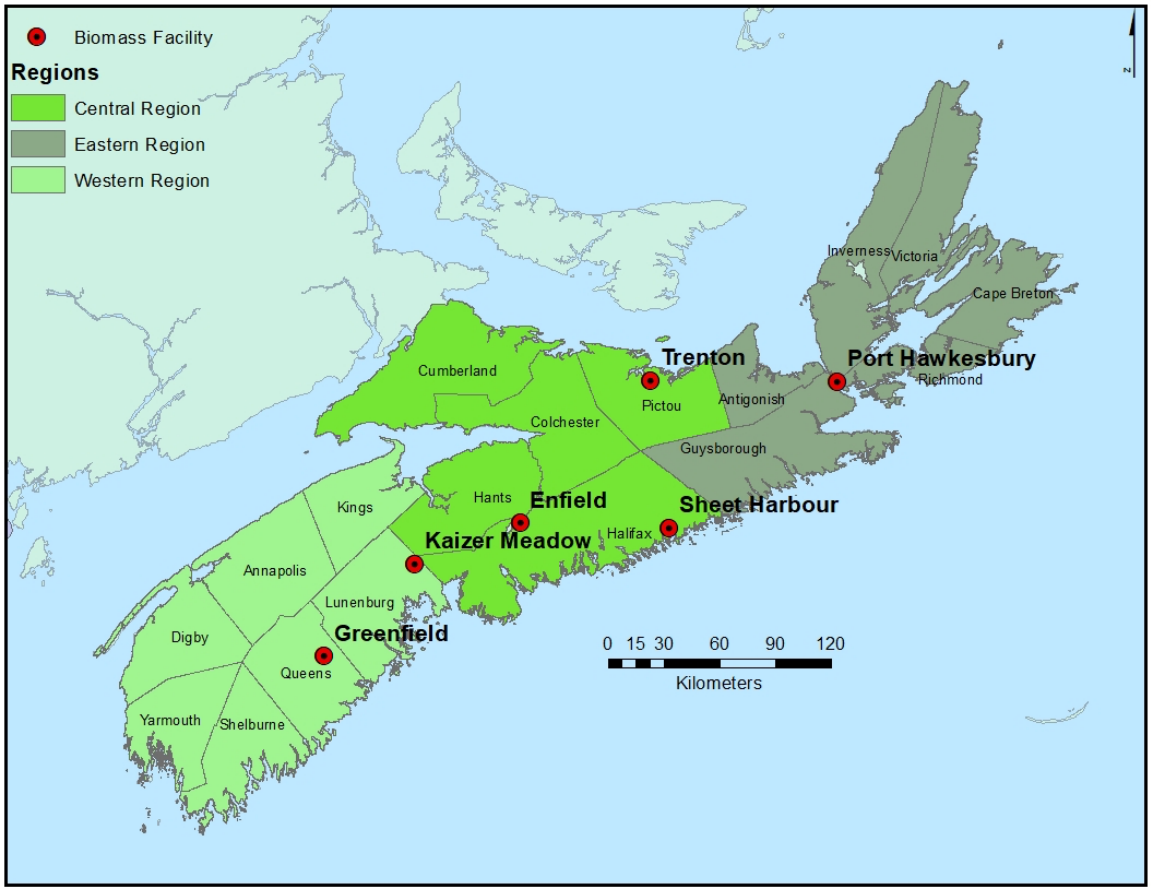


Figure 13. Sites selected for feedstock assessment.

Assumptions

Available feedstock is estimated within 200 km of the targeted sites. Road distances were calculated using road spatial data from Nova Scotia.

Forest feedstock

Roundwood is the part of the tree (stem) that is harvested and transported to wood processing plants. In this study, the only part of the stem that is considered available for bioenergy applications is the top portion (smaller diameter, lower quality) traditionally sold as firewood or pulpwood. In this analysis, roundwood will be referred to as fuelwood. Fuelwood availability reported in this study is the difference between the average harvest of the last 5 years (2015 to 2019) and the Sustainable Wood Supply calculations for the next 20 years supplied by the NSDNR (NSDNR, 2016).

Mill residues produced by sawmills acquiring over 1000 m^3 per year have been used to determine the potential availability around the targeted sites. The amount of mill residue available is based on a stronger lumber market that would see increased production rates at the 24 active sawmills from the current average of 80% to full capacity. Since most sawmills utilize (process) softwood species, most of the by-products are softwood and therefore the data will not differentiate between species.

The supply costs of both fuelwood and mill residues (wood chips, fines, bark) have been estimated by distance using the costing parameters shown in the Feedstock Supply Cost chapter.

Northern Pulp

Uncertainties surrounding Northern Pulp's future require two scenarios to be examined for feedstock supply at each potential facility.

The two scenarios are as follows:

1. Northern Pulp re-opens and acquires roundwood and mill residues at the 2019 levels.
2. Northern Pulp remains closed and its 2019 harvest volumes by county are added to the available wood supply. The mill residues previously acquired by Northern Pulp are also added to the available supply from each concerned sawmill.

All scenarios assume a strong lumber market where all sawmills can increase production to their full capacity. With Northern Pulp currently closed, affected sawmills have been able to find markets for their by-products. However, these contracts are mostly short-term or intermittent. A new bioeconomy facility would provide steadier long-term demand for their by-products at similar or better rates. Therefore, the by-products have been classified as available in this scenario. As of early 2020, there was no market for softwood pulpwood or fuelwood logs in the western region, therefore delivered price of fuelwood may be lower than assumed.

1-Greenfield

Greenfield is located in Queens County (Figure 14). It is home to Harry Freeman & Son Ltd., a sawmill with a yearly production capacity of 110 million fbm of softwood lumber.

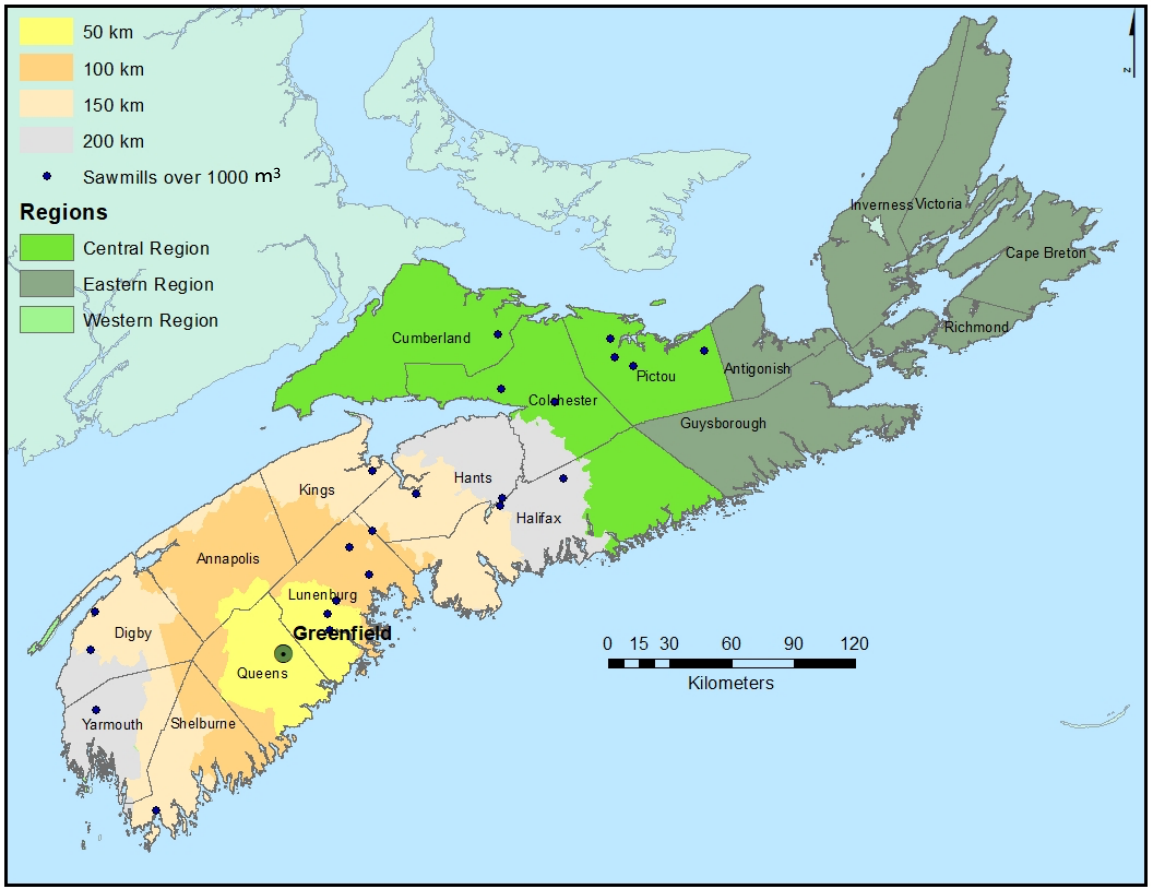


Figure 14. Road distances from Greenfield.

Scenario 1. With Northern Pulp operating

Fuelwood availability within 200 km of Greenfield is equal to 241 400 odt at an average delivered price of $104/odt. Mill residues available within 200 km of Greenfield represent 37% of the provincial total, or 85 450 odt at an average delivered price of $124/odt (Figure 15). There are very little available mill residues outside 50 km of Greenfield, most mill residues for that site comes from Harry Freeman & Sons who have been recently operating near full capacity. Due to the closure of Resolute Forest Products in 2012, available fuelwood has increased in the western region with 59 200 odt annually available within 50 km of Greenfield and more than double that amount (120 950 odt) within 100 km.

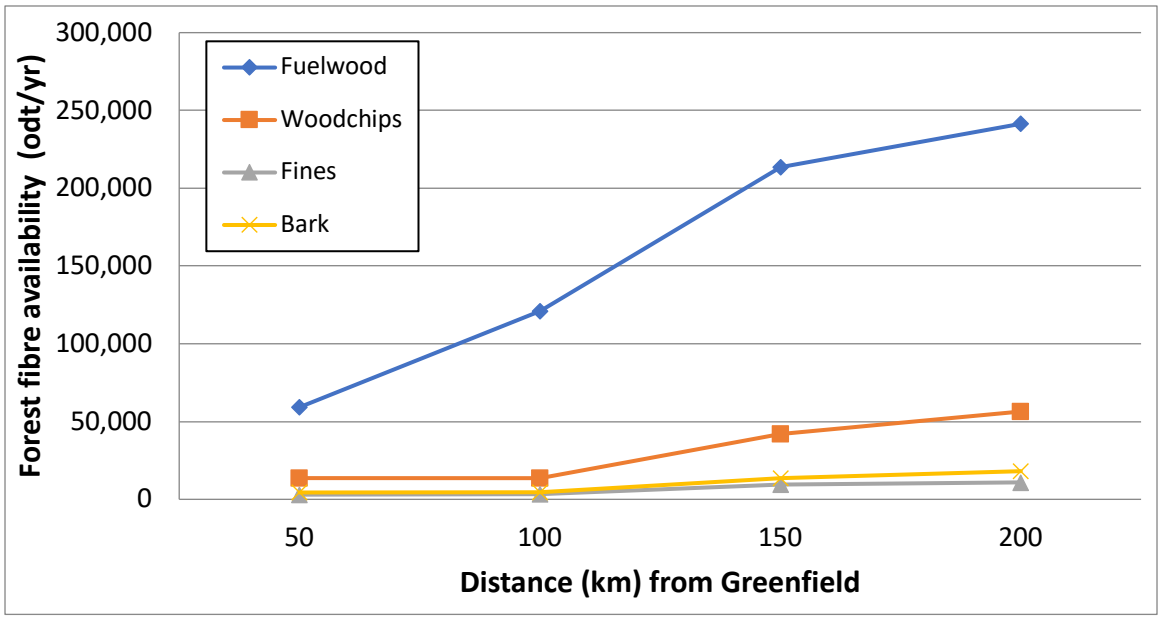


Figure 15. Forest fibre availability surrounding Greenfield with Northern Pulp operating.

Scenario 2. Without Northern Pulp

With the Northern Pulp mill closed, fuelwood availability within 200 km of Greenfield is equal to 300 000 odt at an average delivered price of $94/odt. Mill residues available within 200 km of Greenfield represent 41% of the provincial total, or 247 100 odt at an average delivered price of $106/odt (Figure 16). It is estimated that 94 350 odt of chips would be available within 50 km of Greenfield since Northern Pulp would no longer be purchasing 100% of the Harry Freeman chips (Gardner Pinfold, 2019).

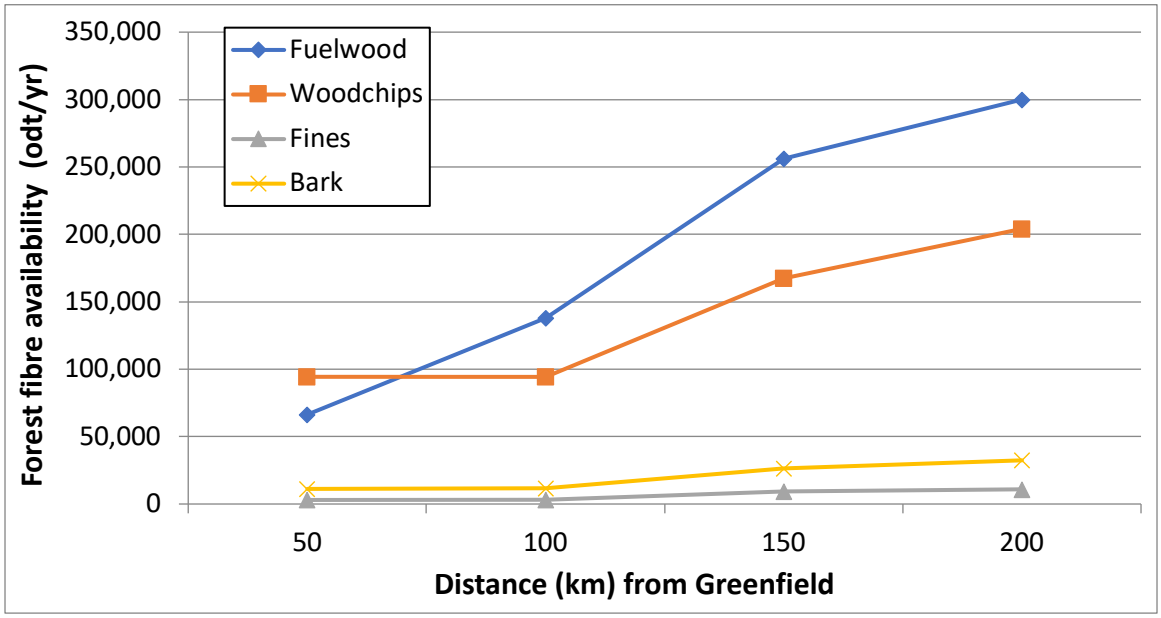


Figure 16. Forest fibre availability surrounding Greenfield with Northern Pulp closed.

2-Kaizer Meadow

Kaizer Meadow is a solid waste management facility in the north-eastern section of Lunenburg County (Figure 17). This site was chosen because of its central location, encompassing a large area for potential fibre sources and the potential to obtain some fuel from the waste management facility. It is also home to Sustane Technologies, a cleantech innovation company focused on municipal waste transformation.

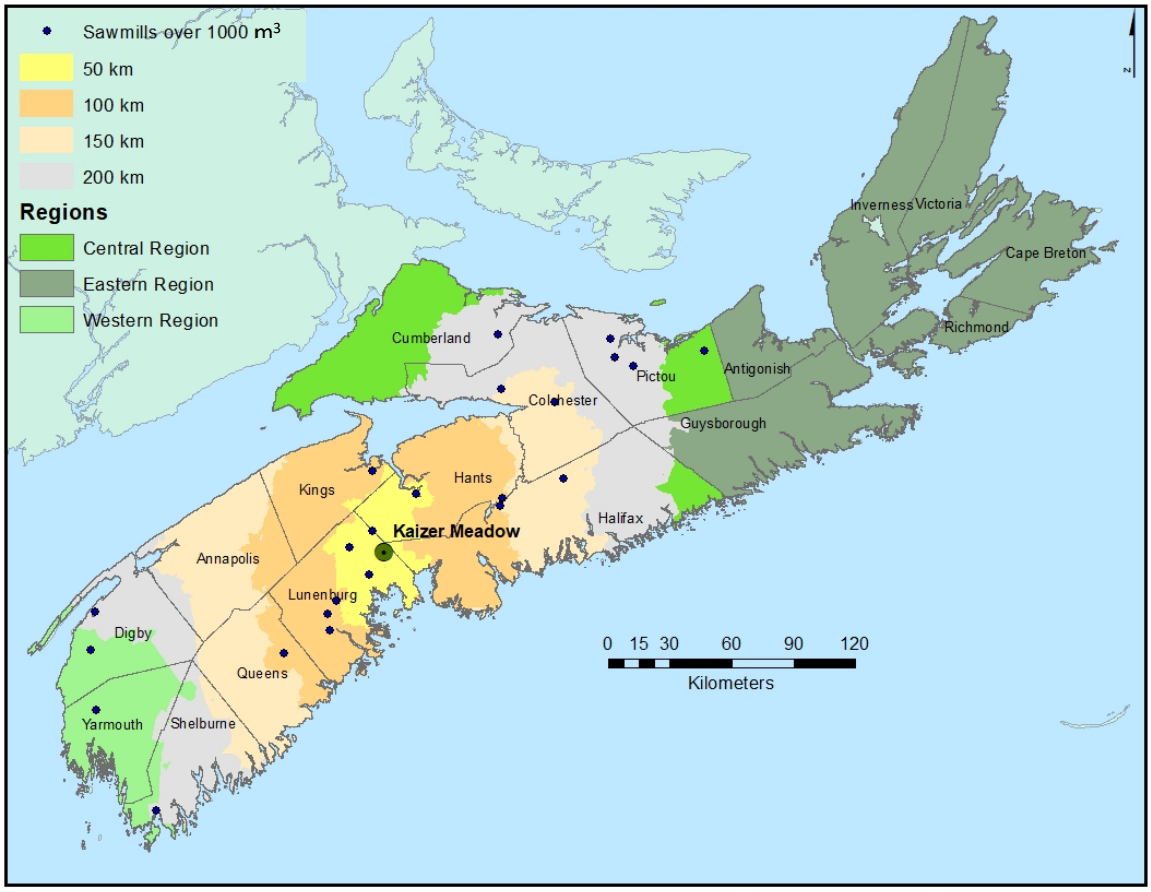


Figure 17. Road distances from Kaizer Meadow.

Scenario 1. With Northern Pulp operating

Fuelwood availability within 200 km of Kaizer Meadow amounts to 226 000 odt annually at an average delivered price of $106/odt. Mill residues available within 200 km of Kaizer Meadow represent 99% of the provincial total, or 227 800 odt at an average delivered price of $127/odt (Figure 18). Over 100 000 odt of fuelwood is available within 100 km and mill residue availability increases significantly after 100 km due to the large volumes available from J.D. Irving's Sproule Lumber facility. The chip mill attached to the JDI Sproule sawmill, used to remove saw material from pulpwood and to produce a greater volume of pulp chips to trade for studwood, is currently operating at a low production rate. This explains the large increase in available mill residues after 100 km.

Figure 18. Forest fibre availability surrounding Kaizer Meadow with Northern Pulp operating.

Scenario 2. Without Northern Pulp

With Northern Pulp closed, fuelwood availability within 200 km of Kaizer Meadow represents 333 550 odt at an average delivered price of $97/odt. Mill residues available within 200 km of Kaizer Meadow represent 100% of the provincial total, or 588 350 odt at an average delivered price of $113/odt (Figure 19). It is estimated that 118 750 odt of chips would be available within 100 km of Kaizer Meadow because of the nearby Harry Freeman and Sons sawmill.

Figure 19. Forest fibre availability surrounding Kaizer Meadow with Northern Pulp closed.

3-Enfield

Enfield is in Halifax County near the southern border of Hants County (Figure 20). This site was selected because of its central location in the province and proximity to large capacity sawmills such as Ledwidge Lumber and Elmsdale Lumber.

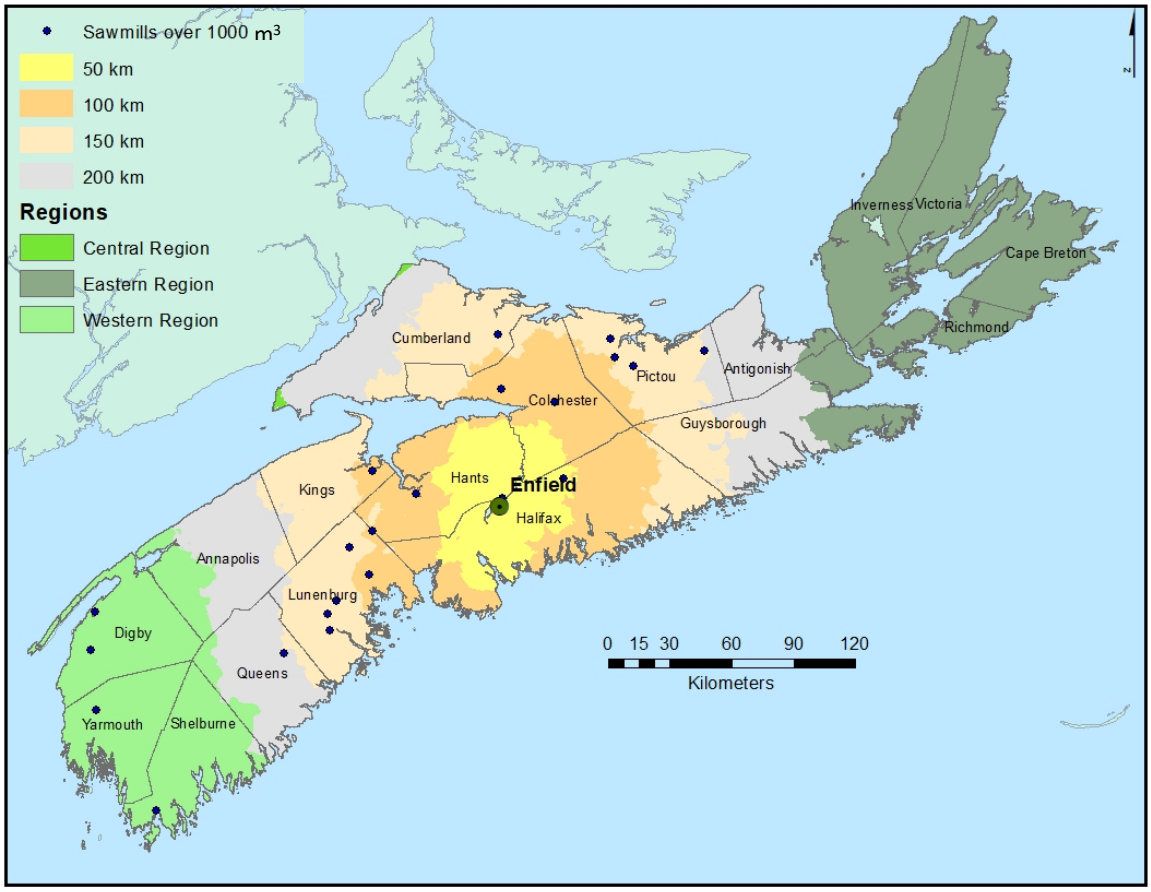


Figure 20. Road distance from Enfield.

Scenario 1. With Northern Pulp operating

Fuelwood availability within 200 km of Enfield amounts to 226 000 odt at an average delivered price of $114/odt. Mill residues available within 200 km of Enfield represent 99% of the provincial total, or 227 800 odt at an average delivered price of $114/odt (Figure 21). In fact, 99% of all mill residues in the province are within 150 km of Enfield and 83% are within 100 km. Enfield's central location and proximity to large sawmills enables it to potentially acquire large quantities of mill residues at a low transportation cost. However, fuelwood availability is lower around Enfield because harvesting in the Central Counties approaches the sustainable supply limit.

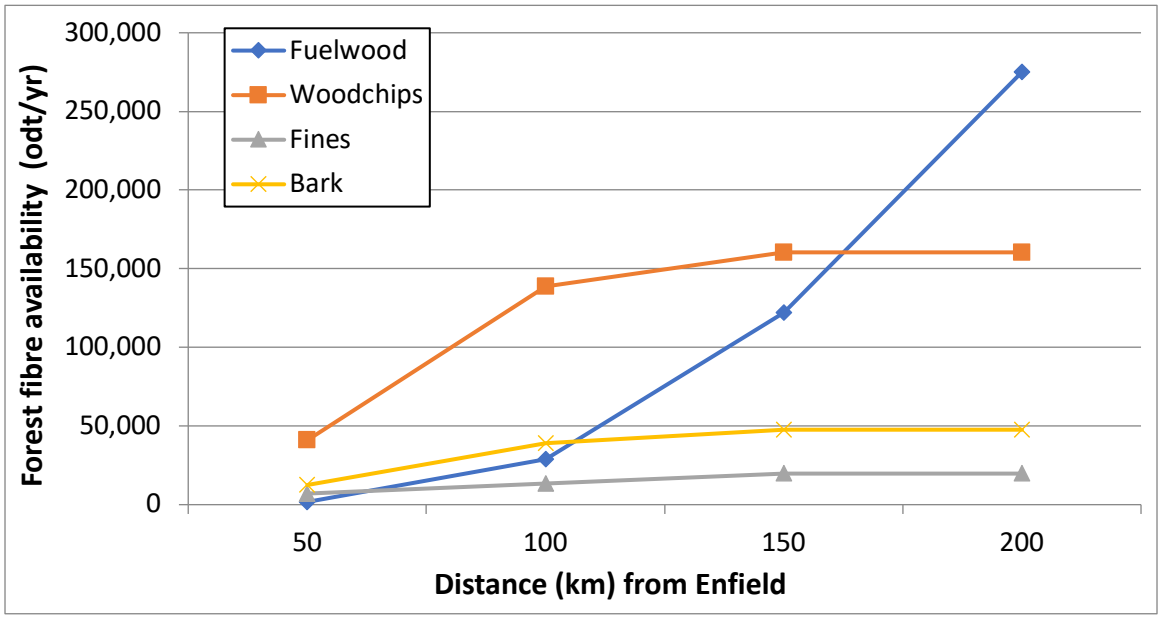


Figure 21. Forest fibre availability surrounding Enfield with Northern Pulp operating.

Scenario 2. Without Northern Pulp

With Northern Pulp closed, fuelwood availability within 200 km of Enfield amounts to 395 100 odt at an average delivered price of $100/odt. Mill residues available within 200 km of Enfield represent 100% of the provincial total, or 597 350 odt at an average delivered price of $104/odt (Figure 22). A volume of 134 800 odt, or 23% of all available mill residues in the province, would be available within 50 km of Enfield. This is because the nearby Elmsdale Lumber and Ledwidge Lumber sawmills would not be sending all their pulp chips to the Northern Pulp facility.

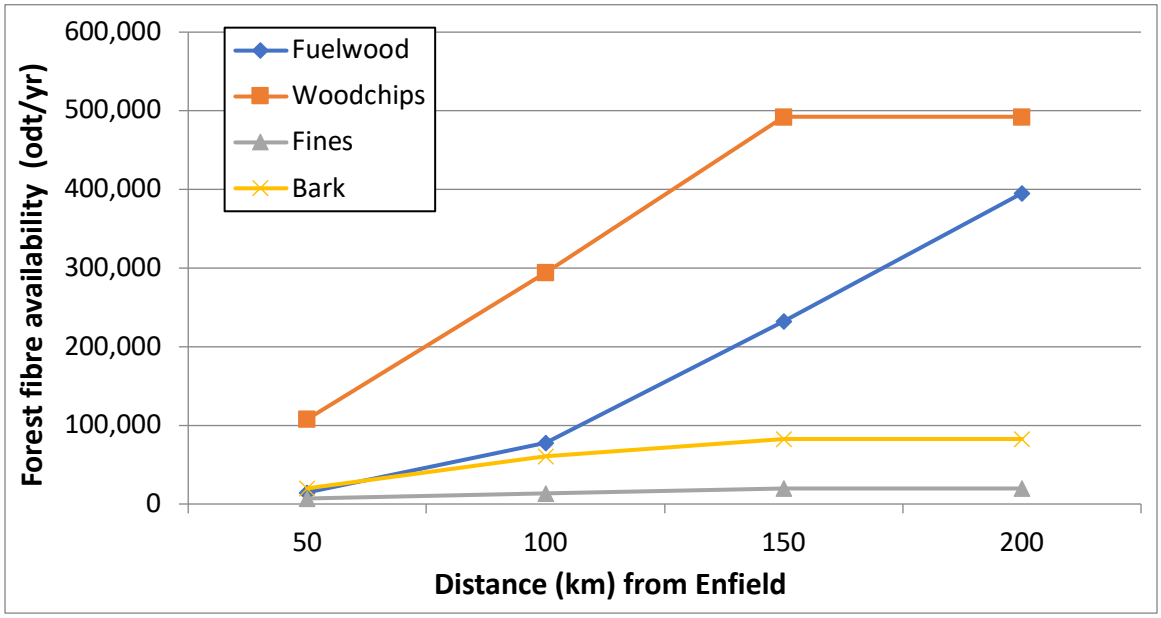


Figure 22. Forest fibre availability surrounding Enfield with Northern Pulp closed.

4-Trenton

Trenton is located in Pictou County, 10 km south of the Northern Pulp mill in Abercrombie (Figure 23). The Trenton site hosts the Nova Scotia Power (NSP) 307 MW coal power generating station.

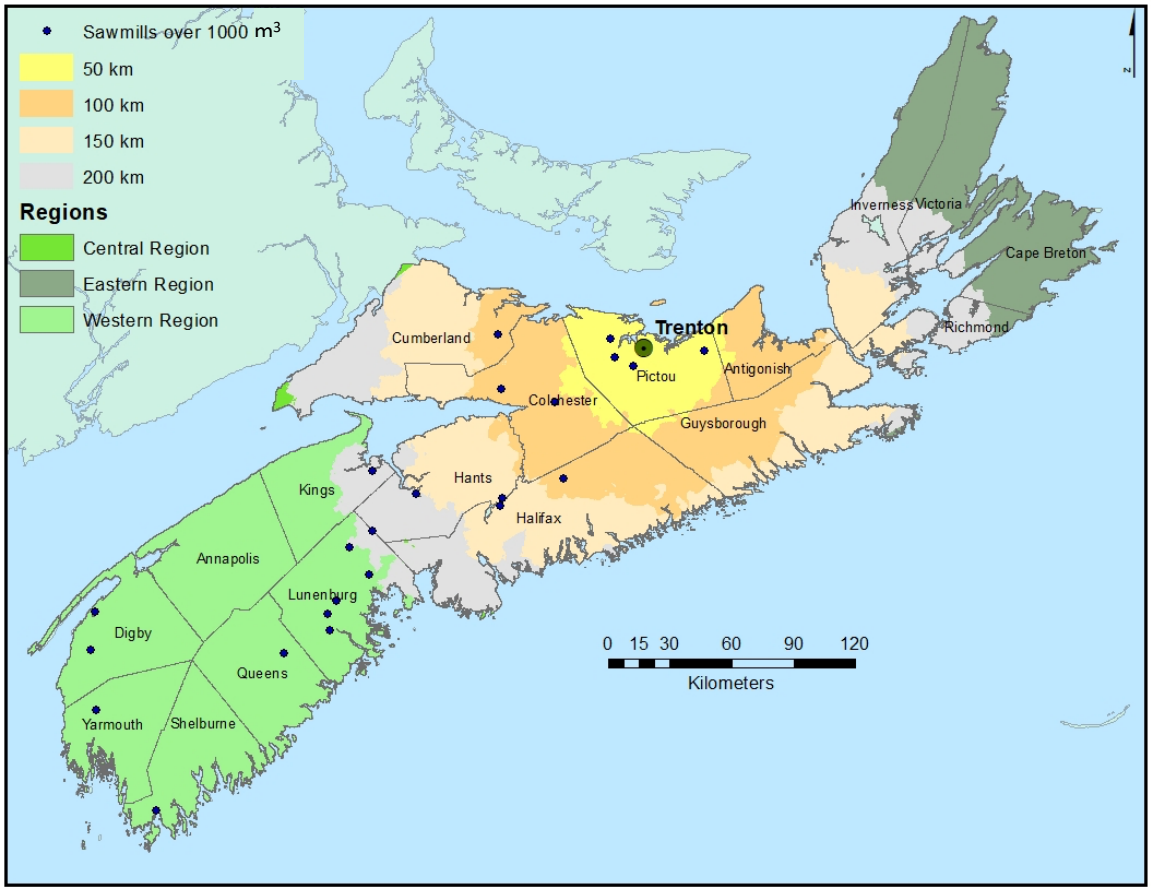


Figure 23. Road distances from Trenton.

Scenario 1. With Northern Pulp operating

Fuelwood availability within 200 km of Trenton amounts to 202 100 odt available at an average delivered price of $106/odt. Mill residues available within 200 km of Trenton represent 83% of the provincial total, or 192 300 odt at an average delivered price of $118/odt (Figure 24). In fact, 63% of all mill residues in the province are within 100 km of Trenton because of its proximity to large sawmills such as Scotsburn Lumber, Groupe Savoie – Westville, and J.D. Irving Sproule Lumber.

Figure 24. Forest fibre availability surrounding Trenton with Northern Pulp operating.

Scenario 2. Without Northern Pulp

With Northern Pulp closed, fuelwood availability within 200 km of Trenton amounts to 341 650 odt at an average delivered price of $95/odt. Mill residues available within 200 km of Enfield represent 79% of the provincial total, or 474 500 odt at an average delivered price of $101/odt (Figure 25). A volume of 353 350 odt, or 59% of all mill residues in the province would be available within 100 km of Trenton. Available fuelwood near Trenton is less than in other locations since it is near the coast, reducing the available area and because harvesting in the Central Counties approaches the sustainable wood supply limits.

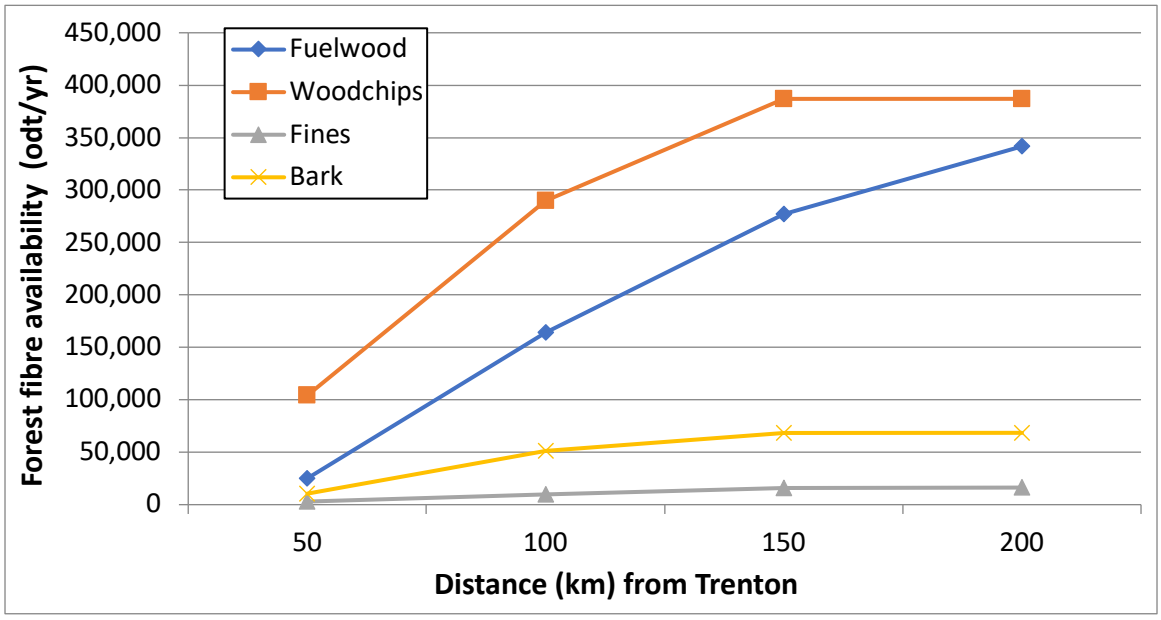


Figure 25. Forest fibre availability surrounding Trenton with Northern Pulp closed.

5-Sheet Harbour

Sheet Harbour is in eastern Halifax County on the Atlantic Ocean (Figure 26) and is home to Great Northern Timber Inc. (GNTI)'s ship loading terminal (deep-water, ice-free port). GNTI also operates a chipping facility in Sheet Harbour with an annual capacity of 300 000 tonnes of random-length hardwood logs (fuelwood and pulp-quality logs). Wood chips are currently being exported to international markets and delivered to Great Northern Pellets in Middle Musquodoboit (formerly Viridis).

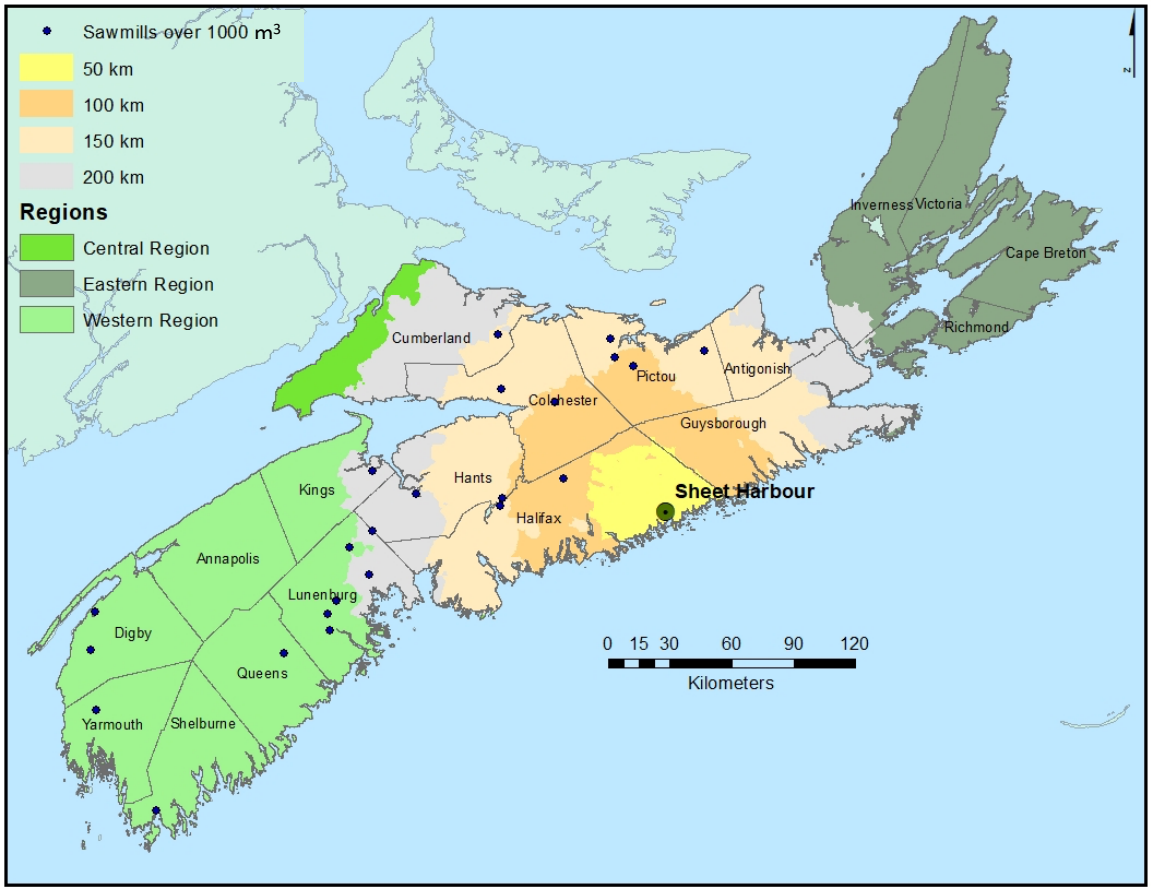


Figure 26. Road distances from Sheet Harbour.

Scenario 1. With Northern Pulp operating

Fuelwood availability within 200 km of Sheet Harbour amounts to 178 500 odt at an average delivered price of $111/odt. Mill residues available within 200 km of Sheet Harbour represent 89% of the provincial total, or 206 332 odt at an average delivered price of $119/odt (Figure 27). There are no major sawmills within 50 km of Sheet Harbour, however 69% of all available provincial mill residues are found within 100 km.

The availability of fuelwood is also very low within 100 km of Sheet Harbour at 36 600 odt. This is because of Sheet Harbour's coastal location, limiting the available forest area, and the Central Counties limited available fuelwood supply. Despite the low availability of fibre nearby, Sheet Harbour is a prime location for international shipping.

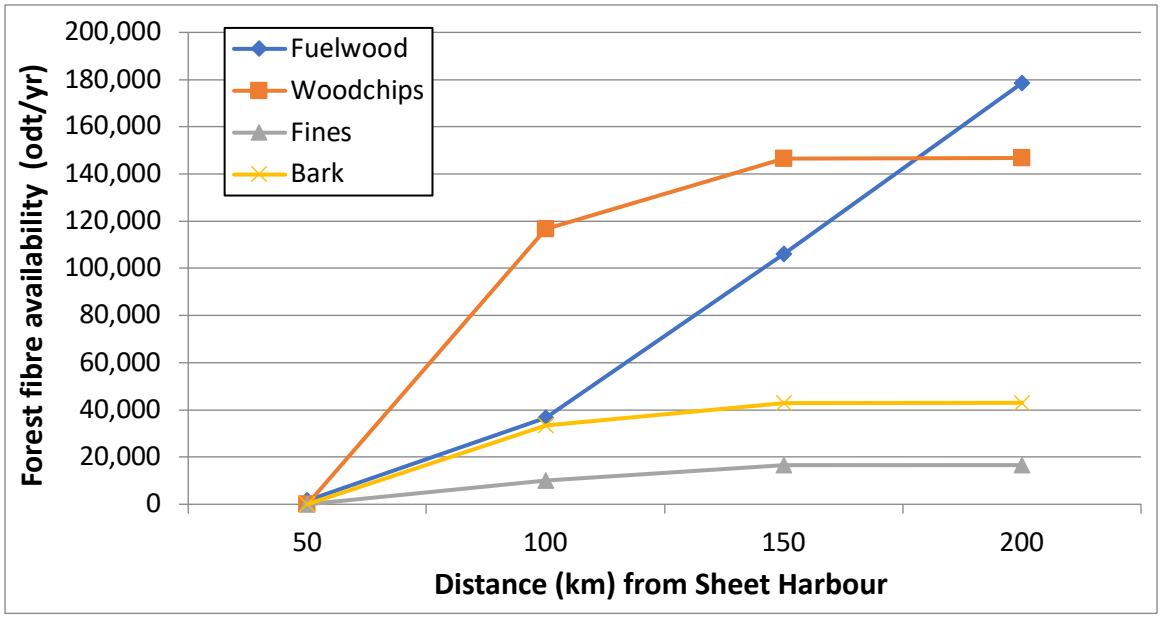


Figure 27. Forest fibre availability surrounding Sheet Harbour with Northern Pulp operating.

Scenario 2. Without Northern Pulp

With Northern Pulp closed, fuelwood availability within 200 km of Sheet Harbour amounts to 302 500 odt at an average delivered price of $100/odt. Mill residues available within 200 km of Sheet Harbour represent 82% of the provincial total, or 488 550 odt at an average delivered price of $106/odt (Figure 28). About 280 900 odt, or 47% of all mill residues in the province would be available within 100 km of Sheet Harbour. Like Trenton, available fuelwood near Sheet Harbour is lower than the other locations being located near the coast, reducing the total land available and because harvesting in the Central Counties approaches the sustainable wood supply limit.

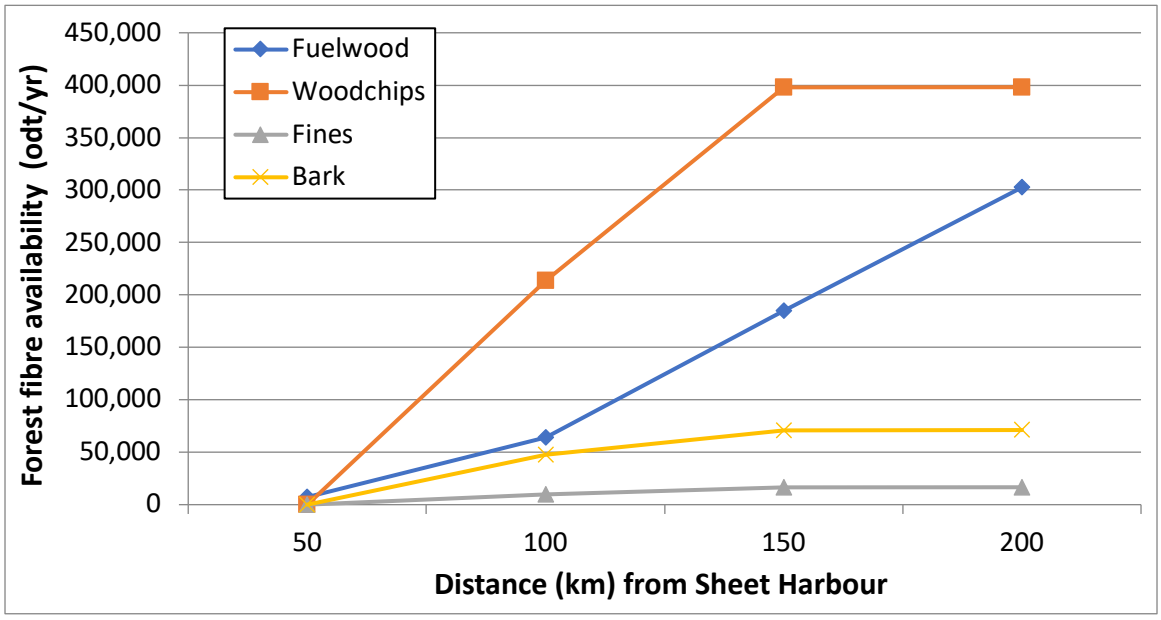


Figure 28. Forest fibre availability surrounding Sheet Harbour with Northern Pulp closed.

6-Port Hawkesbury

Port Hawkesbury is located in Richmond County, at the entrance to Cape Breton Island (on the southwest corner of Cape Breton) (Figure 29). The town of Port Hawkesbury, or more precisely the Point Tupper site, is home to the Port Hawkesbury Paper mill, which also houses the Nova Scotia Power 60 MW plant.

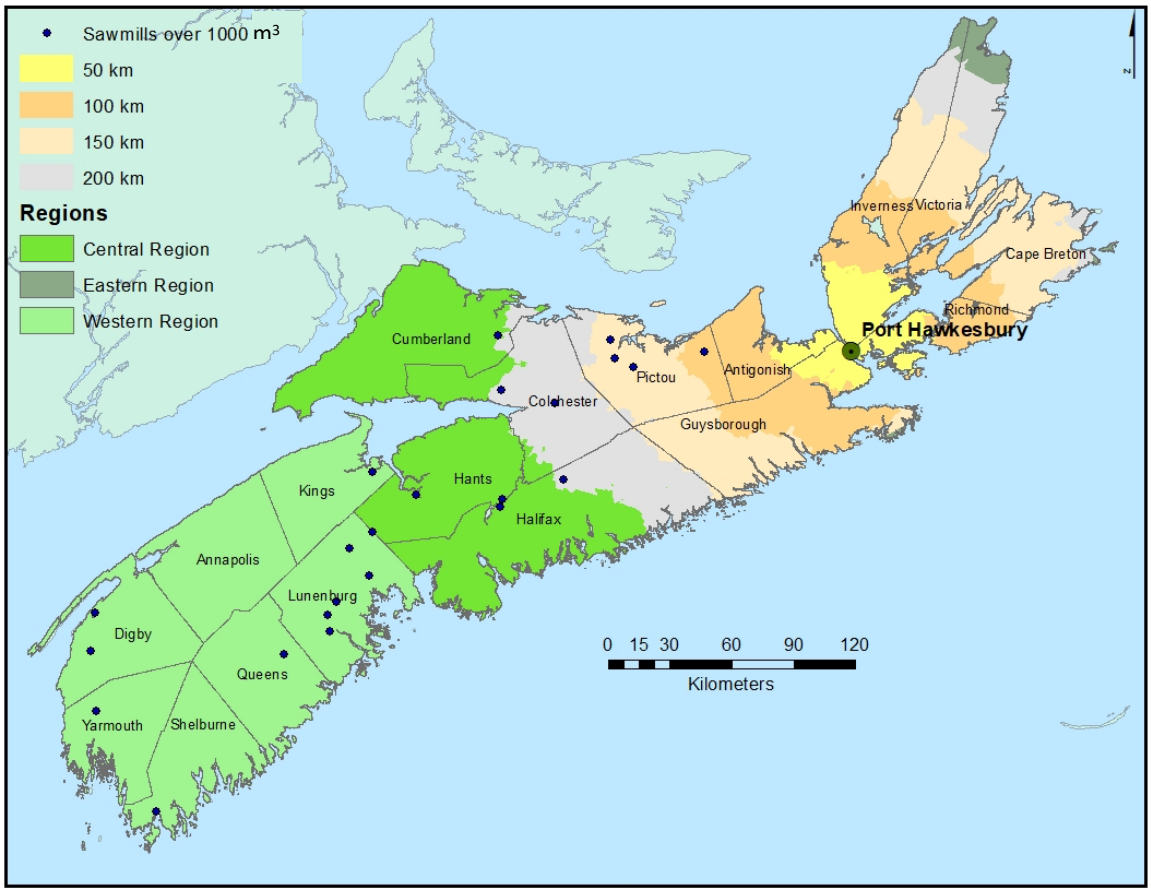


Figure 29. Road distances from Port Hawkesbury.

Scenario 1. With Northern Pulp operating

Fuelwood availability within 200 km of Port Hawkesbury amounts to 113 000 odt at an average delivered price of $103/odt. Mill residues available within 200 km of Port Hawkesbury represent 69% of the provincial total, or 160 000 odt at an average delivered price of $140/odt (Figure 30).

Port Hawkesbury has no sawmills consuming over 1000 m^3 within 50 km and only 1 within 100 km. In fact, 91% of available mill residues within 200 km of Port Hawkesbury is located over 150 km away. Port Hawkesbury is also a prime location for international shipping with ship docking facilities attached to the pulp mill in Point Tupper. There is also an interesting potential availability of fuelwood, with 126 700 odt available within 100 km.

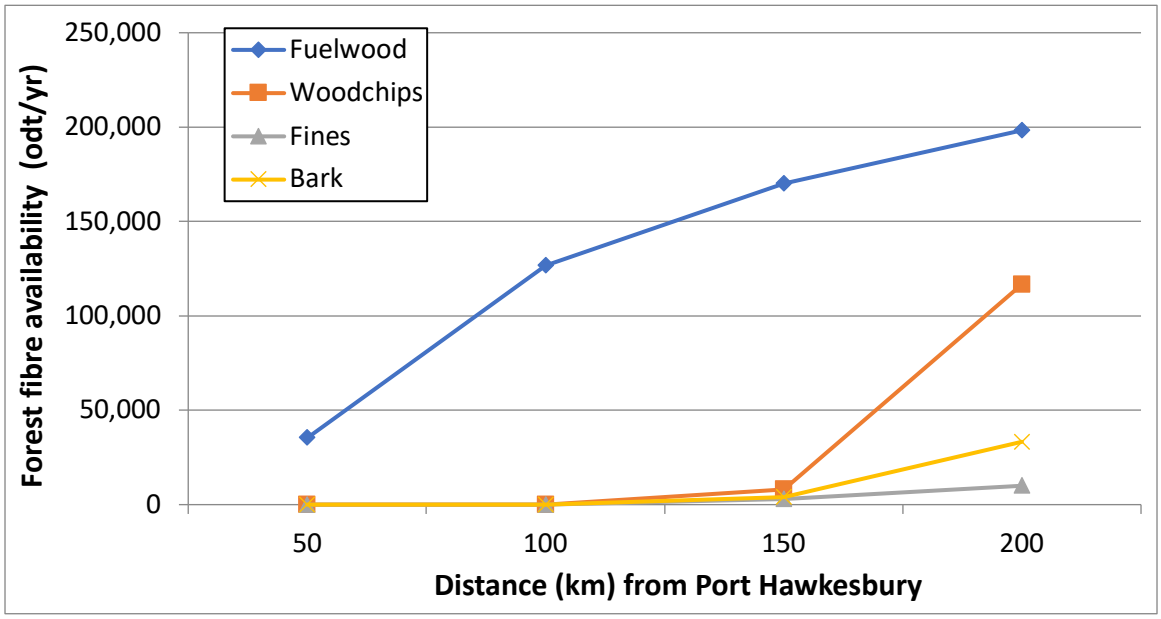


Figure 30. Forest fibre availability surrounding Port Hawkesbury with Northern Pulp operating.

Scenario 2. Without Northern Pulp

With Northern Pulp closed, fuelwood availability within 200 km of Port Hawkesbury amounts to 259 950 odt at an average delivered price of $94/odt. Mill residues available within 200 km of Port Hawkesbury represent 61% of the provincial total, or 365 050 odt at an average delivered price of $122/odt (Figure 31). There is a negligible amount of mill residues available within 100 km of Port Hawkesbury. Fifty-five percent of the fuelwood available within 200 km of Port Hawkesbury, or 144 200 odt, can be obtained within 100 km.

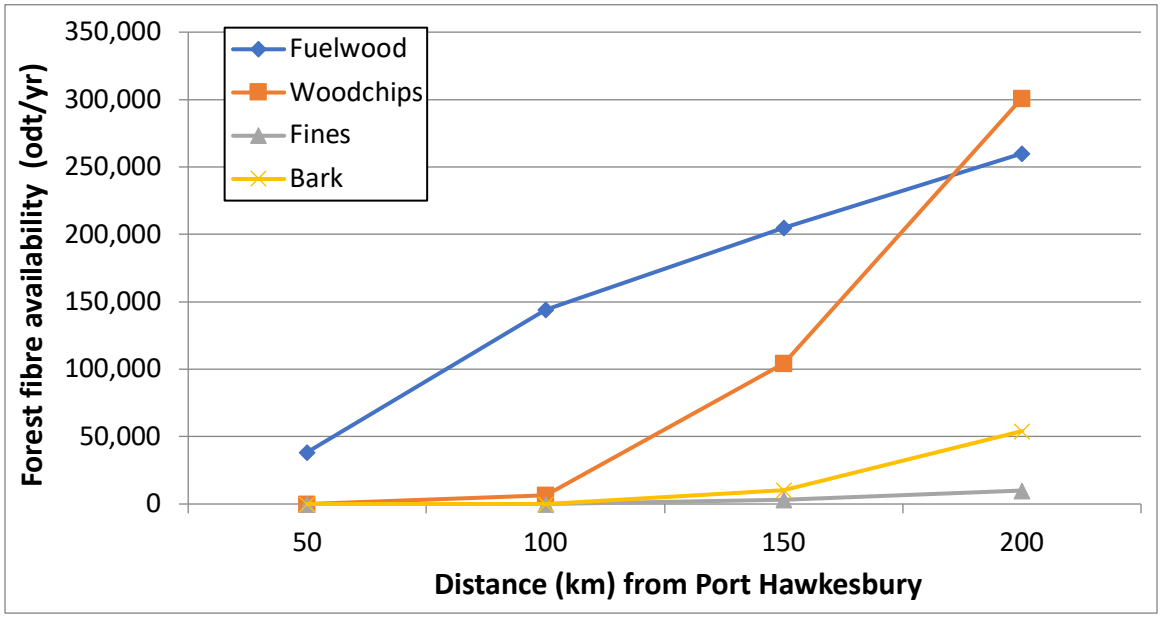


Figure 31. Forest fibre availability surrounding Port Hawkesbury with Northern Pulp closed.

FEEDSTOCK SUPPLY COST

The merchantable part of harvested trees consists of roundwood (logs) of different quality grades: sawlogs/studwood logs for lumber; pulpwood logs, panel board, firewood and high- quality hardwood veneer logs. Wood cost will vary depending on which type of product is harvested. Markets define what mills are ready to pay for logs of a certain quality. High-value logs like veneer and sawlogs can be transformed into high-priced products and sold with good profit margins. Those high-value logs have higher quality specifications to meet which makes them scarcer and more expensive to harvest. High-value logs will also tend to absorb a bigger portion of the harvest costs, allowing lower-quality roundwood to be sold at a lower price than the harvest cost.

There are two ways of presenting the feedstock cost elements in any supply analysis. The first is a pro forma–type analysis where the costs of the different steps in the supply chain are determined. This type of costing assumes that the mill is integrated in the supply chain (i.e., manages a woodland operation) and assumes costs for harvesting and infrastructure development and maintenance. It also assumes that overall value will be maximized by optimizing harvest practices to get the best product, at the right time, to the highest-valued end.

The second approach is market-based, in which the client mill sets prices but does not control the supply chain. With this approach, historical market fluctuations, current demand, and future outlook for a given product are used to determine pricing for specific feedstocks at the mill gate for a given volume and quality.

In this report, both costs analysis methods are presented to provide a better understanding of the elements included in the supply chain, but at the same time illustrate what markets look like compared to pro forma costing. Since multiple feedstocks will be compared in this section, cost information will only be presented in dollars per oven-dry tonne ($/odt) for consistency purposes. Conversions from $/$m^3$ to $/odt have been made using an average wood basic density of 500 kg/m^3 with a moisture content of 50%.

FPInterface pro forma analysis

Feedstock costs will vary according to, for example, the type of product harvested (saw logs, pulpwood, or fuelwood), the harvesting system, the silvicultural treatment (clear-cut, partial cut, or thinning), planning, supervision, overhead, and road maintenance. Cut-to-length (CTL) systems are used in the majority of harvest operations in Nova Scotia. CTL harvest systems operate either with a single-grip harvester/forwarder combination or with a feller-buncher with a single-grip harvester (processor) processing at the stump and a forwarder. The harvester/forwarder combination is the most popular system in the central and eastern regions, representing 75% of the volume. In the western region, the harvester/forwarder system is used in 60-70% of harvest operations on crown land while the feller-buncher/processor/forwarder system is used in about

80% of the harvest operations on private land. There is also a small amount of manual felling and skidding on small private woodlots. A wide variety of equipment brands and models operate throughout Nova Scotia. Most of the gear owned and operated by contractors today is old, although investments in new machinery have increased in recent years. For the costing analysis in this report, commonly used generic machines and productivity calculations used by FPInnovations' FPInterface costing model were used (FPInnovations, 2019). Scheduled operating hours applied to the calculations were provided by local experts around the province.

Transportation costs represent an important factor in the overall supply cost (Table 11). Roundwood transport represents between 20% (at 50 km) to 35% (at 200 km) of delivered feedstock costs. In this analysis, roundwood deliveries are done using log trucks and a stumpage or producer fee is applied. Different truck configurations are used across the province to haul logs to sawmills, therefore local experts were consulted, and a weighted average trucking cost was determined. A more detailed analysis can be found in Appendix 4.

Table 11. Roundwood transportation costs as a function of distance with typical truck configurations used in Nova Scotia.

Distance	Transport cost ($/odt)
50 KM	21.34
100 KM	30.35
150 KM	39.75
200 KM	48.16

The roadside costs presented below do not include transport costs to deliver the feedstock to the customer ($30/odt at 100 km). A detailed assessment per costing element is presented in Appendix 4. Road accessibility has a large impact on total supply costs. Sectors with low road penetration will require higher infrastructure development costs compare to highly developed portions of the province.

Market conditions will tend to shift harvesting costs more heavily onto the most valuable products. As a result, pulpwood will only cover a small portion of the overhead costs and thus, for the same transportation distance, pulpwood should be a less expensive source of fibre than sawlogs. The analysis will not attempt to distribute the cost amongst the products harvested, since this differs for every site. It will be assumed that only one product is harvested per cut block, providing a single roundwood harvest cost (Table 12). Fuelwood costs should be similar to pulpwood costs. The only less expensive element for fuelwood is the stumpage or owner profit. The stumpage fees for fuelwood range from $6-$10/odt while pulpwood stumpage ranges from $6-$28/odt (Hardwood $20-$28/odt; Spruce/Fir $16-$20/odt; other softwood $6-$10/odt). The stumpage fees or owner profit used in this costing analysis were set at $15/odt.

Harvesting, transportation, and other costs should be about the same for private forests as for public lands. Stumpage fees on Crown lands are replaced by owner profit in private forests.

Stumpage fees account for between 6% and 16% of the total supply cost for softwood pulpwood. Hardwood pulpwood stumpage, at $20-$28/odt, represents 16% to 22% of the wood supply cost (at 100 km transport distance).

It is important to note that private forest producers tend to work with older equipment than that considered in the present analysis, with possibly lower hourly operating rates and higher maintenance and repair costs. It is also worth recalling that the price paid for the material are subject to supply and demand and will vary with market conditions.

Table 12. Supply cost breakdown for roundwood harvested in clearcuts and partial cuts with two different harvest systems.

Activity	$/odt			
	Clearcut		Partial Cut	
	Harvester	Buncher/Processor	Harvester	Buncher/Processor
Felling	34.6	12.7	37.3	15.2
Processing	-	26.5	-	27.4
Forwarding	18.9	18.9	24.3	24.3
Stumpage fees[b]	15.0	15.0	15.0	15.0
Other related costs[a]	17.1	17.1	17.1	17.1
Total[b]	**85.7**	**90.3**	**93.8**	**99.1**

[a] Overhead, planning, supervision, road maintenance; Transport costs need to be added. Costing parameters used in FPInterface can be found in Appendix 4.

[b] Stumpage rates are for pulpwood/fuelwood

Markets value analysis

A market-based approach to determine wood value is more realistic for the present study because even though it might cost a certain amount to harvest and deliver wood to a mill, final prices are set by market conditions and what mills are willing to pay. Private woodlot owners follow market trends and respond to the dynamic highs and lows of the lumber market. This influences their decision to harvest and what to cut, which is largely determined by the sawlog market. Where low-grade fibre markets do exist, woodlot owners will take this opportunity to harvest pulpwood/fuelwood, in addition to their sawlog volume. However, due to the closure of the Northern Pulp mill, market prices have decreased for both low-grade roundwood and mill by-products.

What the market is willing to pay

H.C. Haynes Inc. is a company that operates as a wood broker and wholesaler, buying and selling wood to forest companies across Nova Scotia. They maintain a list of rates and specifications established by forest companies that is used here as an accurate representation of market values for roundwood products. In addition, local experts provided regional market prices to establish a provincial average for roundwood and mill by-products, before and after the Northern Pulp's

closure (Table 13). After the closure, pulpwood and fuelwood demand decreased but prices in eastern Nova Scotia decreased only slightly. However, western Nova Scotia had no market for any softwood pulpwood/fuelwood or hardwood fuelwood, meaning it was left in the woods. Mill residue prices have decreased significantly due to oversupply and low demand (Table 14). Mill residues such as chips traditionally purchased FOB for $90-$104/odt now sell for $70-$82/odt. Fines (sawdust and shavings) normally purchased for $70/odt now sell for $30/odt and bark which normally sold for $24-$28/odt now sells for between $6-$26/odt. All prices shown assume that roundwood costs includes delivery while mill by-products are FOB.

Table 13. Roundwood availability and costs; 2015 and 2020

Products	Quality	2015		2020 - Northern Pulp Open		2020 - Northern Pulp Closed	
		Available volumes (odt)	Market prices ($/odt)[a]	Available volumes (odt)	Market prices ($/odt)[a]	Available volumes (odt)	Market prices ($/odt)[a]
Softwood fibre	Pulpwood/ Fuelwood	195 000	95-120/80-100	215 000	116-136/64-80	360 000	116[b]/80[b]
Hardwood fibre	Pulpwood/ Fuelwood	665 000	95-120/80-100	345 000	96-110/64-84	465 000	104-110/80[b]

[a] Delivered roundwood price. Additional comminution is required at $10-$20/odt.
[b] No market in the western region. Prices reflect the central and eastern regions.

Table 14. Mill by-product availability and costs; 2015 and 2020

Products	Quality[b]	2015		2020 - Northern Pulp Open		2020 - Northern Pulp Closed	
		Available volumes (odt)	Market prices ($/odt)[c]	Available volumes (odt)	Market prices ($/odt)[c]	Available volumes (odt)	Market prices ($/odt)[c]
Softwood fibre	Wood chips	110 000	65-110	111 000	90-104	436 000	70-82
	Fines[a]	30 000	45-65	35 000	70	35 000	30
	Bark	35 000	30-60	4 000	24-28	39 000	6-20
Hardwood fibre	Wood chips	15 000	70-100	14 000	90-104	21 000	70-82
	Fines	5 000	50-70	3 000	70	3 000	30
	Bark	8 000	35-60	5 000	28	5 000	14-26

[a] Sawdust and shavings
[b] Mill by-products availability for wood chips, fines and bark with sawmills operating at full capacity
[c] FOB prices (add $30/odt for a transportation of 100 km)

CONCLUSION

Feedstock availability, cost, and competitive demand are the three main drivers to determine the viability and best possible locations for new bioeconomy processing plants in Nova Scotia. The closure of the Northern Pulp facility and the implementation of the Lahey Report will have the greatest impact on fibre availability moving forward. While it is uncertain exactly what effect the Lahey Report will have on the forest industry in Nova Scotia, it is estimated that it will lead to a reduction of 10%-20% of the sustainable wood supply on Crown land (72 000 odt to 144 000 odt). Fibre availability, with and without Northern Pulp in operation, indicates potential viability of wood bioeconomy facilities given the two scenarios. With Northern Pulp operating, there is an overall availability of 560 000 oven-dry tonnes (odt) of pulpwood/fuelwood annually increasing to 825 000 odt if Northern Pulp remains closed.

If Northern Pulp does indeed remain closed, an additional 265 000 odt of roundwood fibre will be available every year and a surplus of 263 000 odt of mill by-products will be available in the province at current sawmill operating rates. If Northern Pulp re-opens, there would be a total provincial deficit of about 60 000 odt of mill by-products (some pulp chips would need to be imported, as was the case before 2020). A sustained strong lumber market with all sawmills operating at full capacity would yield an additional 230 000 odt of mill residues in both scenarios.

Pulpwood and fuelwood demand has decreased since Northern Pulp's closure. However, prices have only slightly decreased in central and eastern Nova Scotia. Conversely, western Nova Scotia's market for softwood pulpwood/fuelwood and hardwood fuelwood disappeared, prompting harvest operations to leave this volume in the woods. Mill residue prices have decreased significantly due to oversupply and low demand. Mill residues such as chips traditionally purchased FOB for $90-$104/odt now sell for $70-$82/odt. Fines (sawdust and shavings) normally purchased for $70/odt now sell for $30/odt and bark which normally sold for $24-$28/odt now sells for between $6-$26/odt.

The amount of mill residues potentially available assumes a strong lumber market where the 24 sawmills consuming over 1000 m^3 operate at full capacity. Six potential forest bioeconomy investment locations were evaluated based on fuelwood and mill residue availability and delivered cost under scenarios in which the Northern Pulp mill either re-opens or not.

In the scenario with Northern Pulp re-opened, Greenfield and Port Hawkesbury have the lowest average fuelwood cost ($104/odt and $103/odt) within 200 km because of an abundant supply located within 50 km (59 200 odt and 35 350 odt). Enfield has the highest availability of mill residues within 50 km (60 500 odt) and the lowest overall average cost ($114/odt) within 200 km.

With Northern Pulp remaining closed, Greenfield and Port Hawkesbury again have the lowest average fuelwood cost ($94/odt). Greenfield, Enfield, and Trenton show promising mill residue volumes available within 50 km with 108 550 odt, 134 950 odt, and 117 600 odt, respectively. This is because of their proximity to large sawmills historically supplying Northern Pulp with chips.

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APPENDIX 1

Forest industry trends

Since 2014, harvest levels have been steady in the three land ownership categories.

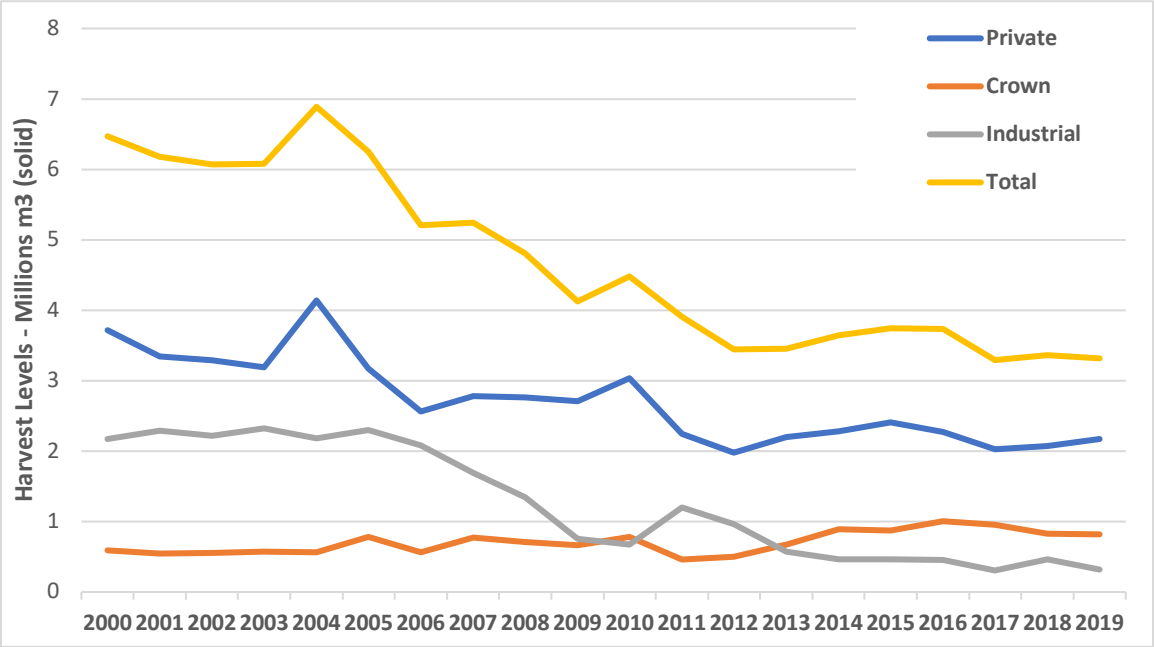

Figure A1. Historical harvesting levels by land ownership from 2000-2019.

The sawmill sector has historically been the major economic driver of the forest industry in Nova Scotia. The pulp and paper sector, while representing an average of 33% of the total harvest since 2007, dropped in 2020 with the closure of the Northern Pulp mill. Bioenergy generation has been tracked since 2012 and has represented an average fibre consumption of 5% of the total harvest since that time.

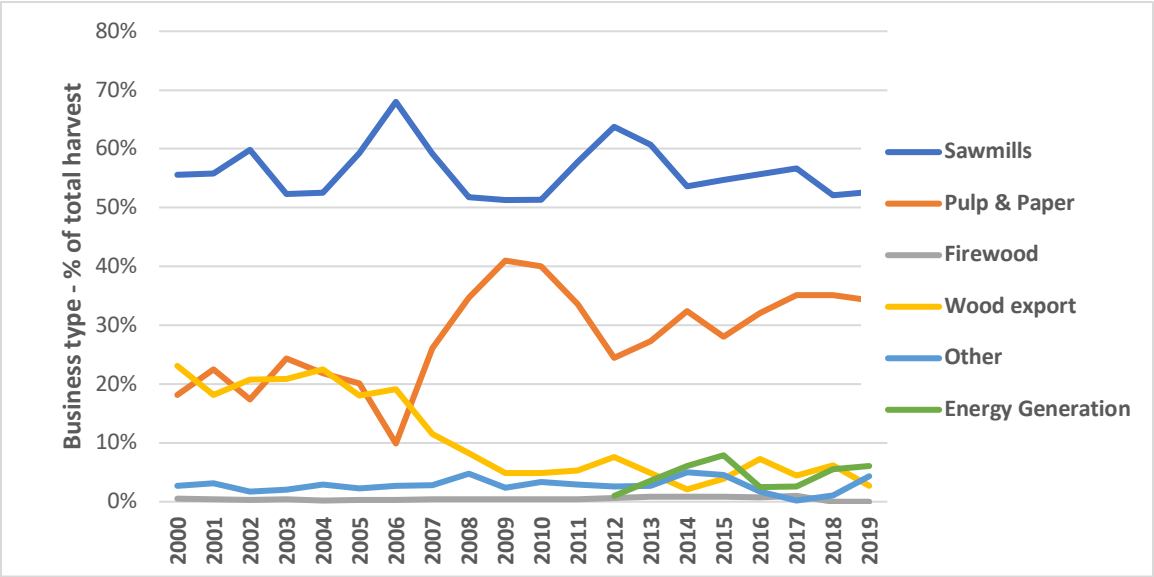

Figure A2. Proportion of wood fibre use per business type from 2000 to 2019.

Sawmill production has seen an almost 70% increase in production since 2014 despite a drastic reduction in the number of smaller sawmills (purchasing less than 1000 m^3) from 75 in 2014 to only 47 in 2019. The increase in production reflects the larger sawmills having increased their production. The 5 largest sawmills account for almost 90% of the province's total lumber production.

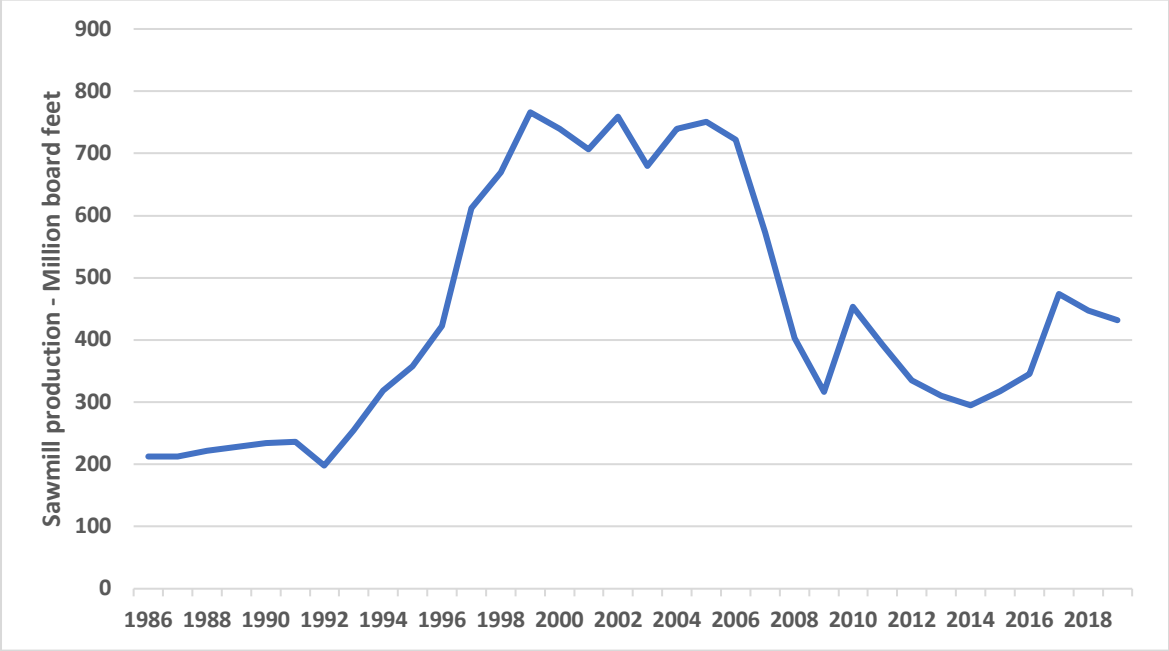

Figure A3. Sawmill production levels from 1986 to 2019.

APPENDIX 2

Wood supply

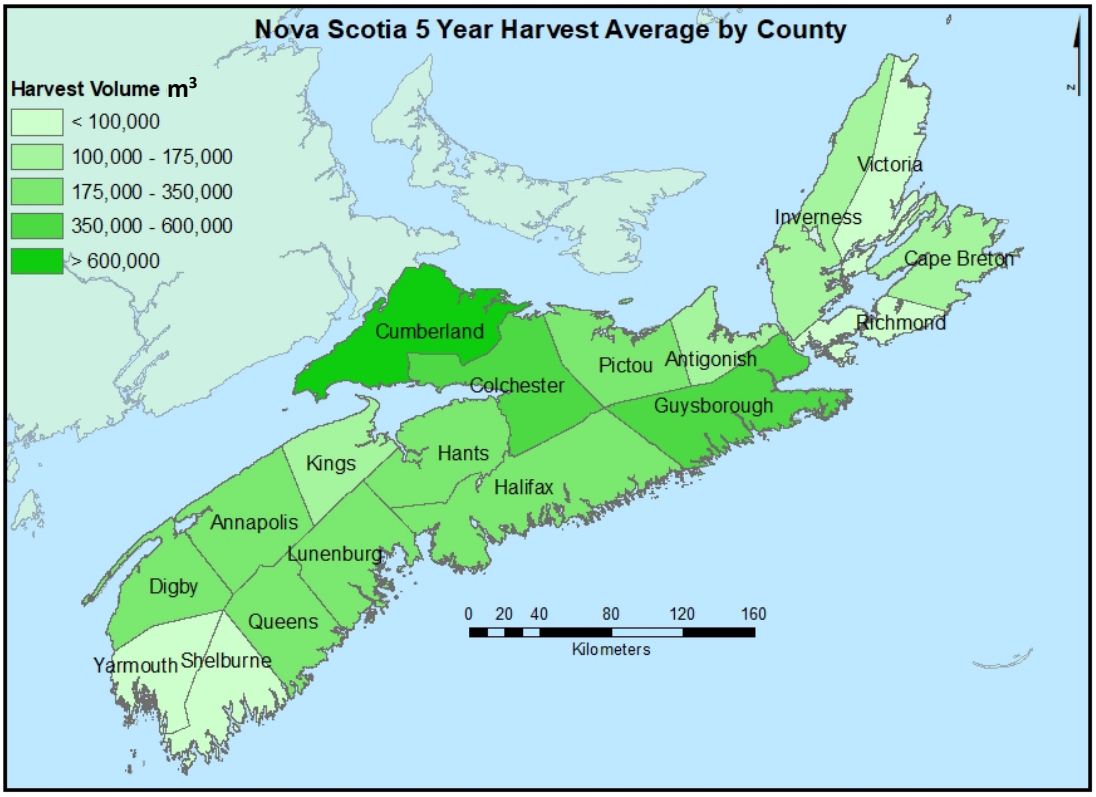

Figure A4. Average 5-year harvest by county (m^3).

Table A1. Available volume by county with and without Northern Pulp operating (odt)

Region	County	With Northern Pulp			Without Northern Pulp		
		SWD	HWD[a]	Total	SWD	HWD	Total
Central	Colchester	31,750	-6,009	**25,741**	49,900	9,600	**59,500**
	Cumberland	47,700	-21,048	**26,652**	76,600	15,600	**92,200**
	Hants	20,850	-6,300	**14,550**	33,050	2,950	**36,000**
	Halifax	43,450	-2,387	**41,063**	65,200	6,500	**71,700**
	Pictou	27,350	-10,125	**17,225**	44,000	4,400	**48,400**
Eastern	Antigonish	12,200	47,250	**59,450**	18,200	52,050	**70,250**
	Cape Breton	12,950	8,450	**21,400**	12,950	8,450	**21,400**
	Guysborough	36,050	67,500	**103,550**	41,600	75,650	**117,250**
	Inverness	13,550	27,800	**41,350**	13,550	27,800	**41,350**
	Richmond	9,300	3,000	**12,300**	9,300	3,000	**12,300**
	Victoria	8,200	3,750	**11,950**	8,200	3,750	**11,950**
Western	Annapolis	53,800	32,150	**85,950**	61,200	37,850	**99,050**
	Digby	36,350	12,050	**48,400**	43,350	13,000	**56,350**
	Kings	17,150	27,400	**44,550**	20,550	31,950	**52,500**
	Lunenburg	44,850	28,300	**73,150**	52,800	33,100	**85,900**
	Queens	74,550	19,850	**94,400**	83,050	24,150	**107,200**
	Shelburne	9,650	1,700	**11,350**	10,950	2,150	**13,100**
	Yarmouth	14,850	11,250	**26,100**	16,900	11,600	**28,500**

[a] Negative values reflect the addition of 450 000 m^3 of harvested firewood to all counties on a weighted basis.

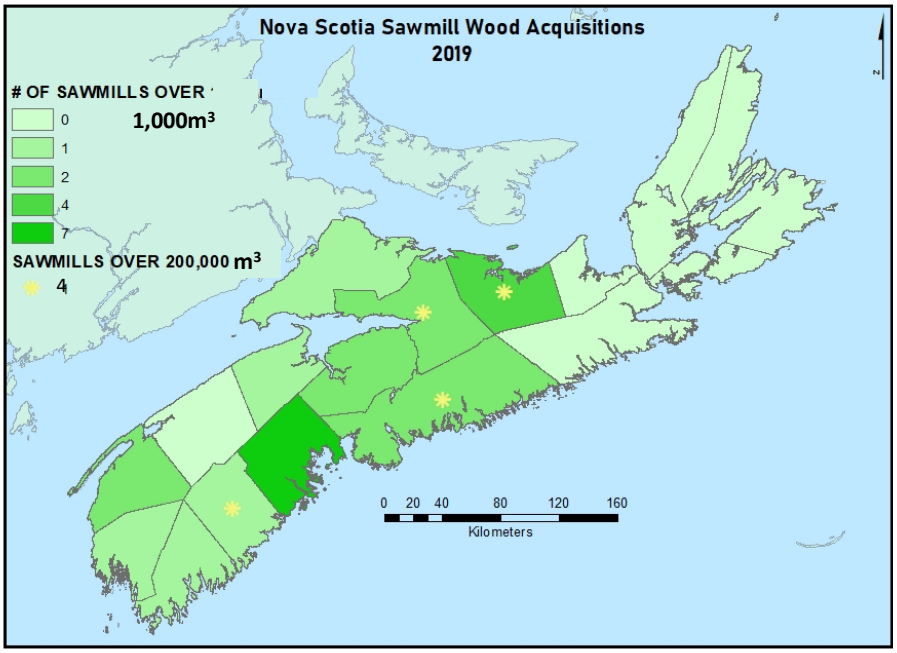

Figure A5. Sawmill wood consumption in 2019 (m^3).

Table A2. Provincial secondary forest product volume produced between 2015-2019 (m^3)

Secondary Products	2015	2016	2017	2018	2019
Firewood/Slabwood	56,313	53,810	56,555	44,805	48,649
Fuel-Energy chips/ Pellets	111,211	97,771	24,485	67,825	106,688
Baskets/ Components cutting boards/ Flooring/ Fruit boxes/ Mouldings	968	10,252	1,002	1,044	8,100
Hog fuel	292,066	260,031	391,663	380,130	363,864
Sawn products	996,272	1,105,906	1,125,439	1,041,255	1,016,461
Pulp/Paper/Hardboard	625,739	634,181	628,192	646,126	569,415
Poles/Posts/Pilings/House logs/Railway ties	7,912	5,704	6,653	6,228	4,273
Shavings	53,715	65,786	66,378	63,593	68,183
Sawdust	106,548	101,473	61,541	88,432	88,295
Bark/Bark mulch	2,229	55,071	55,206	58,810	44,661
Pulp Chips	798,123	787,923	882,113	743,844	418,317

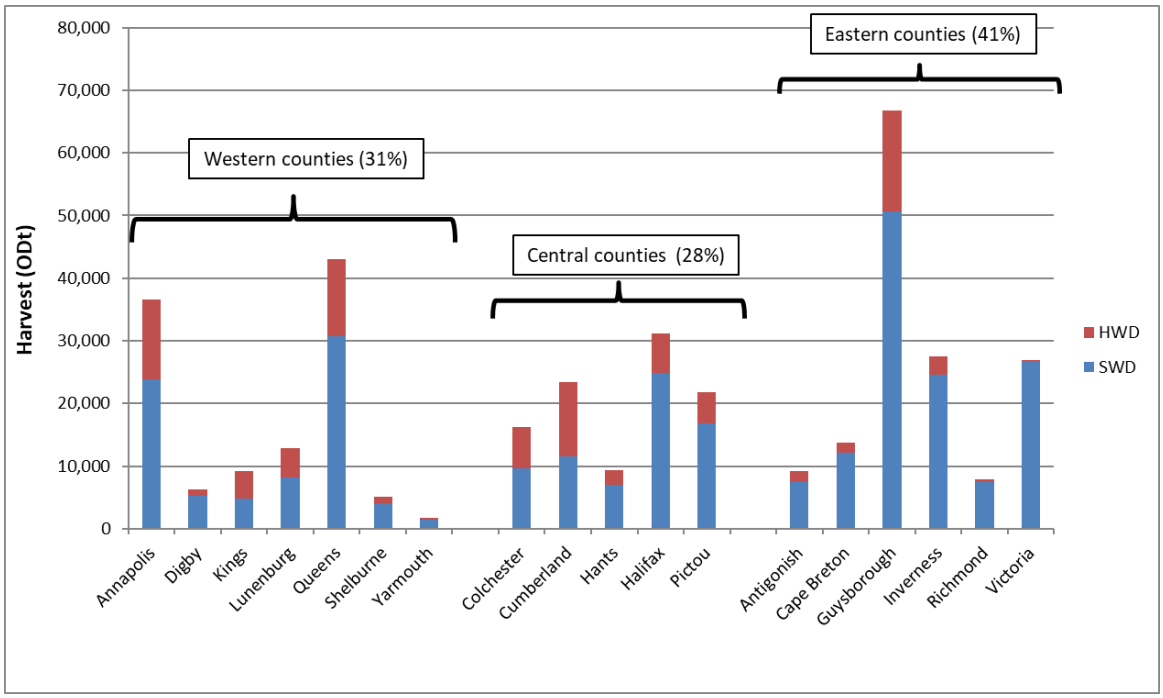

Figure A6. Average annual harvest (2015-2019) on Crown lands by region.

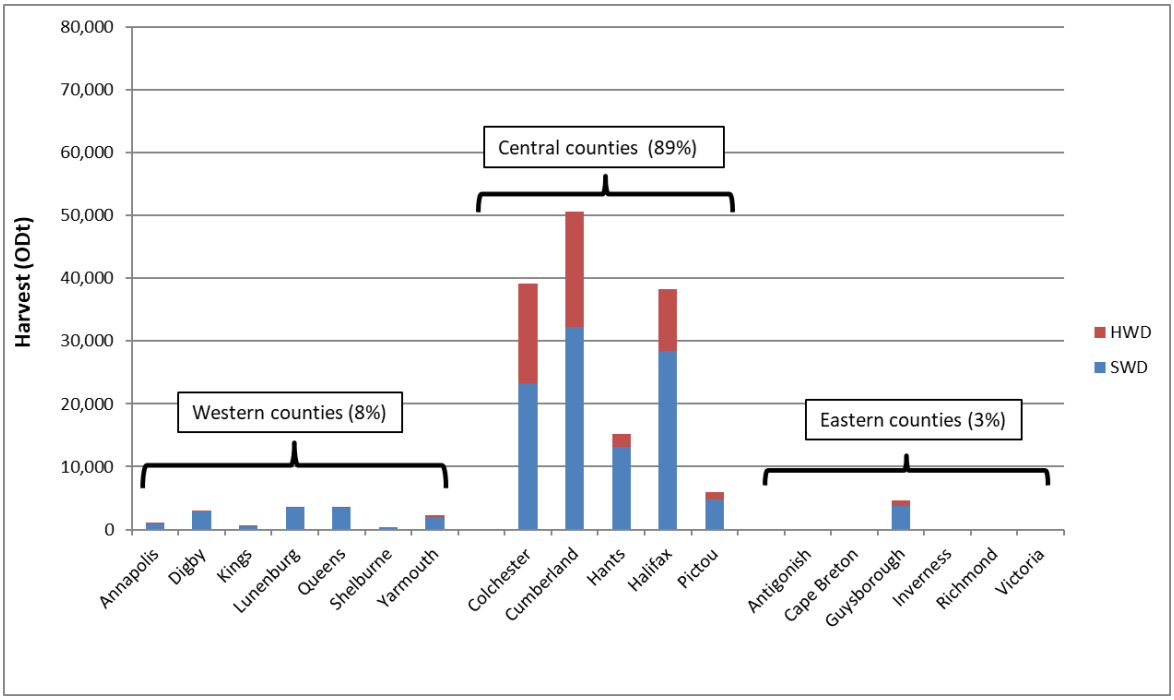

Figure A7. Average annual harvest (2015-2019) on Industrial lands by region.

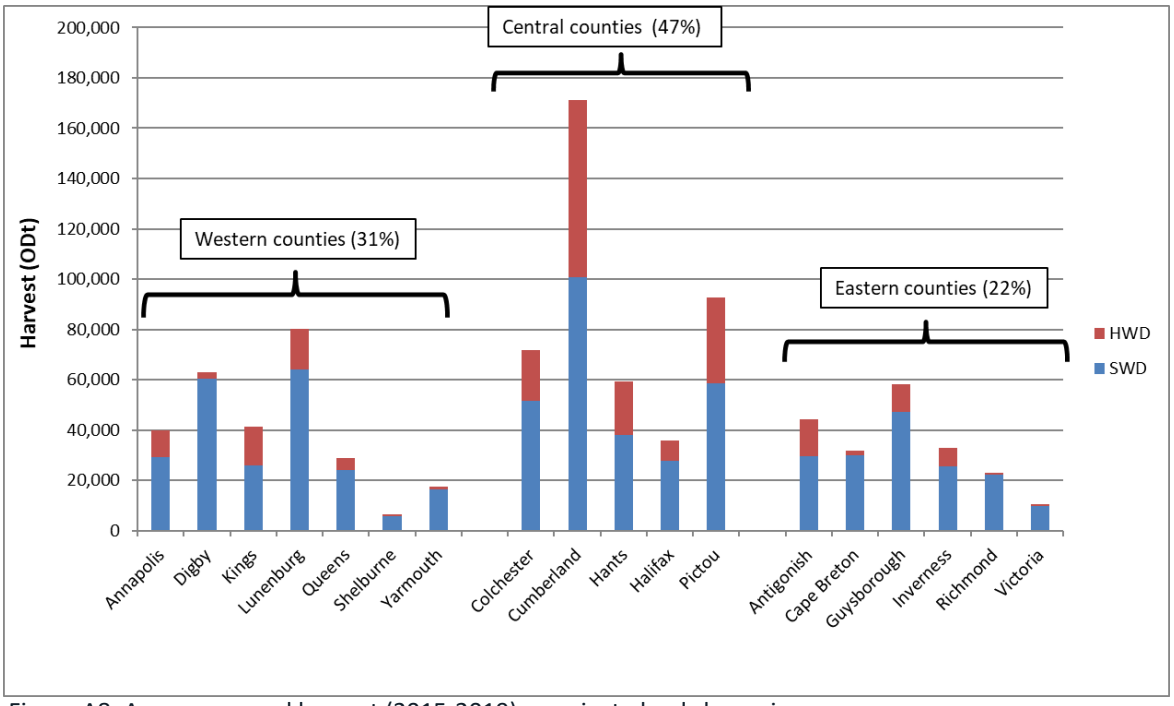

Figure A8. Average annual harvest (2015-2019) on private lands by region.

APPENDIX 3

Distances to potential bioeconomy locations

Table A3. Distances from sawmills to potential forest bioeconomy investment locations

SAWMILL	Distance (km)					
	Greenfield	Kaizer Meadows	Enfield	Sheet Harbour	Trenton	Port Hawkesbury
J.D. Irving Sproule Lumber	213.8	137.5	65.2	89.6	55.2	167.7
Nova Tree Company	228.1	148.9	79.5	119.1	83.4	195.9
Vernon Sprague and Sons	254.3	175.1	105.8	145.3	85.1	199.9
A.F.T. Sawmill Ltd.	150.8	212.7	279.3	372.4	368.3	480.8
Lewis Mouldings & Wood Specialties Ltd.	127.4	188.3	254.8	348.0	343.8	456.3
Ledwidge Lumber Company Ltd.	149.7	101.1	0.2	106.5	118.0	230.5
F.W. Taylor Lumber Ltd.	183.8	129.1	41.0	65.8	87.3	194.1
Elmsdale Lumber Company Ltd.	153.3	98.7	4.8	101.6	113.1	225.6
E & M Burgess Enterprises Ltd.	123.2	40.5	60.7	153.8	149.7	262.2
S. G. Levy & Sons Ltd.	131.9	56.4	89.6	182.7	178.6	291.1
Elmer Lohnes Lumbering Ltd.	29.7	57.5	119.9	213.9	236.7	347.9
Turner and Turner Lumber Ltd.	35.5	58.0	120.4	214.4	237.2	348.4
J. A. Turner & Sons (1987) Ltd.	35.4	58.1	120.5	214.5	237.4	348.5
Maurice Bruhm Ltd.	47.4	52.3	114.8	208.8	231.6	342.7
Millett Lumber	69.1	20.1	90.9	184.9	205.8	318.3
L.E. Elliott Lumber Ltd.	99.3	24.0	93.6	186.8	182.6	295.1

SAWMILL	Distance (km)					
	Greenfield	Kaizer Meadows	Enfield	Sheet Harbour	Trenton	Port Hawkesbury
Lester D. Collicutt Forest Products	83.7	36.4	108.1	202.1	198.3	310.7
Groupe Savoie Inc., Westville Division	260.6	184.9	112.6	89.4	12.6	122.8
Dave's Lumber Ltd.	250.2	173.9	101.7	99.0	18.3	130.9
Williams Brothers (1986) Ltd.	295.8	219.6	147.3	123.5	33.9	85.3
Scotsburn Lumber Ltd.	257.5	181.3	109.0	108.9	24.7	139.6
Harry Freeman & Son Ltd.	0.9	87.1	149.5	243.5	266.4	377.5
Thomas Scott Lumbering Ltd.	127.4	195.7	258.1	352.1	375.0	486.1
Churchill Lumber	177.7	240.7	308.1	401.3	397.1	509.6

APPENDIX 4

Forest feedstocks costing pro forma

Generally, default values for harvesting production and costs were used to run the costing model in FPInterface. However, some parameters were modified to better reflect local conditions in Nova Scotia (Table A4). These values were applied equally to all harvest equipment based on information provided by local experts.

Table A4. Customized parameters in the FPInterface harvesting model.

Parameter	Value
Scheduled hours/day	11
Shifts/day	1
Fuel price	1.1 $/L

Different trucking configurations are used to transport roundwood across the province. To establish a weighted average cost, the model was run multiple times using different configurations (Table A5). Some parameters were also changed in the model (Table A6).

Table A5. Roundwood transport costs with different truck configurations ($/m^3)

Distance	Truck-trailer configuration		
	4-axle trailer	3-axle trailer	B-train
0-50km	6.01	6.43	5.48
51-100km	10.25	10.91	9.32
101-150km	15.01	15.93	13.68
151-200km	19.64	20.82	17.91

Table A6. Customized parameters in the FPInterface trucking configurations

Parameter	Value
Scheduled hours/day	14
Shifts/day	1
Fuel price	1.1 $/L

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