Forest-based Circular Bioeconomy in Newfoundland and Labrador

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We acknowledge that the lands on which this document was developed are situated are in the traditional territories of diverse Indigenous groups, and we acknowledge with respect the diverse histories and cultures of the Beothuk, Mi'kmaq, Innu, and Inuit of this province

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EXECUTIVE SUMMARY

A paradigm shift towards new economies ('green', 'digital', and 'blue') aimed at sustainability and innovation is rapidly underway. Within the framework of the green economy, the circular bioeconomy represents a catalyst for systemic change, offering a means to address many of the economic, social and environmental challenges faced by society.

In its 2020 bioeconomy pathway report the Newfoundland and Labrador Forest Industry Association (NLFIA), provided a review of the 'bioeconomy' and discussed the increasing demand for renewable, bio-based raw materials. The report also reviewed regional and global trends in the development of the forest-based bioeconomy as a means of meeting sustainability goals (Bowers, 2020). As a follow up to the pathway report, the current project specifically addresses how the Newfoundland forest industry is forging a path to clean, green growth through development of a 'circular bioeconomy'. To ensure that growth is sustainable and equitable, research was systematically directed to identifying opportunities and challenges faced by the Newfoundland and Labrador (NL) forestry sector. It is recognized that to remain productive and competitive, forest-based industries must accelerate innovation, be forward thinking in the use of wood fibre, and effectively leverage biomass supply chains. Likewise, the need for diversification of the economy and sustainable approaches to economic development are considered critical to NL. Like many areas of Canada, the forest sector in NL is in transition and committed to a low-carbon, highly innovative and sustainable future. The current research supports a more resilient sector encompassing partnerships, stakeholder engagement, and capacity building.

The importance of skills, training, and workforce capacity in unlocking the economic and wider benefits inherent to the province have been acknowledged in government policy, industry, and academia. Promoting education, training and skills across the emerging circular bioeconomy offers potential to unlock the creativity and energy of many Newfoundland citizens. Mainstreaming of the green economy in the province's education system would represent a meaningful first step. Particular attention is given to workforce issues, the future role of PSEs, as well as research and development, all of which can foster development of a forest-based circular within the province. Ultimately, this research seeks to better position the forest sector in promoting economic growth, forest sustainability, social inclusion, and the preservation or improvement of livelihoods.

While different pathways toward an expanded circular exist, there are common steps that will be required by regions and sectors for economic success.

I JUSTIFICATION AND OVERVIEW OF NLWIC PROJECT

Research Objectives

The forestry industry has been an important part of the province's history—evolving from a largely extraction-based industry to a modern focus on sustainability, conservation and protection of forest resources and, in more recent decades, recognition of cultural, spiritual and environmental values. The forest industry has traditionally focused on pulp and paper and wood products. This focus misses higher value products such as medical (e.g., antifungals and antimicrobials), materials (insulation, biopolymers), biochemicals (fire retardant coatings, corrosion inhibition, replacement for petrochemicals), and inter-industry synergies and collaboration opportunities.

NL has seen a significant reduction in forest sector jobs in recent years (NRCAN, 2017). In addition to the cyclical problems encountered by the industry, pending labor shortages linked to the continued decline of working-age residents and to skill shortages continue to challenge the sector. Embracing diversity and inclusion will help meet this challenge but in the near-term forest sector workforce issues in the province are expected to limit the sector's ability to innovate and take full advantage of the emerging green economy. Moreover, uncertainty around revised tariffs on Canadian newsprint imports is causing enormous challenges related to maintaining and expanding international forest product markets in NL. More encouraging for innovators however, there is currently a surplus of available harvest in the province due to reduced production in the newsprint and sawmill industry. In response, the forest industry in NL has been searching for ways to develop the bioeconomy in ways that increase skilled jobs in the sector. The province's Forest Sector Workplan, "The Way Forward on Forestry" was published in 2019 focusing on NL's great potential to diversify the forest sector and develop a dynamic and sustainable sector supporting economic growth and job creation.

Given the potential of a forest-based circular bioeconomy to foster greater resilience in rural Newfoundland and Labrador through economic and workforce expansion and diversification, the

Newfoundland and Labrador Workforce Innovation Centre (NLWIC) provided funding for a three-year research project focused on assessing Newfoundland's forest-based bioeconomy potential.

A collaborative research team comprised of forest industry representatives and researchers and graduate students from Memorial University and College of the North Atlantic was formed and set out to answer the following research questions and sub-questions:

- What opportunities exist in the area of employment diversification for a forest-based bioeconomy in NL?
    - What bioeconomy applications are best suited for NL?
    - What jobs are likely to become available through bioeconomy development?
    - How do we attract and foster the participation of underrepresented groups, including women, indigenous peoples, and youth to these new jobs?
- What opportunities exist in the area of product development, network, and procurement processes for forest-based bioeconomy in NL?
- How can we prepare the forest sector in NL for opportunities in bioeconomy development?
    - What transformative technologies are required?
    - What new skills and training are required for bioeconomy jobs?
    - How can we best provide skills and training necessary for bioeconomy development?
    - Do training programs exist currently or are changes/new programs needed?

In pursuit of these questions, the following overarching research goals were identified:

1. Investigate the current state of the forest-based bioeconomy in NL
2. Identify the most promising opportunities for diversification, adaptation and development
3. Suggest ways in which the forest sector can innovate and prepare for changes in required technologies, products, training and skill development
4. Begin knowledge mobilization of research results
5. Inform future sector research and strategy development.

Based on the goals, the research team established operational objectives which were used to guide information and data collection for the study. The five resulting operational or sub-objectives were identified as follows:

- Determine aspirations among forest industry leaders for a bioeconomy transition and consequent partnerships
- Identify relevant stakeholders and partners interested in fostering the forest-based bioeconomy transition
- Solicit bioeconomy opportunities (e.g., product and workforce diversification) and champions
- Identify regional and intraregional challenges and barriers to a bioeconomy transition
- Provide recommendations for addressing challenges and fostering the bioeconomy transition

In addition to the lead research team[1], the following community collaborators were engaged to help guide the research: Women in Resource Development Corporation (WRDC), Econext (formerly the Newfoundland and Labrador Environmental Industry Association), Qalipu First Nation, and the provincial Department of Fisheries, Forestry, and Agriculture.

II. INTRODUCTION

Background

In 2018-19, in collaboration with the recently formed Newfoundland and Labrador Industry Association (NLFIA) and other stakeholders, the NL government, through the Cabinet Committee on Jobs, produced a work plan to support economic growth and foster private sector job creation. The plan offered several opportunities to diversify the province's forestry sector and called for stakeholders to collaborate in advancing the 'green' economy. In their reviews, McKinsey (2019), Bowers (2020), and Newfoundland and Labrador (2021), further emphasized 'green' opportunities, most notably those associated with an emerging circular bioeconomy.

Although potential benefits for the province exist, a number of uncertainties and challenges must be addressed if the province is to advance development of a forest-based bioeconomy. Among the most important challenges faced by the sector is the need to identify future skill

[1] Members of the lead research team included Dr. Stephen Decker, Grenfell Campus of Memorial University; Mr. Bill Dawson, Newfoundland and Labrador Forest Industry Association (NLFIA); Dr. Wade Bowers, Barnett Clarke Associates; Dr. Kelly Hawboldt, Faculty of Engineering Memorial University; Dr. Ken Carter / Dr. Mery Perez, Grenfell Campus Office of Engagement; Mr. Brent Howell, College of the North Atlantic; Mr. Carl Noseworthy, NLFIA; Mr. Lucas Garcia; PhD student in Transdisciplinary Sustainability at Grenfell Campus.

sets, and to recruit, train and retain new workers. Moreover, historically the industry has been male dominated, a condition that is inherently limiting. Work is needed to identify strategies and guidelines for implementing policies and procedures that will increase youth and women's participation and advancement in the forest sector. Future potential exists through the development of novel products that will help move the sector from simply productivity (based on sawlogs and pulp) to value. That is, there is potential in the province to focus on value-added products, thereby diversifying the product line of current mills. For example, there is high potential for the forest products industry to use its waste and residues to produce new products and to make electricity and heat for its own operations and for new joint-venture enterprises. These developments could have a positive impact on job creation and indirectly help address the province's demographic challenges.

To take advantage of forest-based bioeconomy opportunities and to advance economic growth and create sustainable employment, the Newfoundland and Labrador Workforce Innovation Centre (NLWIC) funded a research project in 2019 to increase awareness of the circular bioeconomy, and to seek opportunities to promote the province's economic stability and competitiveness. The project, led by NLFIA in collaboration with Memorial University, and the College of North Atlantic, specifically examined opportunities and barriers to the development of a forest-based circular bioeconomy in the province. The project also called for increased collaboration as a means to achieving the province's sustainability goals.

Status of Forest Industry in Canada

Canada has approximately 10 % of the world's forests and 30 % of the world's boreal forests. (Nilsson, 2015). The sector is an important part of the country's economy as it directly employs over 200,000 people (NRCAN, 2020). Lumber production continues to play a central role in Canada's forest sector. Softwood lumber is the most important product in terms of volume (57.7 million m3) and export value (CAD 8.0 billion) in 2019. Sawmill residues also provide a large portion of the feedstock used for pulp manufacturing, with a total pulp production of 15.4 million tonnes in 2019, which is either converted into different paper grades within Canada or exported as market pulp (CAD 8.0 billion in 2019). Moreover, lumber can be further processed into engineered wood products, such as glue-laminated timber (glulam) and cross-laminated timber (CLT), enabling tall wood building construction (NRCAN 2020).

For the last several decades, Canada's forest sector has experienced substantive disruption. In 2000 Canada's forest products sector generated $24.4 billion in output, representing 1.8% of Canada's total Gross Domestic Product (GDP). By 2020, total sector output had declined by 24.9%, or $6.1 billion, and only represented 0.97% of Canadian GDP. The impacts of this decline have been experienced in resource-dependent communities across all of Canada. Average harvest rates have dropped due to major market changes driven by widespread uptake of the Internet, which reduced the need for printed newspapers dramatically impacting revenues from classified ads; and declines in single-family home construction and corresponding increases in multi-family, multi-story buildings which has reduced demand for wood building products (Milley, 2022).

Gagnon et al. (2022) noted that the transition to a circular bioeconomy has significant implications for Canadian forest industries in a context where demand for some traditional products, such as newsprint, is declining and investments are being made towards diversification. As well, given the growing number of regulations, strategies and programs associated with climate change, the demand for forest-based products is expected to rise because they are considered sustainable, renewable and good candidates to replace many fossil-fuel-based products (Smyth et al., 2020). As such, the Canadian forest industry continues to actively seek investments in bioproduction, and through Forest Products Association of Canada (FPAC) the industry continues its transformation as a means of remaining productive and competitive.

Status of Forest Industry in Newfoundland and Labrador

In providing jobs, stimulating local industries, and diversifying Newfoundland and Labrador's production capacity and export base, the forest sector is an important contributor to the provincial economy (Milley 2008). The provincial government's revenue base draws from the forest sector through taxation of personal and corporate income taxes and from sales of goods and services. However, it is important to note that in recent years, the relative contribution of the forest sector (Goods-Producing) to the province's GDP has dropped considerably. Compared to other natural resource industries, forestry (combined with agriculture and logging) accounts for less than $200 million to NL's GDP. This component represents only 0.6% of the total GDP. However, it must be noted that a significant component of the forestry sector's GDP is captured

in manufacturing and when added raises the contribution of the sector to over $300 million. In contrast to forestry, oil extraction and mining contribute 14.4% and 6.3%, respectively. In 2018, direct employment in the forest sector accounted for 1.1% of the Goods-Producing sector.

Photo CBPPL Credit: G. Forward.

The pulp and paper sector remains key to the forest sector in the province. Corner Brook Pulp and Paper Limited (CBPPL) produces newsprint at the mill located in Corner Brook. With a capacity of 255,000 metric tonnes, CBPP uses a thermomechanical pulping (TMP) process to produce high-quality newsprint for markets in Canada, the United States, Asia, and Europe.

Raw material in the form of balsam fir and black spruce roundwood is chipped on site or from sawmill-processing residue (pulp chips) delivered from local sawmills. In addition to newsprint, the mill generates electrical power from its subsidiary, Deer Lake Power, and produces on site electricity from its 15-megawatt cogeneration plant. In their 2018 Discussion Paper, McKinsey (2019) noted the declining demand and increased competition for newsprint, the province's main forestry export. It is noteworthy that the value of Newfoundland and Labrador's newsprint exports declined by 81% between 2000 and 2017. Further, the number of employees in the Corner Brook mill declined from more than 2,000 to about 300. This trend makes clear the need to revitalize the forest sector and to diversify the economy, steps crucial to sustaining this industry. Currently, with approximately 5,000 employed in the integrated industry, including sawmills, woodlands, and related occupations, there are compelling reasons to better understand the vulnerability of the sector to both market forces and to climate change. Arguably, both challenges can be met if the sector can embrace a 'green' economy strategy.

Although there are many small seasonal sawmills in Newfoundland and Labrador, most of the province's lumber production is achieved by three larger mills that operate throughout the year. Sexton Lumber Co. in Bloomfield, Burtons Cove Logging and Lumber Ltd. in Hampden, and Cottles Island Lumber Company Ltd. in Summerford account for nearly 90 per cent of all lumber manufactured in the province. They also have kiln-drying capacity to dry lumber and sell pulp chips and processing residues to CPLS Softwood lumber, either balsam fir or black spruce, accounts for most sawmill production. In NL only a very small amount of hardwood (birch) lumber is manufactured. Newfoundland and Labrador have a limited market for dimensional lumber – 50 per cent is generally sold outside the province, primarily in Eastern Canada and the United States. Because of the relatively smaller tree size, most lumber produced in Newfoundland and Labrador is smaller dimension and manufactured into either two by four, or two by six, framing lumber. Lumber lengths are generally restricted to 12 feet or less. Lumber greater than 12 feet is usually imported into the province. Finger-jointing capacity has recently been introduced in the province, enabling the sawmill sector to produce longer length lumber and meet market demand. This technology has enabled more locally produced lumber to remain in the province, and decreased dependence on the export market. All 3 major sawmills in Newfoundland are family owned and operated, a characteristic which significantly changes the operating dynamics of these businesses relative to mills that are part of large corporations.

Photo Credit: G. Forward

The owners are operating managers actively engaged in all aspects of their operations. These individuals are closely involved with and understand the equipment and business issues and requirements of the operation. Mills are located in rural NL and mill owners exhibit a strong sense of responsibility towards the communities in which they operate, particularly with regard to employment opportunities for local citizens. Owners and stakeholders also have a deep concern over the potential impacts of climate change on both the sustainability of the resource

and on the economic stability of their communities. These mills are more likely to continue operating during poor market conditions, even if at a loss, in order to maintain a stable workforce (and to encourage these workers not to look elsewhere for employment). It is expected that recruiting and maintaining a skilled and stable workforce will continue to be a key challenge for sawmills. One complicating factor is the uncertainty associated with climate change impacts on the sector and the willingness and ability of the sector to respond.

III. FOREST-BASED CIRCULAR BIOECONOMY

Circular Bioeconomy Defined

Societies and economies everywhere are in rapid transition. The Fourth Industrial Revolution is well underway and represents a fundamental change in the way we create, exchange, and distribute value. This technological shift is effectively merging our physical, digital, and biological worlds into one. As such, we see the emergence of new domains such as the biodigital, and emerging new economies including the 'green' economy typically encompassing both the bioeconomy and circular economy[2] (Figure 1).

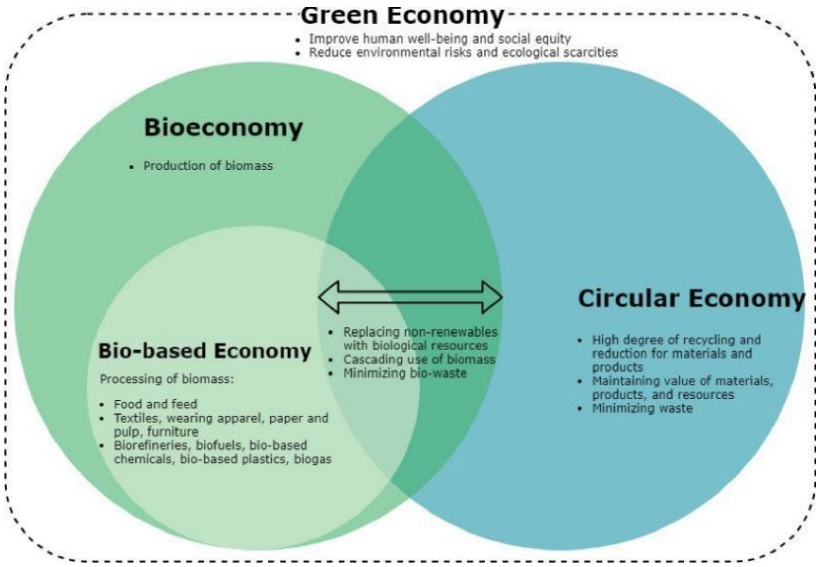

Fig. 1. Relationship between green economy, bioeconomy, bio-based economy, and circular economy. Source: Kardung et al. (2021)

[2] Herein, the term *circular bioeconomy* is used throughout to denote the two primary subsets of the 'green' economy. Note, a number of authors exclude production of biomass from their definition of a 'bio-based economy'.

A number of fast-developing technologies are influencing the transition of global growth and development, including clean technology, artificial intelligence, augmented reality, robotics, 3-D printing, and advances in biotechnology (e.g., genome editing). These tools offer promising smart solutions for intractable challenges associated with resource management, climate change impacts, and environmental damage including the erosion and loss of natural capital (e.g., biodiversity loss). The current industrial transition calls for effective governance of these solutions in ways that empower, foster collaboration, and help build a more sustainable foundation for social and economic development. A myriad of factors at both global and local scales are influencing this transition, including market forces, sustainability issues, and the role and stability of social institutions[3]. As such, the future is unpredictable and uncertain. More than 50 countries and international organizations worldwide are currently working on strategies and policies to promote a transition to a bioeconomy (Sanz-Hernandez et al., 2022). While many efforts focus on a science perspective (e.g., chemistry, engineering, technology, biomedicine or biology), there is growing attention to the importance of social and economic issues that underpin bioeconomic development. Indeed, good governance will require input from a diverse range of stakeholders beyond traditional government intervention (Devaney et al., (2017). Although social institutions are interdependent, it can be argued that in NL, as elsewhere, economic and educational institutions are vital to social and economic development, and thus, underpin the wealth and well-being of citizens. To meet training needs associated with the current transformation, a measure of institutional adaptation and reform will be necessary. Indeed, future earners and learners may no longer be able to rely on current education and training programs acquired in today's educational institutions to adequately prepare them for rapidly emerging economies, in particular the green economy. Rapid technological advancements will transform existing jobs, shifting the demand for skills, and creating whole new professions. As discussed below, attention to academic programming, research and development, human resources, gender equity, and leadership capacity are among the issues that will require closer attention. This document gives particular attention to the opportunities and challenges associated with the development of the circular bioeconomy within the forest sector of NL. Section X of the report also focuses on the preparedness of post-secondary educational

[3] *Social institutions* commonly include Family, Economy, Religion, Education, and Government or State.

institutions in meeting future training needs to advance the development of the circular bioeconomy, a domain of high priority to forest-based industries in the province.

Biomass Conversion

Global energy demand is projected to rise by almost 28% by 2040 compared to current levels. The depletion of non-renewable fuel sources (fossil fuels) and the negative effects of greenhouse gas emissions has placed increased attention on a number of alternative options to confront the global energy crisis. Increasingly, biomass is viewed as a viable option to help meet global climate targets. To use biomass with optimal efficiency, several countries have developed development strategies centered around the concept of a circular bioeconomy.

Recently, the European Commission set a long-term goal to develop a competitive, resource efficient and low carbon economy by 2050. The circular bioeconomy is viewed as a key element in its low carbon economy strategy and is expected to generate significant market opportunities and future jobs (Scarlat et al., 2015). The move towards a circular bioeconomy makes better use of residues and wastes as a resource, calls for stronger integration of resource sectors, and focuses more on material and high value applications of biomass. Biomass is a promising energy source for producing either solid or liquid fuels. As noted by Osman et al. (2019) biomass is classified as non-lignocellulosic or lignocellulosic in nature and exists in various forms such as woody, herbaceous, aquatic debris, farming manure and other forms.

Unlike other sustainable energy sources such as wind, solar, geothermal, marine and hydropower, conversion of biomass can directly produce not only fuel but a variety of materials and chemical by- products (Quereshi et al., 2021; Wang et al., 2019). A myriad of technologies is used to convert biomass into fuel or chemicals, including gasification, combustion, pyrolysis, enzymatic hydrolysis routes and fermentation processes (Abou Rjeily et al., 2021; Chen and Wang, 2016). Numerous workers have examined the waste-to-energy methodologies and policies associated with biomass conversion (Akalın et al., 2016; Ansari et al., 2020; Astrup et al., 2015; Bach & Skreiberg, 2016; Kumar and Sani, 2018; Caruso et al., 2019; Collotta et al., 2019; Matsuura et al., 2018; Nanda et al., 2020; Yamakawa et al., 2018). For NL to advance its traditional bio-based industries, the conversion of biowaste material from forestry, agriculture, and fisheries offer high potential. Innovation, conversion efficiency and collaboration among these resource sectors could help shift the province towards a resource efficient and low-carbon economy.

Particular attention has been given to life-cycle assessment as a means of addressing sustainability including quantifying energy use and utilization, as well as assessing the potential for conversion and performance of biofuels (Arushanyan et al., 2017; Bandh & Malla, 2022; Bisinella et al., 2021; Chandel and Sukumaran, 2017; Eriksson et al., 2007; Michaga et al., 2022; Fruergaard & Astrup, 2011; Kumaniaev et al., 2020; Martin et al., 2018; Osman et al., 2021). Much current work is focused on technological and economical feasibilities as well as sustainable assessment of approaches (thermochemical and biochemical) associated with biomass conversion. For example, recent work by Kaloudas et al. (2021) reviewed biofuel feedstocks with a focus on lignocellulose, algae and microbes for production of biofuels, biogas and biohydrogen.

The demand for bio-based products can vary widely, from the use of biomass for bioenergy utilization to other highly technological products like multi-story mass timber buildings. For instance, a recent report commissioned by the European Union in the context of the EU 2050 series highlighted the potential crisis in meeting future demands for biomass (Material Economics, 2021). Specifically, although the report states that the use of bioenergy in Europe has grown by 150% since 2000, future scenarios anticipate an increase in demand from 70 to 150%. According to an analysis by the Material Economics in Europe (2021), this foreseen demand would require "an area the size of Germany […] to be dedicated to energy crops alone or additional ca. 340 million tonnes of forest wood per year […]" (Material Economics, 2021). The authors further state that this means not only an increase in production but also a prioritization of biomass to high-value materials and chemicals. Therefore, although this report focuses on the European context, the Canadian advantages are clear due to its access to large, forested areas (many of which are certified) if decision-makers focus a comprehensive transition in which social, economic and environmental factors are considered. Among other aspects, that would entail a workforce that is representative of the region's inhabitants and products and services derived from a multi-purpose and sustainable forest management.

Within NL, as elsewhere, the use of biomass to promote a robust circular bioeconomy will require careful attention to developments that intersect stand-alone policy areas (e.g., forestry, climate change, agriculture), R&D and innovation, and environmental policy). It will be necessary to provide an integrated response to several broad challenges—e.g., climate change, food security, energy policy, and resource constraints.

Photo Credit: G. Forward

To make optimum use of available biomass (waste/residues) from existing enterprises, sectoral policies should support the development of a bio-based economy, including development of a provincial Circular Bioeconomy Strategy. Such a strategy should maintain natural capital (e.g., productive forest landbase) as a critical economic asset. In addition, existing sector policy frameworks within energy, forestry, agriculture, fisheries, and the manufacturing sector will need to actively support the development of the green economy in the province. The latter offers high potential for new growth opportunities in both traditional and emerging bio-based sectors. Significant attention must be given to fostering green growth through innovation, in the context of the emerging circular bioeconomy. In such a framework, support should be directed to enhanced research and development (R&D) and capacity building underpinned by the province's Post-Secondary Education (PSE) institutions. Section X discusses in detail how PSEs can be better leveraged to promote NL's circular bioeconomy.

IV OPPORTUNITIES AND CHALLENGES FACING THE FOREST INDUSTRY IN CANADA AND NL

Opportunities

The emerging circular bioeconomy is expected to provide important opportunities for the forest sector of NL. The province has a rich forest resource and is in a highly strategic location in the northwestern Atlantic, with gateways to the Gulf of St Lawrence and Europe. In 2018-19, in collaboration with the recently formed NLFIA and other stakeholders, the NL government offered

several opportunities to diversify the province's forestry sector. For example, the forestry sector work plan called for stakeholders to collaborate in advancing the 'green' economy. In their 2018 report, McKinsey also emphasized bioeconomy opportunities. The following represent areas of potential development:

Products with stronger global demand

The provincial industry can shift its focus toward producing paper products with stronger global demand, particularly those that can leverage recycled fibre from the region. Two key examples of such products are: 1) liner board, the demand for which is steadily increasing given the rise of e-commerce and the rapid increase of shipped packages; and 2) Kraft paper, which is also in growing demand, especially in Europe, as retailers substitute plastic with paper bags in response to regulation and environmental concerns.

Softwood lumber and advanced materials for construction

Another avenue for diversification is the shift toward construction materials – particularly softwood lumber – for both the local and the export markets. Currently, Newfoundland and Labrador's construction industry imports a large proportion of the softwood lumber used domestically. New and highly efficient sawmills in Newfoundland have the potential to produce materials at competitive prices, substituting for imports. Already, advancements in sawmill technologies have stimulated regrowth in the lumber industry; today the Province's mills produce over 90 million board feet of lumber per year. A favorable tariff regime may also allow the Province to grow its American export business through a competitive cost position. The Canada-U.S. softwood lumber agreement has provided exclusions for the Province's lumber exporters from U.S. export tariffs and represents a meaningful opportunity for Newfoundland and Labrador to grow its softwood lumber exports into the U.S. This growth could be supported via a renewed focus on advanced building materials that could be marketed locally and exported out of Province (e.g., cross- laminated timber). Related research could be conducted at the newly established Centre for Research located in Corner Brook.

The growing trend to integrated urban design and climate adaptation initiatives offers a prospective means to promote interaction between the immediate natural and built environments. Recent changes in building codes in Canada have given impetus to manufacturers to pursue diverse opportunities to increase interaction between people, nature and the built environment.

Municipalities and the NLFIA can play a leading role in promoting innovative ways to simultaneously build climate resilience and sustainable urban development. Life cycle costing (LCC) is critical for such an approach, however in Europe early analyses indicate long-term gains outweigh the initial costs of investments. Particularly encouraging are innovations in building designs using wood for low rise apartment buildings, educational institutions, and other public buildings. Coupled with more energy efficient retrofitting of commercial buildings, a vision to limit metal/concrete materials and replace them with wood is worthy of consideration, especially in cold climates like NL. The need for new timber framed elements, novel prefabrication methods, and creative wood building projects calls for innovation and intensive exchange between NLFIA, researchers and entrepreneurs.

Accordingly, there are excellent prospects in this domain for academic institutions (Memorial University of Newfoundland – MUN – and College of the North Atlantic – CNA) to develop academic and research programs in wood chemistry, architectural design, engineered wood products, energy efficient building envelopes, and other customized timber-based building systems. More Research and Development (R&D) attention could also be given to supplementary forest goods and services, including NonWood Forest Products (NWFP). The latter emphasizes "secondary", "side-products", or "niche markets"; in a developing circular bioeconomy such products offer potential for an increasing role for NWFPs in future forest-based value chains.

Forestry Biomass and Biofuels

NL has all the prerequisites to become economically stable in a decentralized circular bioeconomy due to availability of biomass. As the next generation of biofuel technology unfolds, biofuels will become more attractive, especially given the high transportation costs associated with most resource industries in NL and throughout North America. The production of biofuel from lignocellulosic biomaterials, which are abundant and economically suitable for fuel production should be considered. As identified in *The Way Forward on Forestry* (Newfoundland and Labrador, n.d.c), forestry biomass and biofuels present alternative forest products that can potentially serve as substitutes for higher-emission fossil fuels. For example, black pellets, which can be used as a replacement for coal and store large volumes of energy, are currently in high demand in Europe, potentially making them economical to export from Newfoundland and Labrador. Producing biofuels would require further study and growth in domestic lumber

production to ensure there are sufficient quantities of wood by-products (chips and residue) to improve fuel production viability. Significant potential also exists in Corner Brook where the CBPP mill operation currently generates wood ash, sludge and excess steam, which alone or in combination with other materials could be used as an input in other processes. For example, setting up greenhouses in the vicinity of the Corner Brook mill could use the industry's excess steam for heating. Developing this opportunity also aligns with the Province's strategic objective to increase food self-sufficiency. Moreover, increased and more efficient use of biomass energy— considered to have zero net GHG emissions if sourced from sustainably managed forests— can mitigate GHG emissions. Reductions in energy use in the order of 20% to 30% could be achieved in conventional pulp mills with existing technologies. Chemical and thermomechanical pulp mills offer the greatest potential for energy savings. Paper drying is the most energy-intensive process across the life-cycle, consuming 15% to 25% of total energy.

Novel Value-Added Products

The economy of Newfoundland needs to move from productivity to 'value'. That is, more effort is needed to seek opportunities based on added value products derived from natural resources, particularly forest biomass. Both CBPP and the three integrated mills have access to raw material that could facilitate the development of new products, most notably, lyocell, a man-made fiber derived from cellulose and with industrial uses such as in automotive filters, ropes, abrasive materials, bandages and protective suiting material. Similarly, lignin, an organic substance binding the cells, fibres and vessels which constitute wood and the lignified elements of plants, is an unexploited treasure – at least from a chemical point of view. Every year approximately 50 million tonnes of lignin are produced worldwide as by-products of the paper industry. Given the untapped potential of wood biomass (cellulose (40% to 43%), hemicelluloses (28% to 35%) and lignin (22% to 29%), there is strong merit in giving more attention to derivatives and applications of these materials. The use of cellulosic fibres along with lignin, a source of aromatic compounds, both show growing demand and represent high potential for the circular bioeconomy.

Challenges and Risks

As noted earlier, creating new circular bioeconomy businesses and opportunities offer significant challenges. A number of challenges and potential risks associated with the development of a circular bioeconomy were reported Bowers (2020). These include, *inter alia*:

- The circular bioeconomy is developing rapidly. Speed, not size, is the key to success in a knowledge-based 'green' economy. Competition to advance 'green' plans and forest-based bioeconomy solutions is intense. Those who delay will find it challenging to enter the marketplace.
- Bioeconomic ideas arise organically out of local driving stakeholders and actors with a common interest. Companies who fail to establish operating networks and are hesitant to cooperate in investing, training, and delivery of bio-economic solutions will miss opportunities.
- High capital costs as well as volatility in energy and recovered prices are key economic barriers to the forest industry. Recently, the confluence of slow global economic growth and high capital costs has lowered profitability within the pulp and paper and sawmill industries. The paper sector is particularly vulnerable to a weakening demand for printing and publishing, which the continued rise of electronic media has reduced market opportunities. Alternative materials for packaging, such as plastic, steel and aluminum create other challenges for the pulp and paper sector.
- Capital investment to build and maintain forest industry facilities is needed, and it will be time consuming to transition to new products. Local industries must be in a position to produce sufficient biomass feedstocks with desirable cost-effectiveness and minimal environmental impacts. Thus, capacity-building cycles for major renovations and technology transitions from planning through construction is challenging. However, as shown throughout Canada, the adoption of modern technologies and processes can lead to significant efficiency gains and to profitability.

- Commodity prices fluctuate considerably because they are determined by supply and demand in global exchange markets. High dependency on commodity exports, such as wood products introduces uncertainties and a level of risk.
- Policies and practices that improve technical and operational characteristics of industry must also address environmental performance. In some cases, the timeframes, trade-offs and operational requirements that mill operators face to improve environmental performance may limit opportunities. Such risk needs careful analysis because apart from slow rates of capital turnover, decisions made to reduce environmental impacts within one area or phase of the fibre life-cycle may limit opportunities in other areas or phases.
- Limits to NL's ability to conduct fundamental research, either through inadequate funding to PSEs such as CNA and MUN, restrictive research regulations, or the inability to develop and attract a skilled workforce, can erode the province's ability to conduct research needed to advance a circular bioeconomy. Falling behind in life science applications of computational and informational science is a particular risk. Lack of investment by industry and/or erosion in government support for fundamental research is a concern that must be addressed.
- There is high risk in a limited product base. Failure to develop and market sawmill residues and non-sawlog timber will be an impediment to developing a circular bioeconomy.
- The trend in NL demographics poses a particular risk. The central issue is that the province is facing significant population decline, especially in rural areas. From a high of 580,065 in 1984, by 2019 the population of NL had fallen to 521,542. Labour is a key factor of production, especially in forestry-related industries. Workforce issues continue to challenge the forest sector.
- Given the focus on 'full' electrification for the province, there is uncertainty in the domestic bioenergy market. As such, there will be a need for an export driven industry. Legislation giving an energy monopoly to NL Hydro should be modified to make provision for alternate energy options. This would open potential for bioheat installations in new buildings and help promote biodiesel in more rural and remote communities in the province.

V ROLE OF THE CIRCULAR BIOECONOMY IN REALIZING ECONOMIC OPPORTUNITIES

Fostering the Sustainability Transition

A circular bioeconomy can only advance within the context of sustainability. The forest sector is expected to play an increasingly strong role in the development of the circular bioeconomy and is a major component of the province's sustainability pathway as it hits critical net zero targets in 2030 and beyond. For example, the NL forest industry is placing increased attention on 'climate smart' forestry to sequester carbon to help mitigate climate change impacts. Given the province's high dependence on resource industries, and its commitment to national and global sustainability goals, both MUN and CNA have in the last decades, placed increased attention on environmental issues, most notably, climate change, biodiversity loss, food and water security, and environmental policy. Current programs provide the basis for local and regional capacity building in multiple resource sectors and have particular relevance to a forest-based bioeconomy. As scholars and practitioners grapple with the challenges brought about by a rapidly changing world, transitioning to a more sustainable way of living is no longer an option; it is now an imperative. Coupled with program offerings in the biological sciences, business, information and engineering technology, technical training, and new graduate programs in interdisciplinary and transdisciplinary science, there is growing evidence of a 'sustainability shift' within NL's PSE institutions – one that provides a solid foundation on which to build a viable and productive circular bioeconomy.

Sustainability is now an explicit part of most business strategies, and more students are being educated for sustainability (Crofton, 2000; Raivio, 2011; Steiner & Posch, 2006; Sterling, 2004; Sterling & Thomas, 2006); it is not by accident that 90% of S&P 500 companies now publish sustainability reports. To remain competitive, local industries, including forest-based companies, will have to demonstrate their commitment to Sustainable Development Goals (SDG) embedded in international agreements and conventions to which Canada is a signature. Chankseliani & McCowan (2020) report that one of these goals (SGD 4) calls for equal access to tertiary education, including universities, as part of the promotion of lifelong learning opportunities for all. These workers further note that PSE institutions have another important role in the SDGs, as a driver for the achievement of the full set of goals, through their role in

human formation, knowledge production and innovation. Currently, Canada ranks 20th globally amongst countries striving to hit the SDGs. The country's availability to improve its record and to be competitive in a global market is in many ways dependent on institutions with a responsibility to educate, train and advance more sustainable approaches to resource development. Consequently, sustainability-oriented programmes are developing at a fast pace throughout Canada and the world (Lambrechts et al., 2013). Interestingly, some of the academic and co-curricular programmes leading the way are faculty professional development and incentive programmes that support the integration of sustainability education into the curriculum including sustainability degree programme.

The establishment of the Environmental Policy Institute and new degree programs in Boreal Ecosystems and Agricultural Sciences, Environmental Policy, Applied Geomatics, and Transdisciplinary Sustainability at Memorial University (GC) are particularly noteworthy, in that they successfully embed sustainability within tertiary curricula and pedagogy, thereby responding directly to sustainability challenges. Michel et al. (2020) argued that for sustainability education to come to fruition requires a change in education culture. That is, it requires much more holistic thinking as described by (Boyd, 2017; Grasso & Burkins, 2010; Nicolescu, 2002; Zhang et al., 2022). Moreover, to be effective at engaging students in such long- term and often abstract thinking, sustainability education should rely on transformative learning experiences that allow students and faculty alike to confront the core assumptions and values underlying sustainability as both an idea and a practice (Savelyeva & McKenna, 2011). Further, it can be argued that the efficacy and relevance of a sustainability education is best realized in its ability to encourage more than just knowledge acquisition; it also provides opportunities for personal growth and an evolution in one's thoughts and mind-set toward adopting a more sustainable lifestyle. One approach to a sustainability education involves teaching students to observe carefully, and think critically, deeply, and more holistically. Many EU countries commit to some sustainability-related goals and are beginning to embed education for environmental sustainability in their education policy strategies (European Commission, 2021). Highly relevant is work by Evans (2019) who articulated and described in depth a set of core competencies for the sustainability field and suggests potentially effective pedagogies for teaching them. These competencies include (i) interpersonal communication,

(ii) creative and strategic, (iii) critical and normative, (iv) systems, and (v) transdisciplinary competencies.

Of the various pedagogical approaches available, informal, and experiential learning offer high potential for training in the circular bioeconomy because it can provide transformative experiences. Such an approach has particular importance in understanding both consumption and sustainability. This implies that in addition to the two traditional missions of teaching and research, PSE institutions have to adapt to changes in social, economic, political, and ecological contexts in order to emerge as key actors for sustainable consumption (Adomssent et al., 2007; Blass et al., 2010; Gombert-Courvoisier, et al., 2014; Karatzoglou, 2013; Martin et al., 2018; Nejati & Nejati, 2013; Yasin & Rahman, 2011; Yuan & Zuo, 2013). The means to achieve a more relevant pedagogical approach to advancing the circular bioeconomy is addressed below (Section X) under the *Role of Secondary Educations Institutions*.

VI CIRCULAR BIOECONOMY EFFORTS/SUCCESSES

Global Trends and Strategies

In a recent report titled *A Pathway for a Forest-based Bioeconomy in Newfoundland and Labrador,* Bowers (2020) reviewed Canadian and global trends in the development of forest-based bioeconomies. One key challenge of the forest-based bioeconomy is to understand and better manage the many aspects of the forest resource to promote economic growth, forest sustainability, social inclusion, and the preservation or improvement of livelihoods. While different pathways toward an expanded circular bioeconomy exist, there are common steps that will be required by regions and sectors for economic success. Ultimately, the circular bioeconomy strives to integrate the biomass flows of different industries such that one industry's waste or emissions become another industry's raw material[4]. This approach

[4] There are various concepts and notions to describe the relationship and interdependencies among players within the forest industry sector. The value chain or more complex value network approaches, are related to systems thinking and the central idea of life-cycle assessments. These encompass, supply chain, (global) value chain, market chain, value web or global commodity chains. These concepts have much overlap and/or at times can be used interchangeably; within the forest industry, most commonly the term "biobased value chain" or forest value chain is used.

effectively creates effective material loops and addresses the dual problem of climate change and resource depletion. This need to be more energy and material efficient is dictated by both global environmental concerns, as well as the threat to the supplies of basic resources. On a social sustainability level, a circular bioeconomy increases the efficiency of local production and thereby strengthens local business with all its side-benefits.

Globally, the circular bioeconomy landscape spans fields from forestry to pharmaceuticals. Recent attention has also turned to the forest sector for novel fabric and cosmetic products. The U.S. and Europe are clear leaders in the global circular bioeconomy landscape; in the US the circular bioeconomy accounts for more than 5 percent of the gross domestic product, valued at approximately 1 trillion dollars. In Europe, the circular bioeconomy is a key component of a smart and green growth strategy with a market size of over 2 trillion Euros. It provides 22 million jobs across diverse sectors, including forestry, agriculture, food, chemicals, and bioenergy. This contributes to around 9% of the total EU labour force. For example, in Germany economic sectors related to the circular bioeconomy provide around 14% of the country's GDP and 13% of all jobs.

In 2012, the Obama administration released an official strategy on the circular bioeconomy entitled the "National Circular bioeconomy Blueprint". This strategy considered the circular bioeconomy based on the use of research and innovation in the biological sciences to create economic activity and public benefit. The US circular bioeconomy blueprint promoted development of new drugs and diagnostics for improved human health, higher yielding food crops, emerging biofuels to reduce dependency on oil, and bio-based chemical products. Since then, most nation states recognize the need to comply with sustainability principles and are taking steps to have economic growth comply with sustainability values. There are strong signals indicating that the demand for renewable, biobased raw materials is increasing substantially. This trend is reinforced by challenges posed by climate change, habitat loss, ocean acidification, pollution, and threats to ecosystem services. Moreover, the circular bioeconomy is the key means to replace fossil fuels while ensuring sustainable food production. In Canada, including NL, the circular bioeconomy is rapidly emerging and offers significant potential from forestry, agriculture, fishery-based biomass, and organic waste. As in other countries, the Canadian circular bioeconomy spans a vast range of industries and is estimated to contribute 6.4% to national GDP.

To establish cascading of biological resources on an economy-wide scale, entire biobased value chains have to be formed and eventually integrated in value networks. The development of new biobased value chains requires cooperation between previously unconnected sectors to handle the specific characteristics of bioeconomic value chains. In Europe, the circular bioeconomy had its genesis in biotechnology strategies, particularly after the 5th EU Framework Programme (1998–2002) where more attention was given to a more competitive and sustainable Knowledge Based Bioeconomy (KBBE). In 2002, the Canadian environment think tank 'Pollution Probe' issued a document entitled Towards a Biobased Economy - issues and *challenges* that provided impetus to the development and concept of the circular bioeconomy in Canada.

Globally, the circular bioeconomy is largely driven by research and innovation in the life sciences and biotechnology; it is enabled primarily by technological advances in engineering and in computing and information sciences. As such, the dimensions of the circular bioeconomy represent a stream of the knowledge-based economy that exists in the new era of information and communications technology. Today, most OECD countries have circular bioeconomy-related strategies in place or envision doing so (Table 1).

Table 1. Selected bioeconomy strategies in chronological order by date of appearance.

Country	**Strategy**	**Year**	**Institution** [5]
OECD-countries	The Bioeconomy to 2030—Designing a policy agenda	2009	OECD
EU	Innovating for Sustainable Growth—A Bioeconomy for Europe	2012	EC
The Netherlands	Framework memorandum on the Bio-based Economy	2012	The Dutch Cabinet
Sweden	Swedish Research and Innovation—Strategy for a Bio-based Economy	2012	Formas
USA	National Bioeconomy Blueprint	2012	The White House
Russian Federation	State Coordination program for Development of Biotechnology in	2012	BioTECH2030

[5] Formas is the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning; BioTECH 2030 is the Russian Technology Platform for bioindustry and bioresources; Biotechcorp is the Malaysian Biotechnology Corporation; DST is South Africa's Department of Science and Technology; BMEL is the German Ministry of Food and Agriculture; MEE is a chosen abbreviation for the Finnish Ministry of Employment and the Economy in cooperation with other ministries; Matis is an Icelandic, government-owned research institute in the areas of food and biotechnology; Alim'agri is the French Ministry of Agriculture, Agri-Food, and Forestry; Bioindustrial Innovation Canada.

Country	Strategy	Year	Institution [5]
	the Russian Federation until 2020 "BIO2020"		
Malaysia	Bioeconomy Transformation Program—Enriching the Nation, Securing the Future	2013	Biotechcorp
South Africa	The Bioeconomy Strategy	2013	DST
Germany	National Policy Strategy on Bioeconomy (in German)	2014	BMEL
Finland	Sustainable growth from Bioeconomy – The Finish Bioeconomy	2014	MEE
West Nordic countries	Future opportunities for bioeconomy in the West Nordic countries	2014	Matis
France	A Bioeconomy Strategy for France (in French)	2016	Alim'agri
Canada	**Canada National Bioeconomy Strategy**	**2019**	**BIC**

VII CIRCULAR BIOECONOMY POTENTIAL IN NEWFOUNDLAND AND LABRADOR

The fact that the circular bioeconomy, and the local solutions of the 'green' economy, are becoming increasingly popular is highly relevant to provinces like NL. Significantly, there is high dependence on rural communities given that development and expansion of the circular bioeconomy requires a sustainable and sufficient supply of biomass feedstock, materials readily produced by the forest sector in forest-based communities (Bowers 2020).

The forestry sector has long been an important part of the economic and social fabric of Newfoundland and Labrador. Since the mid 1800's, settlers used the forests of the province as a resource and a source of employment. NL communities continue to depend on their forests for a wide variety of ecosystem services including clean water, soil integrity, and general well-

being. Increasingly, the importance of the forests to the global carbon cycle is also being recognized.

Economically, the resource has been harvested for paper production, lumber products, and firewood. Larger communities, like Grand Falls-Windsor and Corner Brook were founded as paper production towns, and many smaller towns in rural NL have strong ties to the paper industry. In addition, many citizens in rural areas of insular Newfoundland found employment in the sawmill industry.

Newfoundlanders and Labradorians continue to benefit from the traditional forest-based bioeconomy in terms of goods produced, food consumed, and products manufactured in the province. Along with the fishery sector, the forest sector has been instrumental in sustaining the province's natural and renewable resource-based economy. The core elements of the forest sector continue to pivot around paper production and the lumber industry, both supported by a network of employees scattered across the province. Despite the contributions of lumber and paper to the provincial economy, it is apparent that the forest sector is under extreme stress, given that worldwide the demand for many traditional forestry products is declining. The digital economy, along with a decline of forest commodity prices and a reliance on export markets, are among the factors that offer a serious challenge to NL paper and lumber industries. Consequently, the sector is in a period of structural change and transformation. Many argue that the forest sector is now at a cross-roads and a strategic vision is needed to ensure how best to utilize the publicly owned forest resource.

There are several motivations to promote the development of the circular bioeconomy in NL, not the least of which is to expand and sustain forest-sector enterprises. As such, there is urgent need to diversify forest value chains in the province, and to move from simply 'production' to 'value' (Bowers, 2020). Important drivers include the need to diversify the economy and become more competitive, to capture market opportunities, to revitalize rural NL, to address climate change, and to build economic and social resilience in the province. The latter is best expressed in the need to address the serious demographic problem facing NL. Building regional resilience is vital in an interconnected global economy where external events have significant impact on regional and local communities. Resilience thinking gives regions the possibility to anticipate and respond to unexpected events. The 1992 cod collapse and the

recent drop in oil prices represent clear examples of the sudden stresses for which the province was ill prepared. Rural areas in particular are challenged to deal with these economic downturns and the concomitant demographic decline. Paradoxically, the oil price dip in 2020 could act as a 'positive shock' to the province if it serves as a catalyst for development of the circular bioeconomy and diversification of investment. Indeed, a more diverse economy with added attention to 'green' jobs underpinned by an advanced technology (digitization) strategy offers a solution to the demographic problem and to rural community sustainability. NL is well positioned to consider this pathway given its rich forestry and fisheries sectors, an emerging agriculture sector, and its resourceful people.

In addition to providing jobs, stimulating local industries, and diversifying Newfoundland and Labrador's production capacity and export base, the forest sector is an important contributor to the provincial economy. The provincial government's revenue base draws from the forest sector through taxation of personal and corporate income taxes and from sales of goods and services. However, as reported by Bowers (2020), in recent years the relative contribution of the forest sector (Goods-Producing) to the province's GDP has dropped considerably. Compared to other natural resource industries, forestry (combined with agriculture and logging) accounts for less than $200 million to NL's GDP. This component represents only 0.6% of the total GDP. However, it must be noted that a significant component of the forestry sector's GDP is captured in manufacturing and when added raises the contribution of the sector to over $300 million. In contrast to forestry, oil extraction and mining contribute 14.4% and 6.3%, respectively. In 2018, direct employment in the forest sector accounted for only 1.1% of the Goods-Producing sector. In their 2018 Discussion Paper, McKinsey noted the declining demand and increased competition for newsprint (the province's main forestry export). For example, the value of Newfoundland and Labrador's newsprint exports declined by 81% between 2000 and 2017; the number of employees in the Corner Brook mill declined from more than 2,000 to about 300. This trend makes clear the need to revitalize the forest sector and to diversify the economy, steps crucial to sustaining this industry. Currently, with approximately 5,000 employed in the integrated industry, including sawmills, woodlands, and related occupations, there are compelling reasons to embrace a 'green' economy strategy and specifically advance a forest-related bioeconomy.

The pulp and paper sector remains key to the forest sector in the province. CBPP produces

newsprint at the mill located in Corner Brook. With a capacity of 255,000 metric tonnes, CBPP uses a thermomechanical pulping (TMP) process to produce high-quality newsprint for markets in Canada, the United States, Asia and Europe. Raw material in the form of balsam fir and black spruce roundwood is chipped on site or from sawmill-processing residue (pulp chips) delivered from local sawmills. In addition to newsprint, the mill generates electrical power from its subsidiary, Deer Lake Power, and produces on-site electricity from its 15-megawatt cogeneration plant.

Although there are many small seasonal sawmills in Newfoundland and Labrador, most of the province's lumber production is achieved by three larger mills that operate throughout the year. Sexton Lumber Co. in Bloomfield, Burtons Cove Logging and Lumber Ltd. in Hampden, and Cottles Island Lumber Company Ltd. in Summerford account for nearly 95 per cent of all lumber manufactured in the province. They also have kiln-drying capacity to dry lumber and sell pulp chips and processing residues to Corner Brook Pulp and Paper Ltd. Softwood lumber, either balsam fir or black spruce, accounts for most sawmill production. Only a very small amount of hardwood (birch) lumber is manufactured. Newfoundland and Labrador has a limited market for dimensional lumber – 50 per cent is generally sold outside the province, primarily in Eastern Canada and the United States. Because of the relatively smaller tree size, most lumber produced in Newfoundland and Labrador is smaller dimension and manufactured into either two by four, or four by six, framing lumber. Lumber lengths are generally restricted to 12 feet or less. Lumber greater than 12 feet is usually imported into the province. Finger-jointing capacity has recently been introduced in the province, enabling the sawmill sector to produce longer length lumber and meet market demand from pressure-treating companies. This technology has enabled more locally produced lumber to remain in the province, and decreased dependence on the export market. All 3 major sawmills in Newfoundland are family owned and operated, a characteristic which significantly changes the operating dynamics of these businesses relative to mills that are part of large corporations. The owners are operating managers actively engaged in all aspects of their operations. These individuals are closely involved with and understand the equipment and business issues and requirements of the operation. Mills are located in rural NL and mill owners exhibit a strong sense of responsibility towards the communities in which they operate, particularly with regard to employment opportunities for local citizens.

These mills are more likely to continue operating during poor market conditions, even if at a loss, in order to maintain a stable workforce (and to encourage these workers not to look elsewhere for employment). It is expected that recruiting and maintaining a skilled and stable workforce will continue to be a challenge for sawmills.

VIII METHODS

The research methods engaged for this project combined regional case studies, a review of secondary literature, interviews, facilitated focus group sessions, and workshops. A literature review was conducted to provide an overview of forest-based economic diversification efforts across Canada. This study focused on five forest industry-based regions. Four of the case study regions were centered on major forestry products companies that collectively represent 96% of province's forest harvest and production. These regions, which are represented by the NLFIA, include Corner Brook Pulp and Paper, Sexton Lumber based in Bloomfield, Cottle's Island Lumber, and Burton's Cove Logging based near Hampden. The fifth case study region is Newfoundland's Great Northern Peninsula (GNP) and while there is currently no major forest enterprise located in this region, the GNP's extensive timber resources and forest industry history warrant consideration of the region in this study.

Regional case studies provided an assessment of the current and potential labor force in each case study region as well as an overview of resident demographics, and potential forest industry collaboration opportunities in the region. Full regional overviews are presented below. The secondary literature review provided a literature overview of forest-based economic diversification efforts across Canada. This review focused on forest-based industries and communities that have identified and taken advantage of markets for bio-products and also identified case studies where underrepresented segments of the workforce (persons with disabilities, Indigenous peoples, women, etc.) were engaged in the bioeconomy of the region. This review provided a foundation upon which to base facilitated focus group discussions in each of the case study regions in this project. Interviews were held with forest industry leaders in each of the five case study regions to learn of forest bioeconomy challenges and opportunities and to also gauge willingness and capacity to explore opportunities for regional partnerships with other stakeholders as well as workforce and

product diversification. Information gathered from these interviews were used to develop an invitation list and discussion focus topics for facilitated focus group discussions in each region. Two focus group sessions were held in most case study regions and were focused on identifying assets associated with the local forest industry enterprise that could be leveraged to develop new opportunities for industry synergies, or workforce or product diversification. Finally, a pan-provincial workshop was held with representatives from each case study region as well as relevant government department and branches and researchers to identify intraregional challenges and opportunities for more widespread adoption of a forest-based bioeconomy in the province.

Impacts of COVID-19 Pandemic on Data Collection

As this study afforded an opportunity to make new connections between local forest industry enterprises and their surrounding communities, and perhaps contribute to dispelling perceptions that the forest industry is a relatively antiquated and uninviting place to work, the initial data collection plan involved on-site tours of the mills in each of the case study regions by interested stakeholders and potential partners. However, due to the COVID-19 pandemic, gatherings and visits by such large groups was not possible. The research team therefore engaged Memorial University's Harris Centre and drawing upon the Center's expertise in public engagement, developed an effective, virtual engagement process. This virtual engagement process involved a Harris Centre staff member visiting each region to collect information on the history, workforce, regional connections, challenges, and opportunities of each mill. During this visit, photos were also taken which highlighted each mill's industrial and technical capacity, production process, its place in the region, and employees. These photographs were then overlain with segments of interview recordings with the mill owners or managers to create an audiovisual recording for each region's mill which was then used as a basis for discussions with stakeholders in each region. These mini photo-documentaries proved to be an effective means to bring the mills to the public when the converse was not possible.

The next stage of the virtual engagement process involved inviting a set of relevant stakeholders in each region and engaging with them online via the virtual engagement platform "Bang the Table". The "Bang the Table" platform was used to display both the region's mini-photo documentary as well as the informed consent form for the study and a series of discussion questions which were used to facilitate a live discussion with participants regarding forest-based assets,

opportunities for partnership, or ideas regarding workforce or product diversification. This discussion was encouraged and informed by information in the mini-documentaries as well as information on other forest-bioeconomy development examples from across Canada which were noted in the noted in the secondary literature review mentioned previously. Assets, product or workforce diversification ideas, and partnership opportunities were recorded and presented back to mill owners/mangers in each region and consequently used as a basis for a follow-up focus group involving mill owners/manages and idea/partnership champions. These follow up meetings were designed to provide a basis for future collaboration between forest industry representatives and idea champions in each region.

IX OVERVIEW OF CASE STUDY REGIONS

Case Study Regions

The global economy is transitioning from a linear and fossil fuel-based economy to a circular and bio-based economy (BIC & BioDesign, 2019; Loorbach et al., 2017). Among renewable resource sectors, those involving biomass, such as forestry and agriculture, have an exceptionally high potential as they can yield petro-analogous chemicals and energy that are abundant and easy to access and process (Hakovirta & Lucia, 2019). However, significant resource and workforce management changes must be implemented for renewable-based sectors to achieve their full potential in this sustainability transition. For instance, natural resource sectors (NRS) need to focus on turning residues into creative outputs, increasing product durability and capacity to be re-utilized and recycled, and diversifying their workforce (BIC & BioDesign, 2019; FAO & UNECE, 2020; Muscat et al., 2021). Canada is well positioned in this context as it has a large territory, plenty of natural resources, and well-established technology and training associated with natural resources exploration (BIC & BioDesign, 2019; CCFM, 2018; NRCAN, 2022).

These assets required to support the bioeconomy transition can be found in the Canadian Province of Newfoundland and Labrador (NL). For instance, the forests of Newfoundland span over two-thirds of the 405,212 km^2 area of the Island, most of it being boreal and conifer tree species (McLaren & Pollard, 2009). Between the 17^{th} and mid-19^{th} centuries, forests within a three-mile

radius of the Island's coast were considered a common property resource for domestic use, such as fuel and house construction. This was the case until there was an increasing demand for forest products for commercial purposes (McLaren & Pollard, 2009). This new demand sparked the evolution of sawmilling operations in the Province, which locals embraced as beneficial for agriculture and overall industrial growth (McLaren & Pollard, 2009). The government of Newfoundland and Labrador granted longer leases to paper mill industries in the Province to meet the demand for newsprint until the end of the 20th century when commercial sawmill production regained its significance (McLaren & Pollard, 2009).

With over 23.2 million hectares of forest (5.2 million ha in Newfoundland and 18 million ha in Labrador), the Government of Newfoundland and Labrador (2014) documented that in addition to the province's forest abundance, NL has policies in place to ensure their sustainable management, well performant departments devoted to the protection of ecosystems and biodiversity, and innovative initiatives to improve the sector's productivity (e.g., The way forward on forestry), all dedicated to making the sector more rentable and sustainable for future generations.

Unfortunately, the forestry and forest product sector has faced a significant decline following the 2008 recession, most importantly because of factors such as globalization (competitive companies in jurisdictions with lower labor cost), rising energy prices, and a diminishing demand for printed newspapers (Service Canada, 2019). Nevertheless, through a product diversification campaign focusing on manufacturing materials for textile production, toilet and facial tissues, and corrugated cardboard, the sector in the Canadian Atlantic Region managed to recover where in 2012 it contributed to the expansion of the Gross Domestic Product (GDP) at a rate of over 40% compared to the previous decade (Service Canada, 2019). The NLFIA (n.d.) asserts that the forest Industry in Newfoundland and Labrador "is valued at $383 million annually and provides direct and indirect employment to over 5,000 people". The vast majority of commercial forest resource production in Newfoundland is attributed to four major companies represented by the NLFIA. These enterprises include Burton's Cove Logging and Lumber Ltd. located in the town of Hampden, Cottles Island Lumber Company Ltd. Located in Cottles Island on Newfoundland's northeast coast, Kruger – Corner Brook Pulp and Paper located in Corner Brook, and Sexton Lumber located in the town of Bloomfield near the base of the Bonavista Peninsula. Another forest-focused region of

Newfoundland, currently lacking a large forest enterprise represented by the NLFIA is the Great Northern Peninsula (GNP). Together, these five regions make of the case study focus areas for this study. The sections below provide overviews of each of these regions with a focus on the socioeconomic, demographics, and forest industry status, and potential to develop a forest-based bioeconomy.

Case 1: Great Northern Peninsula - St. Anthony - Port au Choix Region: Bioeconomy Opportunities and Challenges

The St. Anthony - Port au Choix region (SAPC) of the Great Northern Peninsula corresponds to the Local Areas 71 (Strait of Belle Isle), 72 (Quirpon-Cook's Harbour), 73 (Roddickton), and 74 (Hawke's Bay-Port au Choix), which are part of the Rural Secretariat Region in NL - St. Anthony - Port au Choix (Newfoundland and Labrador, 2022; Fig. 2). The SAPC region was chosen for its relevance to natural resource industries, particularly the forest sector. The report will first provide a general overview of the socioeconomic characteristics of the region, followed by its human and natural resource assets, primarily forest-related. Lastly, this work presents comments and suggestions on how the region can participate more comprehensively in the ongoing changes associated with multi-purpose forest management and circular bioeconomy.

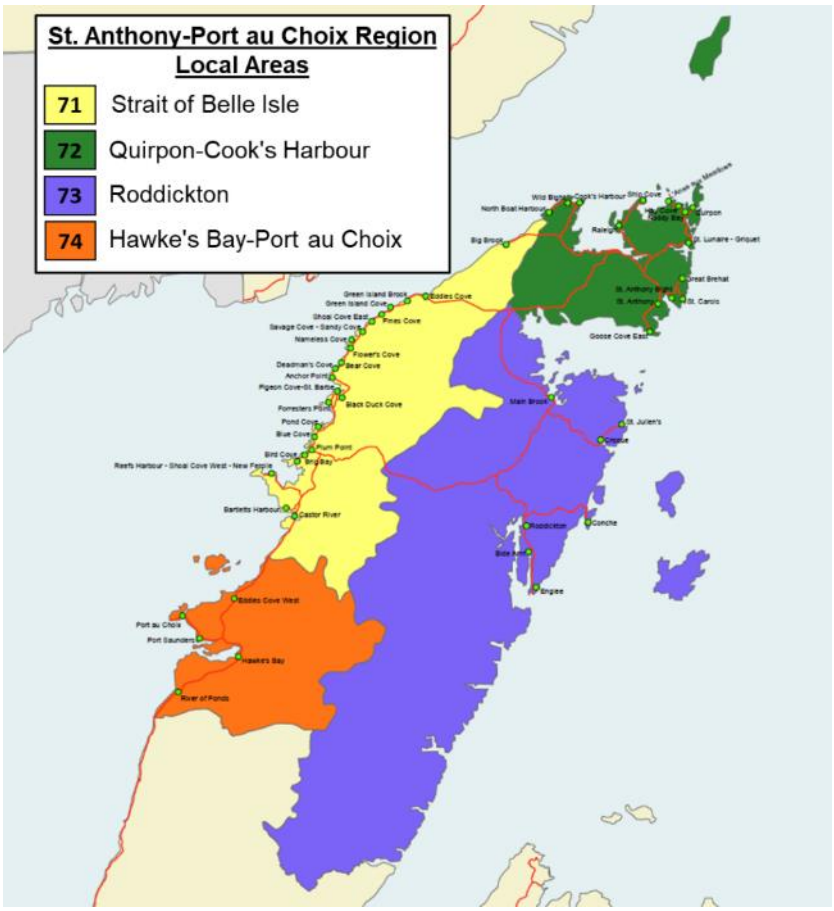

Figure 2. Map representation of the St. Anthony - Port au Choix Rural Secretariat Region in NL. Adapted from Newfoundland and Labrador (2022).

Socioeconomic Overview

Regarding its population, the Government of NL reported that the SAPC region has 11,315 inhabitants, corresponding to 2.2% of the people in the NL (Newfoundland and Labrador, 2022). Concerning population change, there was a -4.43% decrease in the region's population over a 5-year period (2014-2018), which is a significant contrast with the Provincial growth rate of 1% and the Federal rate of 6.2%. Although all Local Areas (LAs) in the SAPC region presented a shrinking trend for their population, there is some variation among them. Notably, the lowest decrease in population was in Quirpon – Cook's Harbour (LA 72) with -3.1% and the highest in Hawke's Bay – Port au Choix (LA 74) with -6.5%. Of the total population in the region, 1,000 self-identify as Indigenous (8.8%), which is the same percentage for the whole Province and higher than the Federal average (4.8%). Indigenous peoples in the region are fairly distributed across Local Areas, with 26-31% in LAs 71, 72 and 74, with the lowest concentration of Indigenous people located in

Roddickton (14%). Furthermore, 155 people in the region self-identify as visible minorities, representing 1.37% of the population in the region, 61.3% of them living in Quirpon – Cook's Harbour (LA 72) (Newfoundland and Labrador, 2022). Regarding immigrants, they represent 1.41% of the population in SAPC (160 people), most of them 68.8% also concentrated in LA 72. These percentages are lower than the Provincial population of visible minorities and immigrants (both at 2.3%) and significantly lower than the Federal rates (21.8% and 21.5%). Regarding labour force size, 61.2% of the region's population (6,930 inhabitants) is within the labour force age category (18-64 years old), thus close to the Provincial and Federal percentages of 63.1%. Nevertheless, the average population age in the SAPC region is 52 years old, therefore higher than the Provincial (46) and 11 years older than the Federal average age (41) (Newfoundland and Labrador, 2022).

Another essential aspect of evaluating the region's economic opportunities and challenges in the bioeconomy context is its average income, employment, and general infrastructure. In 2018, the average income in the SAPC region was CA$29,750.00 per annum, which is lower than the Provincial average (CA$33,500.00) and the Federal average (CA$37,700.00) (Newfoundland and Labrador, 2022). However, while the average income in Quirpon – Cook's Harbour (LA 72) and Hawke's Bay – Port au Choix (LA 74) is respectively CA$32,800.00 and CA$32,900.00, the average in Roddickton (LA 73) is CA$23,900.00. In terms of average income per gender, male workers in the SAPC region receive 1.38 more than female workers (CA$35,775.00 versus CA$25,975.00), which is lower than the Provincial income gap by gender of 1.46 (CA$40,700.00 versus CA$27,900.00) but slightly higher than the Federal gap of 1.35 (CA$44,100.00 versus CA$32,600.00) (Newfoundland and Labrador, 2022).

Among the population of 15 years and over in the SAPC region, 18.3% is unemployed (2,075 inhabitants), which is substantially higher than the Provincial percentage of 7.7% (40,150 inhabitants) and the Federal percentage of 4.1% (1,442,435 inhabitants) (Newfoundland and Labrador, 2022). Among unemployed inhabitants in the SAPC region, 62.4% are men, which is similar to the Provincial proportion (61.6%) but different from the Federal scale (56%). Among industry workers, 16% are employed in natural resource sectors[6], which highlights the impressive

[6] Comprising two categories of the North American Industry Classification System (NAICS): "Agriculture, forestry, fishing, and hunting" and "Mining quarrying, and oil and gas extraction".

participation that such economic areas exert on the SAPC region, particularly when compared to the same data for the Province (7.3%) and the Federal (3.9%) scale. Furthermore, the majority of these workers (39%) inhabit the Strait of Belle Isle (LA 71), and 80.6% of them are men, which represents a higher gender disparity than in the Province (80.1%) and at the Federal level (74%). Finally, the number of dwellings in the region (i.e., houses, apartments, farms, and overall land properties) is 4,750; of those, 89.7% are privately owned, thus higher than the Provincial percentage of 81.2% (Newfoundland and Labrador, 2022).

Human Resource Challenges and Assets

As a sector that heavily relies on modern technology, the forest industry requires a highly skilled labour force (Borzykowski, 2019; FAO & UNECE, 2020). Notably, the employees can only work at their fullest potential if essential parameters such as their well-being and level of education are satisfied. According to Newfoundland and Labrador (2022), 55.3% and 57% of the SAPC region's population reported excellent or very good health and mental health status, respectively (Newfoundland and Labrador, 2022). These self-reported percentages are significantly lower than the Provincial proportions for excellent or very good general health (62%) and mental health status (71.2%). In this context, particularities across LAs in the SAPC region must be noted. For instance, the average general health in the region is mainly affected by the low percentage of people with excellent or very good health status in Roddickton – LA 73 (49,6%) and Hawke's Bay – Port au Choix – LA 74 (47.5%). These same LAs also reported a particularly lower status for their mental health; notably, the highest mental health status on LA 73 was very good, as reported by 40.5% of the population.

Regarding the level of education in the region, 38.8% of the total population aged 15 years and over do not have an education certificate, diploma or degree, 25.7% have a high school diploma or equivalent, and 35.5% completed PSE (Newfoundland and Labrador, 2022). These percentages are very different from the Provincial and Federal averages, particularly for primary and PSE levels. Notably, 23.4% of NL inhabitants aged 15 years and over do not have an education certificate, 25% have a high school diploma, and 51.6% completed PSE. At the Federal level, 18.3% of Canadians have no education certificate, 26.5% have a high school diploma, and 55.3% completed a PSE. Overall, the percentage of the population across all four areas of the SAPC region that completed high school education is fairly similar once the total population of each LA

is pondered. Despite LAs 73 and 74 respectively having 22.6% and 19.1% of the SAPC population without an education certificate, they represent 48.6% and 43% of the people within their LAs. Moreover, 43.1% of the population in the SAPC region with a PSE degree inhabit LA 72, representing 44.7% of the population within the Area (Newfoundland and Labrador, 2022). From the gender perspective, the most disparate distribution among education levels in the region is found for those who completed a high school education (41.9% of males and 58.1% of females); for the other levels, the distributions are balanced by males and females.

Natural Resource Challenges and Assets

Like in most parts of the Province, natural resource industries such as fishing, and forestry played and continue to exert a significant role in the SAPC region. Additionally, tourism closely associated with natural assets has been continuously gaining importance, particularly in the southern portions of the SAPC at the Gros Morne National Park. Established in 1973 and classified in 1987 as a World Heritage site by UNESCO (United Nations Educational, Scientific and Cultural Organization), the National Park comprises 180,500 ha of unique natural and cultural features (UNESCO, n.d.). One of the largest National Parks in Atlantic Canada, Gros Morne portrays "a rare example of the process of continental drift, where deep ocean crust and the rocks of the earth's mantle lie exposed" – i.e., The Tablelands (PAA, 2008a; UNESCO, n.d.). Furthermore, "recent glacial action [resulted in] coastal lowland, alpine plateau, fjords, glacial valleys, sheer cliffs, waterfalls and many pristine lakes" (UNESCO, n.d.). Some of these unique sites can be experienced through year-around hikes, camping, and boat tours such as in the Western Brook Pond (Parks Canada Agency, n.d.a; Parks Canada Agency, n.d.b). In addition to these landscape features, the value of the natural assets in Gros Morne is amplified by its accessibility (about 20 minutes drive from a regional airport) and the near-pristine conditions (UNESCO, n.d.). Furthermore, the Canada National Parks Act ensures that these conditions are preserved, including the observance of the people currently residing in the Park, the management of visitors, and monitoring of potential impacts from resource extraction and the introduced moose population (UNESCO, n.d.; Parks Canada Agency, n.d.c).

In the bioeconomy context, tourism involves appreciating ecosystem services and nonmaterial assets, and decreasing demand for natural resources by efficiently utilizing harvested assets - including their residues (Galanakis et al., 2022; Tyrväinen et al., 2017). According to the authors,

the link between bioeconomy resources (i.e., agriculture, forestry, fishing) and outdoor tourism are vital in a post-COVID-19 era. Examples are the decarbonization of transport systems and the support for lower and environmentally conscious consumers. Furthermore, Tyrväinen et al. (2017) argue that many nature-based tourism organizations are small-scale, located in rural regions and often interact with other resource users. Thus, such activities can significantly benefit areas struggling with socioeconomic and demographic issues (Lundberg & Fredman, 2012). In fact, tourism activities based on forests and other natural resources are already part of bioeconomy strategies in countries such as Finland, Norway, and Sweden (Winkel, 2017). In any case, the direct or indirect exploration of natural assets in the SAPC region is closely associated with its ecoregions, markedly, there are three subregions of the Northern Peninsula Forest – NPF (Beaver Brook Limestone, Northern Coastal, and Eastern Long Range subregions – PAA, 2008b; 2008c; 2008d), one subregion of the Long Range Barrens (Northern Long Range subregion – PAA, 2008a), and the Strait of Belle Isle Barrens ecoregion (PAA, 2008e).

The NPF covers most of the Great Northern Peninsula coastal areas and has one of the shortest growing seasons on the Island, with cool summers and long cold winters (PAA, 2008b; 2008c; 2008d). This is primarily due to the cooling currents from Labrador and the North Atlantic Ocean. Moisture deficiencies do not occur in the NPF as cool summers do not entirely evaporate the water in the soil, despite the low precipitation. Among NPF subregions, the Beaver Brook Limestone is the most climactic favourable to plant growth, particularly in sheltered places with richer soils that sustain larger trees at a denser distribution (PAA, 2008b). Nevertheless, vegetation in this subregion has only about 110 days per year to grow, with balsam fir being favoured as the dominant species as large-scale disturbances are mostly absent. A second subregion in the NPF is the Northern Costal, which is "comprised of coastal headlands and an otherwise flat, generally low-lying landscape" (PAA, 2008c, p. 1). Forest can occur in sheltered areas, but the overall nutrient-poor and basic pH soils prevent forests from being more widespread and fully developed, thus giving place to dwarf shrubs. Due to the limited forest cover, mammals that appear in other parts of the NPF are not as common here; in contrast, a wide variety of bird species are found in this subregion. The last NPF subregion in the SAPC is the Eastern Long Range, with a significant forest cover in its southern portions across the coastal area. However, the locations within the SAPC do not possess the same climatic shelter from the interior of the Island (PAA, 2008d). Trees in this subregion can withstand even in higher altitudes (highest areas being ca. 450 m above sea

level), but they tend to be relatively spaced from each other. The absence of large-scale disturbances (e.g., forest fires, insect infestation, logging) contributes to trees in the subregion being "extremely old for boreal trees", thus harbouring a greater variety of plant and animal species (PAA, 2008d, p. 4). In contrast with areas where large-scale disturbances are more common, forests in the Eastern Long Range are multi-age and multi-storied, thus supporting a variety of microclimates. Although this subregion does not harbour traditional protected areas, the Main River is a Canadian Heritage River and a waterway park, highlighting the many recreational opportunities and ecosystem services it supports.

The second ecoregion in the SAPC is the Long Range Barrens, specifically its Northern Long Range (PAA, 2008a) subregion. It is the most northern subregion of the Island, comprehending most of the Great Northern Peninsula (GNP). It is "characterized by windy, highland areas covered with extensive barrens [that were mostly] never forested", except for a few sheltered valleys (PAA, 2008a, p. 1). Nevertheless, these trees are often underdeveloped and often found in low, dense thickets of tuckamore (i.e., mostly black spruce). According to the report, tuckamore are "areas where growth-limiting factors have resulted in dense thickets of stunted coniferous trees" (PAA, 2008a, p. 2). This subregion has a short growing season, with some of the lowest temperatures and permanent snow cover occurring in some areas or persisting until late June. Therefore, it also has some plants best adapted to occupy areas where snow occurs during parts of the growing season (snow bedding). In terms of wildlife, there are many species of mammals, and the many lakes and rivers in the Northern Long Range subregion harbour various fish species. Finally, a significant portion of the Gros Morne National Park and the Main River occur in this subregion.

The last ecoregion in the SAPC is the Strait of Belle Isle Barrens, which occupies the northwestern tip of the Island and possesses the shortest growing season (PAA, 2008e). Ice in its coastal areas does not fully break until late June or early July and frost events can occur any month in the year. Large areas in this ecoregion have bedrock exposed and when soil occurs, it is shallow, thus only supporting tundra-like vegetation with some "dense masses of tuckamore containing white birch, black spruce, and balsam fir" (PAA, 2008e, p. 2). In terms of wildlife, the region experiences regular visits from birds from arctic areas and occasionally polar bears during spring. The Strait of Belle Isle Barrens has five protected areas, which protect 4% of its territory. They are the Ecological Reserves of Watts Point and Burnt Cape, the L'Anse aux Meadows National Historic Site, the Pistolet Bay Provincial Park, and the Sandy Cove Provisional Ecological Reserve (PAA,

2008e). Among those, the L'Anse aux Meadows site is one of the most noteworthy for its historical importance as the place with the oldest evidence of Norse expeditions in the Americas. Thus, visitors experience not only the scenic landscapes, but also a series of historical activities such as "The Viking Encampment" (Parks Canada Agency, n.d.d).

Forestry Industry

Among renewable resource sectors in the SAPC region, fishing and forestry had the most prominent role, with the potential to reinvigorate if certain agreements advance, despite the long wait. Two mills portray the role of forestry in the region and their respective communities. The mill known until recently as Coates Lumber in Main Brook, hosted the majority of jobs in the area during the first half of the 20th century (Community Stories, n.d.). This positive trend continued for a long time, supported by the demand for pulpwood from the Bowater's mill in Corner Brook until a market downturn in the late 60s to early 70s (Live Rural NL, 2013). The market never fully recovered in the area; the former Coates Lumber mill was forced to lay off seven of its nine workers due to a lack of demand for its products (Barker, 2018). The second lumber mill in the SAPC region is Holson Forest Products, an integrated mill in the town of Roddickton-Bide Arm (Roddickton-Bide Arm, n.d.). Originally founded by fishermen and hunters, the sawmilling operations in Roddickton-Bide Arm began in 1906, with interruptions occurring over the following decades. Similar to the Coates Lumber case, the Bowater's operation in the 1930s significantly changed the forest industry in Roddickton-Bide Arm, with a substantial increase in annual production and employment, followed by the construction of a road that greatly increased the area connectivity (Roddickton-Bide Arm, n.d.). In more recent years, Holson Forest Products was the principal employer in 2006, despite the mill's continuous capacity reductions.

Opportunities for Natural Resource Sectors in the Bioeconomy

The SAPC region has a long history of forestry, most notably the harvesting and shipping of timber by Bowater's Newfoundland Paper Mills Limited (known locally as "Bowaters"). From the late 1940s to 1968 the forest sector played a significant role in the region's economy. Following the departure of Bowaters in 1968, forestry declined. A missed opportunity for the sector and its forest-dependent communities in the SAPC region started in 2009, with the multi-million-dollar announcement by the Provincial Government to modernize the region's sawmilling operations and initiate a pelletizing facility in the Northern Peninsula (Roddickton-Bide Arm, n.d.). Over the

years, the pelletizing operation gained traction after several companies including Timberlands (owned by the British investor Active Energy Group – AEG) expressed interest in manufacturing wood pellets at Hawke's Bay (Roberts, 2018, Roberts, 2019). However, for the operation to be feasible, a suitable port and a thriving sawmill operation would need to exist in the region to complement the pelletizing facility. Unfortunately, to date no new forest ventures has been directed to the region, despite the existence of a rich forest resource base and significant silviculture investments.

SAPC: Final Considerations

The demographic trend for the SAPC region shows a significant population decline, with some variation occurring among Local Areas (Newfoundland and Labrador, 2022). The low percentage of immigrants in the region reinforces the issue by not compensating for the low natural fertility and missing the opportunity to not increase the region's resilience with international partnerships and diversified perspectives (Clair, 2021). In addition, almost 70% of the immigrants in the region are concentrated in one Local Area (Quirpon – Cook's Harbour – LA 72), which further reduces the potential of these individuals to exert a positive influence throughout the region. On the other hand, a relatively high proportion of the population self-identifies as Indigenous, which can be an asset if they are genuinely included in the labour force so that their perspectives and decisions are acknowledged and implemented (see Beaudoin et al., 2021; Lawler & Bullock, 2017 for how such opportunities were realized elsewhere). Overall, a large percentage of the population in the SAPC region is within the labour force age category, but the average age is 52 years old, indicating the risk of not having enough people to replace retirees.

The population in the region has a lower average income than the Provincial and Federal rates, with considerable variation within the region (Newfoundland and Labrador, 2022). While two of the Local Areas (72 and 74) have an average income reasonably close to the Provincial rates, the Area with the lowest average income (LA 73) is 10,000.00 lower than the Provincial average. On the other hand, the wage differences by gender are narrower than Provincial values and just slightly higher than Federal rates. In other words, although the narrower wage gap supports a more inclusive participation of females and males in the labour market, the overall low income leaves little room to invest in crucial factors in the bioeconomy transition, such as PSE, skill training, and research and innovation. Furthermore, the region has a very high unemployment rate compared to

the Provincial or Federal contexts, with most unemployed being males. Another notable fact about the SAPC region that needs to be addressed is the lower status of health and mental health reported by its inhabitants. Undoubtedly, these statuses not only reflect the issues with previously mentioned socioeconomic indicators but can also become an exacerbator as individuals with lower health status cannot be as productive (FAO & UNECE, 2020; Hakovirta & Lucia, 2019). Regarding education, the SAPC region has the highest proportion of the population aged 15 years and over without an education certificate and the lowest percentage that completed a PSE among the five study case regions in this project. More importantly, individuals without an education certificate are almost 50% of the population in two of the four Local Areas in the region. In general, the low level of education significantly hampers the bioeconomy development in the region and the potential to innovate, engage in entrepreneurship activities, and work in positions of high decision power and added value (Kennedy et al., 2021).

The influence of the NRS in the region is impressive, even for NL parameters. For instance, a very high proportion of the region's industrial workers are employed in fisheries, forestry, and tourism. (Newfoundland and Labrador, 2022). The impressive participation that NRS have in the SAPC region is even higher when we consider the high unemployment rate, the low average income, and the fact that the vast majority of workers in the SAPC's natural resource industry are males. Overall, one of the bioeconomy-related sectors with the greatest potential in the SAPC region is tourism. The province is known for its scenic landscapes, and the Great Northern Peninsula concentrates unique sites with natural and historical importance, such as the Gros Morne National Park, the L'Anse aux Meadows National Historic Site, and one of the Canadian Heritage Rivers – the Main River (Parks Canada Agency, n.d.a; n.d.d). Moreover, the region's proximity to a regional airport in Deer Lake further supports the development of outdoor tourism activities. In terms of forest growth and availability, the region does not have the optimum growing season due to harsh conditions such as the air currents from Labrador and the North Atlantic. In fact, two of the three major ecoregions in the SAPC region are characterized by barren landscapes, therefore demanding a management approach that considers the relatively lower availability of forests, among other factors (PAA, 2008a; 2008e). In other words, it reinforces the importance of adopting a more sustainable management approach that explores other non-lumber assets and upcycling residues. Moreover, the lack or low occurrence of landscape-wide disturbances in the region resulted in multi-age and multi-storied habitats with greater potential to host a more diverse set of

plant, animal, and fungus species. Therefore, sustainably managing natural assets in the SAPC needs to be inherently multi-functional to yield the most significant benefits to these unique and diverse ecosystems at the lowest impact (BIC & BioDesign, 2019; FAO & UNECE, 2019).

Despite the potential of NRS in the region, no major sawmilling operation is currently ongoing in the SAPC. Nevertheless, there are harvesting operations in the region that currently ship lumber to other mills in the province, which is not optimum for creating and keeping a higher value in the community. In fact, the proposals around the construction of a pelletizing facility in Hawke's Bay and the modernization of existing mills bring optimism for the bioeconomy development in the region. This pathway is in line with recommendations made in a recent report on Workforce Strategies for NL (Freshwater & Ward, 2022). Notably, the report advocates for Smart Specialization Strategies, which consist of investments based on a region's strengths combined with incremental innovations. However, negotiations around the pelletizing facility and related sawmilling operations have been stuck for quite a long time, leading to increasing frustration, despite reports of significant work being done in the background by Governmental representatives (Roberts, 2018, Roberts, 2019). The issue is complicated given the geographically large area with a small population and ineffective regional governance (Freshwater & Ward, 2022). According to the authors, many local/municipal governments are too small to play an influential role in identifying and acting upon local opportunities, including exerting influence power on provincial players. While a certain level of regionalization is not implemented, mayors and council members have limited capacity to pressure potential investors and governmental officials to build upon the strengths of the SAPC region and address its current shortcomings.

CASE 2: BURTON'S COVE REGION: BIOECONOMY OPPORTUNITIES AND CHALLENGES

A second region under consideration for bioeconomy development encompasses the existing assets, potential opportunities, and possible challenges within the Burton's Cove (BC) region. The selected region corresponds to Local Areas 38 (Deer Lake-Cormack), 41 (Jackson's Arm), and 58 (White Bay South), which are part of two Rural Secretariat Regions (the Corner Brook - Rocky Harbour and the Grand Falls-Windsor-Baie Verte Harbour Breton) of the Province (Newfoundland and Labrador, 2022) (Fig. 3). A list of municipalities in these Local Areas can be found in Appendix A. The region was chosen for its relevance to natural resource industries, particularly the forest sector located in the White Bay area of NL, and our focus is on Burton's Cove Logging

and Lumber Ltd. at Hampden, NL. The report will first provide a general overview of the socioeconomic characteristics of the region, followed by its human and natural resource assets, primarily forest-related. Lastly, this report offers comments and suggestions on how the area can participate more comprehensively in the ongoing changes associated with multi-purpose forest management and circular bioeconomy.

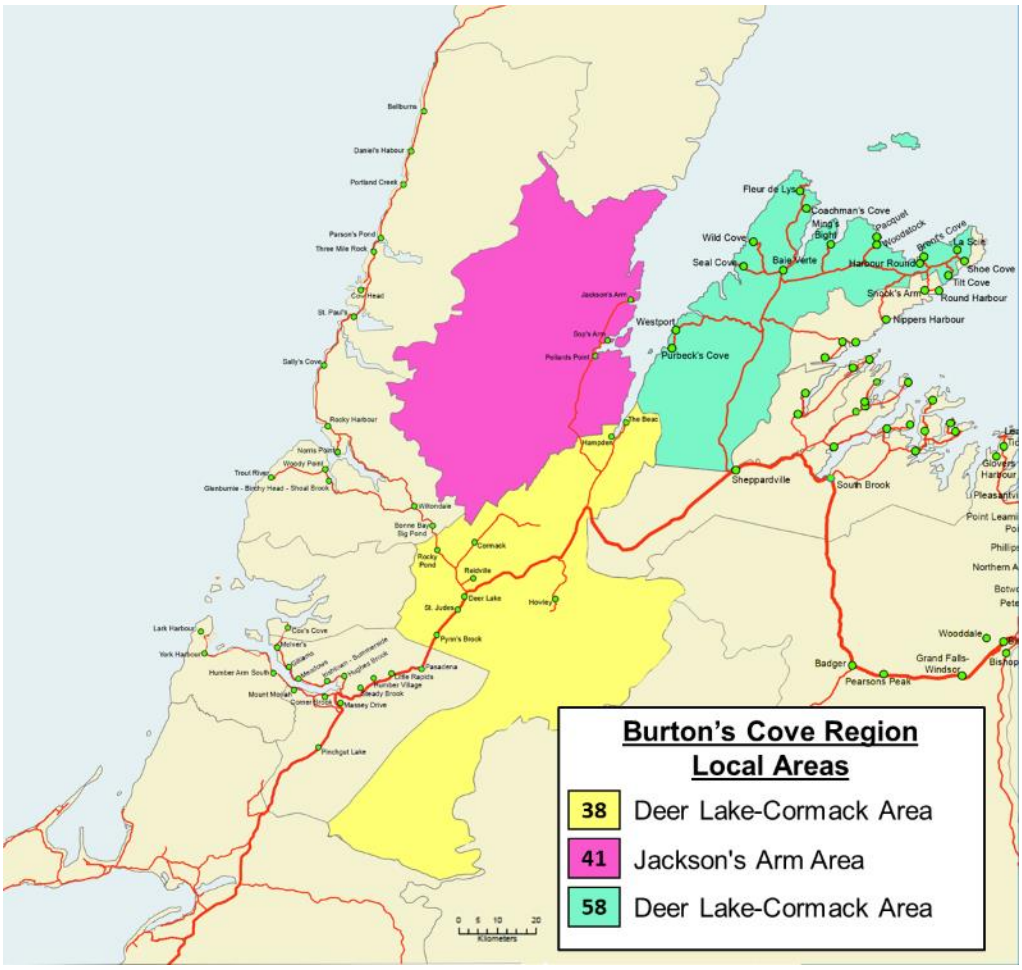

Figure 3. Map representation of the three Local Areas that constitute the Burton's Cove region. Adapted from Newfoundland and Labrador (2022).

Socioeconomic Overview

Regarding its population, the last Canada census (2016) reported that the BC region has 12,370 inhabitants, corresponding to 2.4% of the population of NL (Newfoundland and Labrador, 2022). Most of the population in the region lives in the Deer Lake-Cormack area (LA 38) with 7,435 inhabitants (60.1%), followed by White Bay South area (LA 58) with 4,185 inhabitants (33.8%), and the Jackson's Arm area (LA 41) with 750 inhabitants (6.1%). From 2014 to 2018, the region's

population decreased on average by 2.4%. While this contrasts with the Provincial (1%) and positive Federal growth rates (6.2%), it is noteworthy that the Deer Lake-Cormack area population increased by 3.8% for the same period. Of the total population in the BC region, 1,285 self-identify as Indigenous (10.4%), which is higher than the Provincial and Federal percentages of 8.8% and 4.8%, respectively. Meanwhile, 140 of the region's inhabitants identify as visible minorities (1.1%) and 105 as immigrants (0.9%) (Newfoundland and Labrador, 2022). These percentages are substantially lower than the Provincial population of visible minorities and immigrants (2.32% and 2.27%) and much lower than Federal rates (21.8% and 21.5%). In terms of labour force size, 60% of the region's population (7,420 inhabitants) is within the labour force age category (18-64 years old); thus, close to the Provincial (63.1%) and Federal (63.12%) percentages. Nevertheless, while the current average age at the Provincial level is 46 and at the Federal is 41, it is significantly higher in the BC region at 52 years old (Newfoundland and Labrador, 2022).

Although the average population change for the BC region decreased by 2.4% over the past years, the most populous area (Deer Lake-Cormack) grew by 3.8%, which is higher than the average increase of 1% for the whole Province of NL (Newfoundland and Labrador, 2022). This growth potential and proximity to communities of significant size (i.e., BC region at ca. 12,000 inhabitants) are critical for bioeconomy enterprises such as the Burton's Cove mill. It represents a potential market demand nearby for bio-based products, by-products, and services, as well as prospective workers. Unfortunately, some of these positive prospects may not last in the long term if changes are not implemented. For instance, although most inhabitants are of working age (60%), the average age in the BC region (52 years old) is just a little more than a decade away from the retirement age of 65. Additionally, the current population of immigrants (0.9%) indicates that the influx of this group in the region has been minimal, a missed opportunity for sustainable growth of the region's demographics. On the other hand, the BC region has a population of Indigenous inhabitants (10.4%) that is higher than the Provincial average (8.8.%) and more than double the Canadian average (4.8%). This may represent an excellent opportunity for the natural resource sectors to diversify their workforce and implement alternative resource management practices of great potential (Wyatt et al., 2019).

Another essential aspect of evaluating the region's economic opportunities and challenges in the bioeconomy context is its current average income, employment, and general infrastructure. In 2018, the average income in the BC region was CA$26,566.67 per annum, which is substantially

lower than the Provincial (CA$33,500.00) and the Federal average (CA$37,700.00) (Newfoundland and Labrador, 2022). However, there is a standard deviation of about CA$3,000.00 among the three local areas in the BC region. Notably, the average income in the Deer Lake-Cormack area is CA$29,000.00, in the White Bay South is CA$27,600.00, and in the Jackson's Arm area it is CA$23,100.00; the latter being 1.63 lower than the Federal average income. In terms of average income per gender, male workers in the BC region earn, on average, 1.69 more than female workers (CA$36,100 versus CA$21,300), which is higher than the Provincial gap of 1.46 (CA$40,700 versus CA$27,900) and even more than the Federal gap of 1.35 (CA$44,100 versus CA$32,600).

Among the labour force population in the BC region, 12.1% is unemployed (1,495 inhabitants), which is higher than the Provincial percentage of 7.7%, and the Federal percentage of 4.1% (Newfoundland and Labrador, 2022). Among unemployed inhabitants, the gender gap is narrower in the BC region than in the province and closer to Federal rates. Notably, 56.2% of the unemployed in the BC region are men, 61.6% in the province, and 56% at the Federal level. Among the employed population in the BC region, 17.3% work in natural resource sectors[7], which is substantially higher than the Provincial (7.4%) and Federal (3.9%) percentages of workers in these areas. Among them, 79.9% of these workers are men, which is comparable to 80.1% in the province and 74% at the Federal level. Finally, the number of dwellings in the region (i.e., houses, apartments, farms, and overall land properties) is 5,235, representing 2.4% of all dwellings in the Province (Newfoundland and Labrador, 2022). Of those, 82.6% are privately owned, thus similar to the Provincial percentage of 81.2%.

The combination of a low average income and a high unemployment rate reinforces the importance and potential of the NRS in the BC region. The substantial percentage of workers in these sectors (17.3% contrasting with 9.9% in NL and 13.4% in Canada) underline the sectors' major importance as an employer in the region (Newfoundland and Labrador, 2022). On the other hand, the overall low average income and high unemployment highlight the urgency of a successful sustainability transition toward the bioeconomy. In other words, the creation of specialized and higher-paying jobs supported by innovative products of high added value and the full utilization of by-products

[7] Comprising two categories of the North American Industry Classification System (NAICS): "Agriculture, forestry, fishing, and hunting" and "Mining quarrying, and oil and gas extraction".

to generate a direct socioeconomic gain in the area. Furthermore, men are the majority of the unemployed (56.2%) and workers in NRS (80%) in the BC region. This elucidates two points: a) NRS in the region are extremely male dominated; b) these jobs are essential to the socioeconomic stability in the region, mainly because men concentrate the majority of the income. In fact, for every dollar a man receives in the BC region, a woman gets 59 cents. Since workforce diversification is one of the critical aspects of a successful sustainability transition, promoting gender balance in NRS must be one of the main strategies (BIC & BioDesign, 2019; Muscat et al., 2021). Finally, these sectors' importance as major employers in the BC region can be extended to their capacity to influence others, particularly a younger generation in their career decision. Therefore, it is imperative that these workers are satisfied with their jobs and aware of the potential advantages that a bioeconomy transition means to NRS.

Human Resource Challenges and Assets

As a sector that heavily relies on modern technology, the forest industry requires a highly skilled labour force (Borzykowski, 2019; FAO & UNECE, 2018, 2020). According to Community Accounts (Newfoundland and Labrador, 2022), 60.6% and 77% of the BC region's population reported excellent or very good health and mental health status. Compared to the Provincial self-assessment, the percentage of the population that reported their health status as excellent or very good in NL is barely higher for general health (62%) and lower for mental health (71.2%).

Regarding the level of schooling, 32.6% of the region's inhabitants had no certificate, diploma or degree, 26.4% had a high school diploma or equivalent, and 41% had a post-secondary education – PSE (Newfoundland and Labrador, 2022). These percentages differ in the province, particularly concerning people with no certificate and those with a PSE degree. Notably, 23.4% of NL inhabitants do not have an education certificate, 25% have a high school diploma, and 51.6% completed a PSE. From the gender perspective, women in the BC region are the majority of people with no education certificate or diploma (52.3%) and high school degree (56.9%), but men are the majority with a PSE certificate (53.2%). While in the province, women are the majority of people at all educational levels, even if by a slim margin. Notably, women in NL are 50.2% of those without a certificate, 54.1% with a high school degree, and 50.7% with a PSE diploma (Newfoundland and Labrador, 2022). The distribution of people according to their highest level of education in the BC region is remarkably contrasting compared to the Federal percentages. That

is, 18.3% of Canadians have no education certificate, 26.5% have a high school diploma, and 55.3% completed a PSE. Specifically, there is a difference of ca. 14% among people without an education certificate and ca. 14% with a PSE degree between inhabitants in the BC region and at the Federal level. In terms of the gender educational gap, the differences are overall smaller for country-wide percentages than in the BC region. Notably, 50.9% of Canadians with no certificate are men, whereas women are 51.3% and 51.8% of those with a high school and a PSE degree.

Naturally, the population's overall well-being and education level in a given region are essential for supporting the demand for skilled and healthy workers, particularly in the bioeconomy transition (FAO & UNECE, 2020; Hakovirta & Lucia, 2019). In the context of the BC region, the high percentage of inhabitants reporting very good and excellent general and mental health is highly beneficial to the forestry and other NRS in the area. On the other hand, the educational level in the region can be a barrier. A high level of education is essential in industries such as the NRS, which are increasingly adopting modern technologies quickly. The benefits of a skilled workforce to the NRS are numerous, but they are equally crucial for the communities in which these industries are located. Overall, a higher level of education allows citizens to find jobs more easily, in positions with higher wages and lower chances of layoffs (Kennedy et al., 2021). Additionally, PSE can broaden citizens' perspectives at a personal and professional level, potentially reflecting on entrepreneurship initiatives that are critical for the emergence of disruptive ideas (Kuckertz, 2020).

In summary, the high percentage of individuals with no education certificate indicates that initiatives aiming to increase the proportion of people with a PSE degree cannot be implemented without, or at least concomitantly, addressing the primary education issue. As a major employer in the region, NRS' role in this issue is crucial, particularly considering two events: 1) the privatization of the Adult Basic Education (ABE) program in 2014, which reduced CNA's funds and its ability to facilitate the transition from primary to PSE, thus decreasing overall enrolment; and 2) the termination of MUN's division of Lifelong Learning at the St. John's campus. The latter's cancellation has been described as "limiting access of the general public to the… university… and contributing to a sense of disconnection between the university and the community, particularly in rural areas" (Kennedy et al., 2021, p. 106). Meeting bioeconomy's education requirements involves the participation of many players from the Provincial Government and NRS organizations to foster critical learning programs (Life Long and informal) and apprenticeship opportunities related to

renewable resource areas (Hakovirta & Lucia, 2019).

Natural Resource Challenges and Assets

Like in most parts of the province, natural resource industries such as fishing, forestry, and mining played and continue to exert a significant role in the BC region. Additionally, there is an increasing interest in tourism activities closely associated with natural assets in places such as the Sir Richard Squires Provincial Park. Established in 1954, the Provincial Park is located in the Deer Lake-Cormack area (LA 38), and it is known for its waterfalls, hiking trails, wildlife, and angling (Newfoundland and Labrador, n.d.a). In the bioeconomy context, tourism involves appreciating ecosystem services and nonmaterial assets and efficiently utilizing harvested resources such as biomass from forestry residues (Galanakis et al., 2022; Tyrväinen et al., 2017). Tourism activities in the region are further supported by the proximity (ca. 65 km) to a regional airport in Deer Lake, NL.

In addition to the tourism industry, the bioeconomy is evidently associated with the natural resources and conditions available in a region's ecosystem. For instance, a region's climate, soil, natural disturbances, and other aspects determine which plant and animal species are found for direct and indirect exploration. In the case of the BC region, five of the nine ecoregions in the island portion of Newfoundland and Labrador (PAA, 2008f, 2008g, 2008h, 2008i, 2008j). A brief description of these ecosystems follows. The Central Newfoundland Forest (CNF) ecoregion is present in most of the BC region, including the municipality of Hampden, where Burton's Cove Logging and Lumber Ltd is located (PAA, 2008f). The CNF climate is predominantly continental, one of the driest ecoregions on the island, primarily due to the influence of the Long Range Mountains to its east and warm summers. Therefore, CNF's boreal forests are prone to fires, favouring extensive stands of tree species such as black spruce and white birch, with balsam fir occurring in areas where fire is less frequent (PAA, 2008f). The second ecoregion is the North Shore Forest (NSF), which is present in the upper portion of the White Bay South area (Local Area 58) (PAA, 2008h). The NSF has the warmest and driest summers of any coastal location on the island, despite its proximity to the ocean. Consequently, forest fires are even more frequent and extensive than in CNF, leading to sizable fire stands of black spruce. Most of this ecoregion is forested, but trees on the coastline have their growth impaired due to direct exposure to wind from the Atlantic Ocean.

Two ecoregions are found on the other side of the White Bay in the Jackson's Arm area (Local Area 41): the Northern Peninsula Forest subregion of the Easter Long Range (ELR) and Northern Long Range subregion of the Long Range Barrens (LRB). First, the ELR is mostly forested with trees at much higher elevations than other parts of the province due to the lower exposure to the North Atlantic Ocean (PAA, 2008i). Nevertheless, it is still one of the coldest ecoregions of the province, with short growing seasons. Due to infrequent fire or other disturbances (natural or anthropic), forests in the ELR are categorized as old-growth, harbouring a high biodiversity of animals and plants due to the variety of habitats created by multi-age and multi-storied structure (PAA, 2008i). Balsam fir is the dominant species, with black spruce occurring in higher altitudes. Regarding fishing resources, the ELR has the three-spine stickleback, ninespine stickleback, Atlantic salmon, brook trout, rainbow smelt, and American eel. Second, the LRB is present in most of the Great Northern Peninsula, and it is known to be windy, with highland areas covered with extensive barrens (PAA, 2008b). Forests grow only in sheltered regions due to various growth-limiting factors that make trees stunted and found in areas known as tuckamore.

The last ecoregion in this case study area is the Corner Brook subregion of the Western Newfoundland Forest (WNF) (PAA, 2008j). Found in the southern portion of the Deer Lake-Cormack area (Local Area 38), this ecoregion is considered one of the most favourable for plant development due to its warm summers protected by the Long Range Mountains and its rich soils. Forests in the WNF are dominated by balsam fir and ferns at the ground level. Rivers and ponds in this subregion are inhabited by the nine-spine stickleback, three-spine stickleback, black-spotter stickleback, arctic char, Atlantic salmon, brook trout, rainbow smelt, American eel, mummichog, and banded killifish (PAA, 2008j).

Mining operations in the BC region also have historical importance, particularly in the White Bay South area. For instance, the exploitation of asbestos deposits in the region dates back to 1963 (Rennie, 2010). Currently, Anaconda Mining Inc. runs multiple operations in the White Bay South region, particularly gold mining in the Baie Verte Mining District (Signal Gold Inc., 2022a, 2022b). According to the Provincial Government, there are primarily five mining operations in NL, providing jobs to more than 7000 people (Newfoundland and Labrador, n.d.b). In the BC region, there are about 400 mining workers, corresponding to 4.1% of the sector's total workforce in the province. Among those, men are the overwhelming majority (380), accounting for 95% of the sector's workforce in the region.

Forestry Industry

Naturally, the price of traditional forest products such as lumber and pulp is a determining factor for the growth of the forestry industry in Newfoundland. According to Wernerheim and Long (2010), lumber prices have been declining yearly since 1990. Prices in the global market also affect local products' value; hence, whether the products from Burton's Cove Logging and Lumber Ltd are supplied to the local or international market, their price may affect productivity. For instance, housing demand in NL is one of the parameters that affect the supply of lumber for construction in the province (Wernerheim & Long, 2010). According to the Government of Newfoundland and Labrador (2020a), housing starts in the province fell by 13.8% in 2019 compared to 2018. It is important to note that this decline is mainly attributed to housing market conditions and not to exogenous factors such as a reduced supply of construction materials. In general, the existing market for lumber in Newfoundland is still small, hence most of the forest products are sold outside the Province (Newfoundland and Labrador, 2020a).

Regulations and policies play an essential role in managing the activities and operations in the forest industry. They provide guidelines regarding annual allowable cuts, tenure arrangements, certification requirements, etc. (Kelly, 2012). Sinclair and Kean (2006) highlight that "in practice, the regulation of forest activity creates much tension and dispute as groups with different interests compete for access". For instance, paper mills in Newfoundland are given priority access to forest lands, and sawmills have to purchase the right to access these lands. As previously mentioned, the most significant forestry player in the BC region is Burton's Cove Logging and Lumber Ltd in Hampden, NL. The mill started as a small family business by logging and selling lumber on a local scale (Fullerton, 2014). With time, the government realized that lumber produced by small sawmills had a reduced fibre content and recommended the establishment of integrated sawmills which contributed to Burton's Cove Logging and Lumber Ltd as an integrated mill in 1998 (Fullerton, 2014). Presently, the mill is considered one of the major contributors to Newfoundland's forest industry (Kean, 2018). It employs about 42 people in Hampden and is one of the largest employers in the area.

Burton's Cove Logging and Lumber Ltd has demonstrated much potential for growth and expansion over the years since it was first set up in 1998. Employing people with excellent knowledge and expertise enabled access to innovative ideas, while visits to highly efficient mills

in other provinces provided insights into new technologies and strategies to increase production and expand Burton's Cove mill operations (Fullerton, 2014). Some of these innovations included using 3D-scan for scale volume of logs, MEC Dry Kiln's hot air application on wet logs, and Canadian Food Inspection Agency (CFIA) certification of their kiln to move into the U.S. market (Fullerton, 2014). The government of Newfoundland and Labrador is investing in forestry innovation to improve and diversify the industry (Newfoundland and Labrador, 2014). In addition to the provision of loans in 2013, the Provincial government also supported Burton's Cove Logging and Lumber Ltd by introducing finger-jointing to enable sawmills to produce longer-length lumber (Newfoundland and Labrador, 2020b). The government's support and investment in the forest industry is an avenue for Burton's Cove Logging and Lumber Ltd to expand its operations and adapt to emerging trends.

Opportunities for Natural Resource Sectors in the Bioeconomy

Bioenergy is one of the alternatives to fossil fuels in the Province of Newfoundland and Labrador, and it has been considered a primary opportunity for the forest industry (NEIA, 2016). Bioenergy can be used as a fuel and energy source for heating in industrial infrastructures. This could be an opportunity for Burton's Cove Logging and Lumber Ltd to manage its residues and sell a portion of them to other companies, such as Corner Brook Pulp and Paper Ltd. Additionally, by-products such as sawdust are helpful for agricultural purposes, which is most welcome if it reduces the production costs (e.g., importation and subsidies) involved with traditional amendments while also diverting residue from landfills. Ibeawuchi et al. (2015) show that sawdust can make organic mulch to help control weeds and increase soil decomposition. Another study showed that applying plant residues such as sawdust increases soil fertility and enhances plant growth (Moyin-Jesu, 2007). With the existing food insecurity issues in the province, particularly evident during the COVID pandemic, opportunities like this are advantageous for multiple players and sectors (Walsh, 2020).

For instance, the soil in Canada is overall acidic (pH 6.0 and lower), particularly in western portions of the country, i.e., the Maritimes and Newfoundland (Elliott et al., 2022). In this context, the use of residues from the forest sector, such as wood ash, has been pointed out by researchers worldwide as an effective alternative to lime. Notably, the application of ash as a soil amendment is growing in Europe, but not in Canada due to the mandatory approval process for forested lands

and the lack of regulation in some provinces (Hannam et al., 2016). These barriers create a troublesome situation in which the disposal of these residues in landfills is the most cost-effective option; in short, "getting regulatory approval is the main obstacle to land application of ash" in Canada (Elliott et al., 2022, p. 7). Similarly, the use of fly ash in Canadian concrete manufacturing was previously hampered by a strict interpretation of the ASTM (American Society for Testing and Materials) C618 regulations until a less stringent understanding was adopted (Elliott et al., 2022). Concerning NL, "no specific guidance has been developed for wood ash applications on forest or agricultural soils in the province" (Hannam et al., 2016, p. 15). Without clear regulation, any large-scale application of forestry residues in agriculture would require an Environmental Assessment that can pose a barrier even to initiatives that are perfectly cautious with the environment and human health.

Biorefining is an additional opportunity for firms in the forestry industry to add value to their wood products (NEIA, 2016). According to Berntsson et al. (2012, p. 17) several definitions of biorefining exist, but the one related to the forest industry connotes the "full utilization of the incoming biomass and other raw materials for simultaneous and economically optimized production of fibres, chemicals and energy". Biorefining can open new markets for wood products and diversify the forestry industry in the province. For instance, Burton's Cove Logging and Lumber Ltd can invest in producing small-timber with high fibre density, cross-laminated timber, and laminated wood panels, which have prospects in residential and commercial construction (NEIA, 2016).

In 2019, the government of Newfoundland and Labrador, along with other partner organizations, including the NLFIA, established a forest sector work plan intending to diversify the forest industry in the Province (Cools, 2019). One of the project's objectives is to increase business activities in the forest sector by expanding sawmill production and diversifying wood products (Newfoundland and Labrador, n.d.c). According to the Newfoundland Minister of Fisheries and Land Resources, the government has established $9.6 million in funding for forest industry development projects; secondary forestry processing innovation pilot projects; and to establish forestry biomass market opportunities (Newfoundland and Labrador, 2020b). This is an opportunity that Burton's Cove Logging and Lumber Ltd can take advantage of to expand its operations and increase capacity. Finally, Burton's Cove Logging and Lumber Ltd also has taken advantage of some of the opportunities offered by the Community Business Development

Corporation (CBDC) in the Province (CBDC, 2017) to grow and expand their business as the biggest employer in the area.

BC: Final Considerations

This report overviews the BC region in the context of the bioeconomy transition, focusing on the associated opportunities and challenges involving the region's forest assets and human resources. The ecoregions in this area and their related assets offer numerous options involving multiple NRS, whether renewable (i.e., forestry, fishing, and agriculture) or non-renewable resources (i.e., mining, oil and gas), as well as sectors that indirectly benefit from them such as tourism. In fact, the percentage of workers in industries such as forestry, mining, and fishing is significantly higher in the BC region than the averages for NL and Canada. Particular attention was given to the forest sector, represented by the Burton's Cove Logging and Lumber Ltd, due to its central importance in the region and the report's objectives. In this regard, the mill's history has shown impressive examples of innovation and evolution that, provided sufficient support and market circumstances, bode well for adopting bioenergy, biorefinery, and other bioeconomy-related initiatives. On the other hand, some of the human resources challenges in the BC region can become barriers that must be prioritized and comprehensively addressed.

Education is vital considering the increasing skills required in NRS and the current transition from a petroleum-based and linear-based economy to a bio-based and circular economy. However, the BC region has a high percentage of its population with no formal education certificate, degree or diploma. Therefore, initiatives aiming to address the education issue in the region have to take the basic education level as a priority, perhaps strongly re-evaluating current and former programs such as the ABE and the Lifelong Learning in MUN's St. John's campus (See Section X below). Attention must also be given to informal learning strategies, which are essential in keeping up with the technological advancements in contemporary industries and attracting new workers (Kennedy et al., 2021). Naturally, we know that the privatization and discontinuation of some of these programs (i.e., ABE and Lifelong Learning) could be due to low demand. Nevertheless, the importance that a high and continuous level of education plays in the bioeconomy transition requires authorities to investigate the lack of demand/motivation instead of further impairing the possibility of completing a basic and PSE. The reinstalment and success of such programs could

address the education issue and the decreasing population change by attracting immigrants (Clair, 2021).

Further studies investigating how to foster higher education coverage at all levels among the province's population are critical for a healthy pool of potential skillful employees (Kennedy et al., 2021). Moreover, human resource representatives from the forest sector must establish close relationships with education institutes to mobilize knowledge about forest-based bioeconomy opportunities, thus addressing some misconceptions about the industry. Even if the percentage of citizens interested in joining the sector does not increase immediately, as such initiatives take time, the longer goal of improving public support for the industry is invaluable (Larasatie et al., 2020). If current employees do not see the potential in their industries, they will not incentivize the younger generation to join them. An interesting idea to address people's perception that industries such as forestry are old-fashion and non-sustainable is through the construction of mass timber buildings (Ahmed & Arocho, 2020, 2021; NRCAN, 2021) as also seen in media coverage (Leigh, 2021; Mead, 2022; Wainwright, 2021). Lastly, women are the majority of inhabitants in the region with a high school certificate, thus relatively more prepared to join specialized jobs, especially if given enough support to complete a PSE degree. This is a significant opportunity as it offers the chance to diversify the highly homogeneous and gender-imbalanced workforce in NRS of the BC region.

CASE 3: COTTLE'S ISLAND REGION: BIOECONOMY OPPORTUNITIES AND CHALLENGES

The following explores the existing assets, potential opportunities, and possible challenges associated with the bioeconomy in the Cottle's Island (CI) region. The selected region corresponds to the Local Areas 62 (Notre Dame Bay South), 63 (New World Island), 64 (Twillingate Island), and 67 (Fogo Island), which is part of the Economic Zone 14 (Gander-New-Wes-Valley Region) of Newfoundland (Fig. 4). A list of municipalities in these Local Areas can be found in Appendix A. This region was chosen for its relevance to NR industries, particularly forestry, represented by the Cottle's Island Lumber Company Ltd. at Summerford, NL.

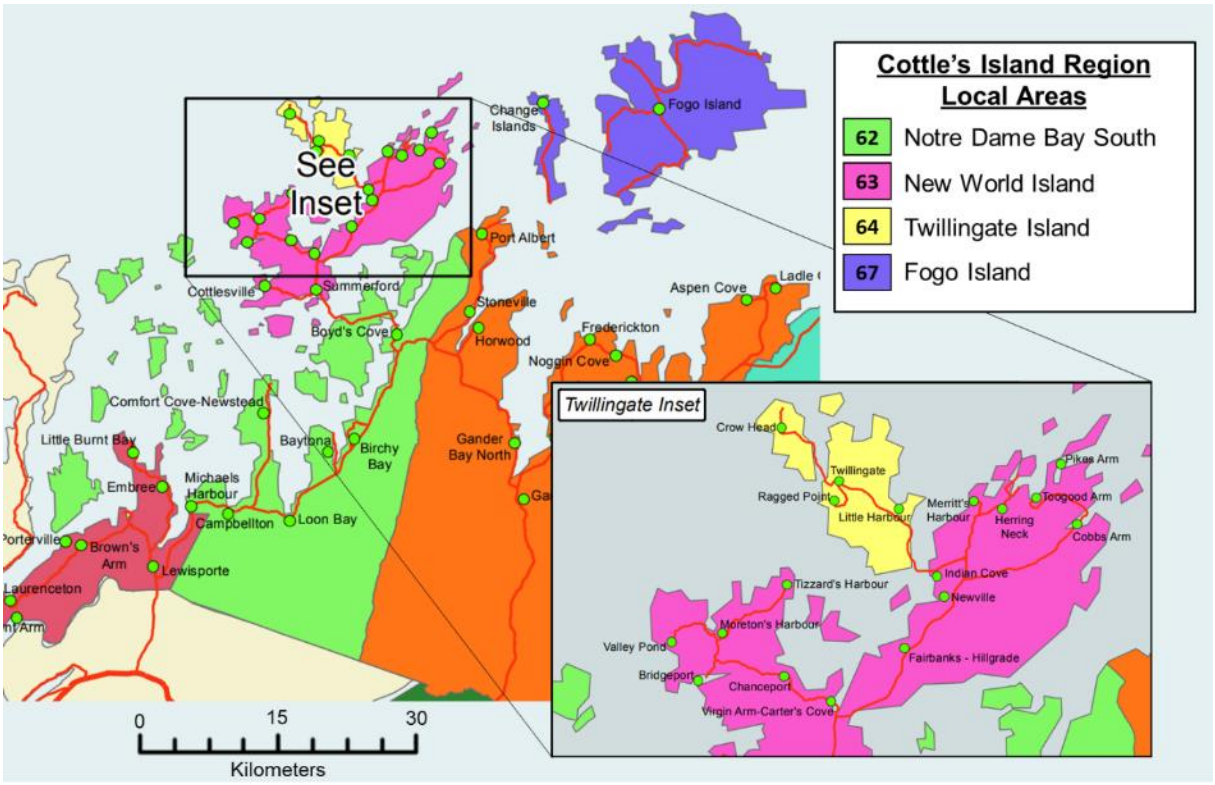

Figure 4. Map representation of the four Local Areas that constitute the Cottle's Island region. Adapted from Newfoundland and Labrador (2022).

Socioeconomic Overview

Regarding the region's population, the last Canadian census (2016) reported that the region had 10,040 inhabitants, corresponding to 1.93% of the people in the Province. Of the total population, 155 self-identify as Indigenous (1.54%), 55 as visible minorities (0.55%), and 45 as immigrants (0.45%) (Newfoundland and Labrador, 2022). These percentages for the whole province respectively are 8.8%, 2.27%, and 2.32%. People are fairly evenly distributed across the local areas in the region, with an average population size of 2,510 people across the four regions. The most populated area is New World Island (3,085 inhabitants), and the least populated is Notre Dame Bay South (2,125 inhabitants). Concerning change over time, the region's population size decreased, on average, -4.33% when comparing the most recent census in 2016 with 2011. According to data reported by Community Accounts (Newfoundland and Labrador, 2022), the population in Fogo Island decreased the most in the region (-7.20%), and Twillingate Island presented the lowest population loss (-2.30%). Meanwhile, the same comparison for the whole Province represented an increase of 1%. In terms of labour force age, 59.41% of the population is

within this category (18-64 years old), thus close to the Provincial percentage of 63.1%. Nevertheless, the average age in the CI region was 54 in 2016, which is almost ten years older than the average of 46 for the Province (Newfoundland and Labrador, 2022). In summary, it is a worrisome scenario if population recruitment (either by birth or immigration) does not increase considerably in the region.

The low percentage of immigrants (0.45%) indicates the region has not been successful in attracting and retaining immigrants for the past years, especially considering they are 2.32% of NL's population and 21.9% of Canada's population (Statistics Canada, 2022a). In fact, the 2021 census showed that four-fifths of the national population growth had been attributed to immigration for the past five years. Nevertheless, for the last six years, NL was fourth from last among Canadian provinces and territories in terms of immigrant population growth, despite its great importance to the province (Clair, 2021; Statistics Canada, 2022b). Furthermore, the average age in the CI region during the 2016 Census was only ten years away from surpassing the labour force age of 64. The situation is worrisome as a sizable, skilled, and diverse workforce is critical in transitioning to the circular bioeconomy system (FAO & UNECE, 2020).

As for other regions, another essential aspect to consider when evaluating opportunities and challenges in the bioeconomy context is the region's income, employment, and general infrastructure. In 2018, the median income in the CI region was $26,750.00 per annum, 20.1% lower than the Provincial median and 37.6% lower than the national median (Newfoundland and Labrador, 2022). However, it is worth noting that this regional average is not homogenous. Notably, the highest income is in the Fogo Island area with $31,300.00 (6.6% lower than the Province), and the lowest is in the New World Island with $23,500.00 (29.9% lower than the Province). According to the Community Accounts ((Newfoundland and Labrador, 2022) data, this contrast is even more evident when considering gender aspects. On average, a male worker in the region earns $33,575.00 while a female worker earns $22,875.00 (a difference of 46.8%). This pay gap is even wider (53%) between male and female workers in the Fogo Island area.

In terms of employment and fields of work, the CI region presented a relatively high unemployment rate in 2016 compared to Province-wide rates (Newfoundland and Labrador, 2022). Notably, 30.6% of inhabitants in the region are unemployed, double the Provincial average of 15.6%. Furthermore, unemployment in the region is significantly higher among men (35.7%) than

women (18.6%), which is a wider gender gap than the Provincial average rates of 24.4% for unemployed men and 12.5% for unemployed women. Among employed inhabitants in the CI region, 6.6% work in natural resource sectors[8], which is higher than the 3.6% for the whole Province; thus, highlighting the comparative importance of the industry in the region. Strikingly, 11.3% of males in the region are employed in the natural resource sector, but only 1.8% of females. Lastly, the number of dwellings in the region (i.e., houses, apartments, farms, and overall land properties) is 4,550 (Newfoundland and Labrador, 2022). Of those, 91.5% are privately owned, which is 10.3% higher than the same rate for the whole Province.

The combination of a lower income and a high unemployment rate in the CI region constitutes a significant challenge for the bioeconomy transition. An unemployed citizen or someone with low income cannot fully support their professional development or, perhaps more importantly, that of their children, further impairing the entrance of young skilled workers into the workforce. In addition, these socioeconomic challenges may influence (at least indirectly) the perception of younger generations to avoid seeking opportunities in the natural resource sector, even if it means moving out of their region for temporary jobs. In fact, mill owners in Newfoundland have already reported a shortage of skilled labour. Furthermore, it is notable how there are considerably fewer unemployed women in the region, yet their average income is lower than men. Even though the natural resource sector plays a substantial role as a regional employer, it is acutely male dominated. Altogether, these characteristics could impair the CI region's potential in the circular bioeconomy system, mainly concerning forests' assets. On the other hand, some of the factors presented above (e.g., women's low average income and participation in natural resource sectors) could be seen as barriers that, if comprehensively addressed, could enable the CI region to tap into substantial opportunities.

Human Resource Challenges and Assets

The forest sector naturally requires highly skilled labour, which is particularly pertinent during the Bioeconomy transition (Borzykowski, 2019; FAO & UNECE, 2020). Therefore, inhabitants' wellbeing and education are essential parameters in workforce quality. According to data in Community Accounts (Newfoundland and Labrador, 2022), 69.3% and 68.7% of the population

[8] Comprising two categories of the North American Industry Classification System (NAICS): "Agriculture, forestry, fishing, and hunting" and "Mining quarrying, and oil and gas extraction".

in the CI region reported excellent or very good health status and mental health, respectively. In fact, these self-assessment results are higher than those reported for the whole Province in terms of overall health (62% as excellent or very good) and slightly lower than the Provincial mental health (71.2% as excellent or very good).

Regarding the highest level of schooling, 40.6% of the inhabitants had no certificate, diploma or degree, 25.5% had a high school diploma or equivalent, and 34% had post-secondary education (Newfoundland and Labrador, 2022). Except for high school diploma holders, these numbers significantly differ with Provincial rates, respectively, 23.4%, 25%, and 51.6%. Some of these differences are particularly startling when evaluated by gender. For instance, among the individuals in the CI region with high school as their highest degree, 61% are women, while the Provincial percentage is 54.1% (Newfoundland and Labrador, 2022). Among those with a post-secondary degree, 56.3% in the CI region are men and 49.3% in the Province. In summary, the region has a high percentage of the population that did not complete high school, almost double the Provincial rate. Furthermore, while most people who completed their high school are women, men are the majority of those with a post-secondary degree. Still, only about a third of the population in CI region has a post-secondary degree, which indicates a potential challenge for the bioeconomy sector in the region on recruiting skilled workers.

It is undeniable that developing a knowledge-based system such as the bioeconomy requires a high level of schooling combined with multidisciplinary skills (FAO & UNECE, 2020; Hakovirta & Lucia, 2019). In this case, the relatively low schooling level of inhabitants in the CI region is undoubtedly a barrier that must be addressed. Nevertheless, researchers have argued that other factors may play equal importance (e.g., entrepreneurship, sales, and communication skills) without the need for a post-secondary degree (Kuckertz, 2020). In addition, there are strong arguments supporting the role of informal learning in bioeconomy careers (Hakovirta & Lucia, 2019). According to the authors, a formal and structural education certainly helps, but most institutions cannot keep up the pace of constant changes and innovations in the bioeconomy and other highly technological sectors. This could be a pathway to address the declining rates of interest in science, technology, engineering, and mathematics (STEM) disciplines (Hakovirta & Lucia, 2019), and most importantly, for regions with significant bio-based assets but workforce/skill challenges. According to the authors (2019), another benefit of investing in informal learning is its accessibility to marginalized and underrepresented rural and minority groups.

Natural Resource Challenges and Assets

Like most of the Province, fish and forest resources have and continue to play a significant role in the CI region. In addition, there is an increasing interest in tourism activities closely linked with the cultural and natural assets of the region. For instance, tourism activities in CI involve going for hikes, boat and fishing tours, whale watching and looking for icebergs migrating south from Greenland (Byers, 2007; Newfoundland and Labrador, n.d.d). The direct or indirect exploitation of these natural assets is associated with the two ecoregions found in the CI region (out of nine in the island): Central Newfoundland Forest (CNF) and North Shore Forest (NSF) (PAA, 2008k, 2008l). Due to their proximity, the characteristics of these two ecoregions are reasonably similar, some being exacerbated in NSF, primarily due to the North Atlantic Ocean. CNF's climate is predominantly continental, being one of the driest ecoregions on the island, mostly due to the influence of the Long Range Mountains to its east and warm summers. Therefore, CNF's boreal forests are prone to fires, favouring extensive stands of tree species such as black spruce and white birch with balsam fir occurring in areas where fire is less frequent (PAA, 2008k).

Meanwhile, NSF comprises the majority of the CI region and it has the warmest and driest summers of any coastal area on the island, despite its closeness to the ocean (PAA, 2008l). Consequently, forest fires are even more frequent and extensive than in CNF, leading to sizable fire stands of black spruce. Most of this ecoregion is forested, but trees on the coastline have their growth impaired due to direct exposure to wind from the Atlantic Ocean. Of the major tree species in the CI region, white spruce has lower importance due to its scarcity in the Province. On the other side, the extensive stands of black spruce are quite relevant as it is the most valuable pulpwood species in the island followed by balsam fir. Lastly, the occurrence of white birch in the region is also significant as it is the most important hardwood in the island (Newfoundland and Labrador, n.d.e).

The occurrence of tourism in the region is closely associated with bioeconomy practices, either supporting or because of it. For instance, it involves appreciating ecosystem services, nonmaterial assets, and the efficient utilization of harvested resources such as biomass from forestry residues (Galanakis et al., 2022; Tyrväinen et al., 2017). According to the authors, the link between bioeconomy resources (e.g., agriculture, forestry, fishing) and activities such as tourism are vital in a post-COVID-19 era: the decarbonization of transport systems and the support for lower and

environmentally conscious consumption. Furthermore, sustainable nature-based tourism in protected areas such as the Dildo Run Provincial Park in the CI region can trigger a positive feedback loop. It may benefit other bioeconomy industries through environmentally conscious consumers that recognize the facilities created by contemporary technology and economic system but recognize that a linear petroleum-based regime is irreconcilable with the sustainable nature-based activities and services.

Furthermore, Tyrväinen et al. (2017) argue that many nature-based tourism organizations are small-scale, located in rural regions and often interact with other resource users. Thus, such activities can greatly benefit rural regions struggling with socioeconomic and demographic aspects such as the CI and further support other regional bioeconomy endeavours (Lundberg & Fredman, 2012). For instance, tourism activities based on forests and other natural resources are already part of bioeconomy strategies in countries such as Finland, Norway, and Sweden (Tyrväinen et al., 2017). Some of these benefits supported by sustainable nature-based tourism in a Bioeconomy regime can already be seen in the Fogo Island area (Fogo Island Inn, n.d.).

Like other parts of the Province, the 1992 cod moratorium significantly impacted the CI region since most communities depended on fisheries resources due to their proximity to the ocean (Bavington, 2010). Nevertheless, the industry still plays a significant socioeconomic role in the region after diversifying their marine species of interest and repurposing fishing vessels to other activities such as boat tours and watching whales and icebergs (Newfoundland and Labrador, n.d.d). In addition, there is a variety of fish species (e.g., Atlantic salmon and brook trout) that occur in the many lakes and rivers in both ecoregions (PAA, 2008k, 2008l). Sustainable fishing can also be achieved through aquaculture, which takes advantage of the region's extensive coastline, the ideal cold-water conditions, and the high-quality reputation of the North Atlantic seafood (Newfoundland and Labrador, 2020c)

Forest Industry

The most significant forestry player in the CI region is Cottle's Island Lumber Company Ltd. at New World Island in Summerford, NL. Self-described as "small, sustainable and self-sufficient," Cottles Island Lumber is a family-owned business with almost 50 years of existence (Cottles Lumber, 2016a). The company sells a variety of products of high quality due to strict selection of raw materials and complete control of their operation. They are responsible for logging, sorting,

trucking, and sawmilling operations as well as the production and sale of value-added products. Pulpwood harvested by Cottle's Island Lumber is sent to the pulp mill in Corner Brook while saw logs are transported to Cottle's sawmill; most residue wood chips and bark are later sent to the pulp mill too. Once in the sawmill, lumber is dried in kilns to a specific moisture percentage, depending on the final product. Kilns are fueled using sawmill residues (Cottles Lumber, 2016b). Wood materials are then subjected to a moulder and processed in the finishing lines. According to the mill's website (Cottles Lumber, 2016c), they produce fuelwood and wood pellets from other operations' residues, certified lumber from black spruce and balsam fir, decking, siding, panelling, and flooring. Cottle's Island Lumber products are sold in Newfoundland, Eastern Canada, and US markets. The combination of CI region's natural and socioeconomic assets with the mindset and breadth of operations that Cottle's Island Lumber already practice was instrumental in its selection as one of the project's case study regions. Nevertheless, the circular economy can bring forth numerous other opportunities for the region, especially if cooperatively tackled by a diverse set of stakeholders.

CI Final Considerations

This report highlights the CI region's great potential in transitioning to a circular forest-based bioeconomy. The region has plenty of renewable resources to be sustainably explored and a well-established forestry industry represented by Cottle's Island Lumber Company Ltd. The mill's operation is critical as it has complete control of its production and an evident interest and capacity to innovate, as shown by the variety of products they already produce. This is particularly impressive considering the mill went through a major setback due to a fire event in 2015 in their core warehouse. Despite the great potential, significant challenges need to be addressed in the region, particularly concerning human aspects. Issues range from a relatively low income, decreasing demographic, and a high percentage of the population with no high school diploma, therefore fewer people with post-secondary education. Furthermore, these issues are particularly acute if seen through a gender lens. Although significant, these challenges are not prohibitive considering the number of solutions that could be explored. These include the importance of informal learning for innovation and entrepreneurship and the attraction of diverse and skilled immigrants, both critical aspects of this transition. Aiming to address some of these challenges, the Forest-based Bioeconomy project is coordinating consultations at the regional and provincial level with the participation of mill owners and stakeholders identified by the mill owners and the

project committee. Stakeholder selection was deliberatively broad so that the demand and supply for different bio-based products and services would be covered, having the mill's operations as central in these consultations. These discussions aim to demonstrate all the opportunities that a forest-based bioeconomy entails in the CI region and the benefits that regional and provincial stakeholders may access within sustainability principles if long-term partnerships are established among them.

CASE 4: CORNER BROOK REGION: BIOECONOMY OPPORTUNITIES AND CHALLENGES

The following explores the existing assets, potential opportunities, and possible challenges associated with the bioeconomy in region 4, the Corner Brook (CB) region. The selected region corresponds to the Local Areas 39 (Corner Brook-Pasadena) and 40 (Bay of Islands), which are part of the Rural Secretariat Region: Corner Brook - Rocky Harbour (Newfoundland and Labrador, 2022; Fig. 5). The region was chosen for its relevance to natural resource industries, particularly the forest sector in western NL, and our focus in this report is represented by the Corner Brook Pulp & Paper Ltd. (CBPP) at Corner Brook, NL. The report will first provide a general overview of the socioeconomic characteristics of the region, followed by its human and natural resource assets, primarily forest-related. Lastly, this work offers comments and suggestions on how the area can participate more comprehensively in the ongoing changes associated with a multi-purpose forest management and circular bioeconomy.

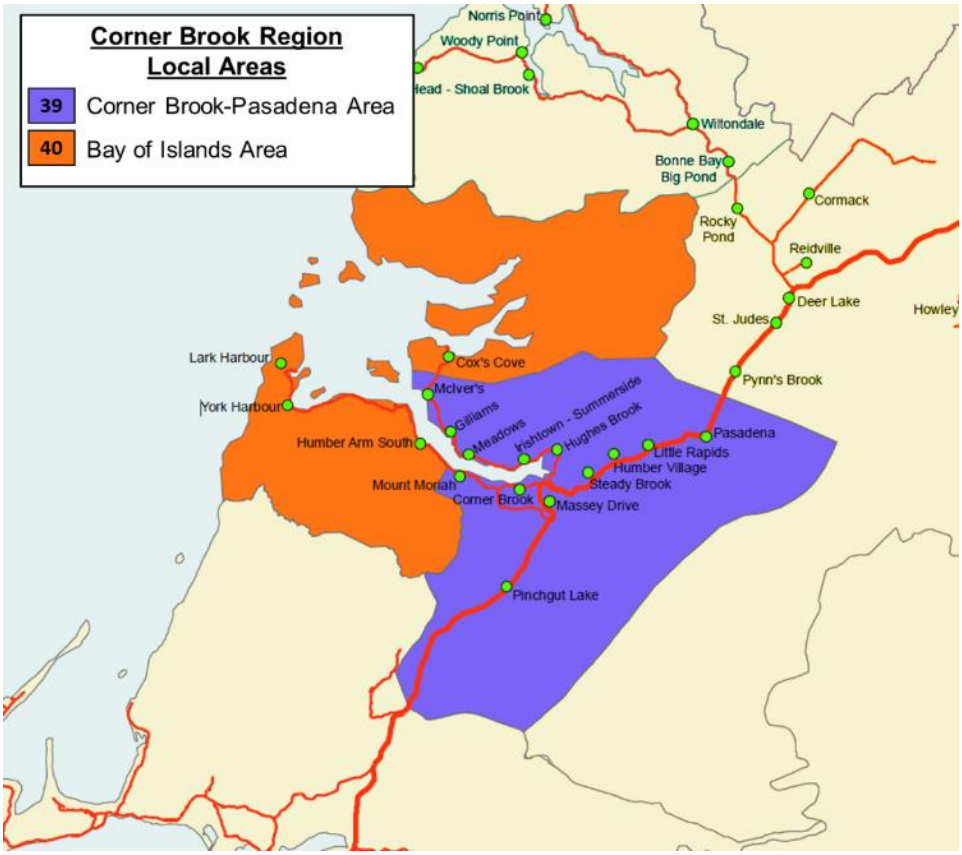

Figure 5. Map representation of the two Local Areas that constitute the Corner Brook region. Adapted from Newfoundland and Labrador (2022).

Socioeconomic Overview

Regarding its population, the last census (2016) reported that the CB region has 33,775 inhabitants, corresponding to 6.5% of the people in the NL (Newfoundland and Labrador, 2022). Furthermore, there was a 1.6% increase in the region's population over a 5-year period (2014-2018), which is higher than the average Provincial rate of 1% but lower than the Federal rate of 6.2%. However, it is essential to consider the difference between the two Local Areas in the CB region, specifically, while the Bay of Island had a growth of 0.6%, Corner Brook-Pasadena had 2.5%. Of the total population in the region, 8,580 self-identify as Indigenous (25.4%), which is significantly higher than the Provincial (8.8%) and Federal (4.8%) proportions of the population. Contrastingly, 335 of the region's inhabitants identify as visible minorities, representing 1% of the population in the region, and 610 are immigrants (1.8%) (Newfoundland and Labrador, 2022). These percentages are substantially lower than the Provincial population of visible minorities and immigrants (both at 2.3%) and significantly lower if compared with the Federal rates (21.8% and 21.5%). In terms

of labour force size, 62.1% of the region's population (20,980 inhabitants) is within the labour force age category (18-64 years old), thus close to the Provincial and Federal percentages of 63.1%. Nevertheless, the average population age in the CB region is 48, therefore higher than the Provincial (46) and the Federal (41) population age (Newfoundland and Labrador, 2022).

Another essential aspect of evaluating the region's economic opportunities and challenges in the bioeconomy context is its current average income, employment, and general infrastructure. In 2018, the average income in the Corner Brook region was CA$32,400.00 per annum, which is lower than the Provincial average (CA$33,500.00) and the Federal average (CA$37,700.00) (Newfoundland and Labrador, 2022). However, it is noteworthy that the inhabitants of Local Area 39 have an annual income of CA$34,500.00. In terms of average income per gender, male workers in Corner Brook-Pasadena Area earn 1.37 more than female workers (CA$40,500.00 versus CA$29,600.00), which is close to the Federal income gap of 1.35 (CA$44,100.00 versus CA$32,600.00) but lower than the 1.46 difference for the Province of NL (CA$40,700.00 versus CA$27,900.00) (Newfoundland and Labrador, 2022). There is no data on the average income per annum for Local Area 40.

Among the population of 15 years and over in the CB region, 7.2% is unemployed (2,440 inhabitants), which is lower than the Provincial percentage of 7.7% (40,150 inhabitants) but higher than the Federal percentage of 4.1% (1,442,435 inhabitants) (Newfoundland and Labrador, 2022). Among unemployed inhabitants, 62.1% are men, 61.6% in the Province, and 56% at the Federal level. Among industry workers in the CB region, 4.2% are employed in natural resource sectors[9], which is considerably lower than the Provincial (7.3%) and lower than the Federal (3.9%) percentage of workers in these industries. Among them, 82.4% of these workers in the CB region are men, which represents a higher gender disparity than in the Province (80.1%) and at the Federal level (74%). Finally, the number of dwellings in the region (i.e., houses, apartments, farms, and overall land properties) is 14,455, representing 6.6% of all dwellings in the Province (Newfoundland and Labrador, 2022). Of those, 72.4% are privately owned, thus lower than the Provincial percentage of 81.2%.

[9] Comprising two categories of the North American Industry Classification System (NAICS): "Agriculture, forestry, fishing, and hunting" and "Mining quarrying, and oil and gas extraction".

Human Resource Challenges and Assets

As a sector that heavily relies on modern technology, the forest industry requires a highly skilled labour force (Borzykowski, 2019; FAO & UNECE, 2020). According to Community Accounts (Newfoundland and Labrador, 2022), 62.6% and 78.7% of the Corner Brook-Pasadena area population reported excellent or very good health and mental health status, respectively (Newfoundland and Labrador, 2022). Compared to the Provincial self-assessment, the percentage of the population that reported their health status as excellent or very good in NL is barely higher for general health (62%) and higher for mental health (71.2%). There is no data on inhabitants' health and mental health self-assessment in Local Area 40.

With reference to the level of schooling, 22.2% of the total population aged 15 years and over in the Corner Brook region's do not have a certificate, diploma or degree, 25.3% have a high school diploma or equivalent, and 52.6% have some level of PSE (Newfoundland and Labrador, 2022). These percentages are similar to the Provincial and Federal rates, particularly at the PSE level. Notably, 23.4% of NL inhabitants aged 15 years and over do not have an education certificate, 25% have a high school diploma, and 51.6% completed a PSE. At the Federal level, 18.3% of Canadians have no education certificate, 26.5% have a high school diploma, and 55.3% completed a PSE. Overall, the level of schooling is higher in Local Area 39 than in 40. From the gender perspective, most women in the Corner Brook region have a high school certificate (54.5%) and a PSE degree (52.8%). A similar pattern is seen at the Provincial scale, with women being the majority with a high school degree (54.1%) and a PSE degree (50.7%); while those without a certificate is balanced between gender in NL (50.2%) (Newfoundland and Labrador, 2022). Whereas at the Federal level, the gender differences in education are also balanced, with an overall higher percentage of women with a high school or PSE completed.

Natural Resource Challenges and Assets

Like in most parts of the province, natural resource industries such as fishing, and forestry played and continue to exert a significant role in the Corner Brook region. Additionally, there is an increasing interest in tourism activities closely associated with natural assets in places such as the Blow me Down Provincial Park in the Bay of Islands area (LA 40). Although small in territory, the Provincial Park is known for its scenic views from the Blow Me Down mountains to the Bay area, reaching a peak of 750 m at Round Hill (Newfoundland and Labrador, n.d.a; PAA, 2008m).

The park is also unique for its accessibility to geological materials exposed by glaciers that were once part of the oceanic crust and upper mantle. In addition, the region harbours uniquely blue ponds due to the limestone-rich soil, attracting the attention of visitors and regular inhabitants (PAA, 2008n). Tourism activities in the region are further supported by the proximity to a regional airport in Deer Lake, NL. In the bioeconomy context, tourism involves appreciating ecosystem services and nonmaterial assets, and decreasing demand for natural resources by efficiently utilizing harvested assets - including their residues (Galanakis et al., 2022; Tyrväinen et al., 2017). The direct or indirect exploration of natural assets is closely associated with the area's ecoregion. In this report context, the CB region harbours two subregions of the Western Newfoundland Forest (WNF): the Corner Brook subregion and the Serpentine Range subregion (PAA, 2008m, 2008n).

The WNF is one of the largest ecoregions in the island portion of Newfoundland and Labrador and one of the most favourable to plant growth (PAA, 2008m, 2008n). This condition is attributed to warm summers, high rainfall precipitation, and the longest frost-free period on the Island due to the protection offered by the Long Range Mountains from cold north-easterly winds. Wildlife in the WNF is one of the most diverse on the Island due to the favourable climatic conditions, encompassing a variety of mammals, birds, fish and a few amphibians. Furthermore, the presence of rolling hills and rich soils due to the limestone geology in the Corner Brook subregion contributes to larger trees with thick canopy cover (PAA, 2008n). Balsam fir is the most common in this subregion, with black spruce occurring in poorly drained soils or areas where the bedrock is exposed. Since forest fires are not common, the presence of fire stands of black spruce is not widespread. Yellow birch, white pine, red maple, and trembling aspen also occur, although not as frequently, reaching their northern distribution limit in this ecoregion. Concerning the Serpentine Range subregion, it concentrates the most mountainous areas of the WNF (PAA, 2008m). Therefore, although forests occur, trees are not as large as in other parts of the ecoregion. Many places in the landscape are covered with sparse vegetation constituted by serpentine-hardy plant species. At lower elevations within protected places such as valleys, forests tend to be composed mainly of balsam fir.

Forestry Industry

Naturally, the price of traditional forest products such as lumber and pulp is a determining factor for the growth of the forestry industry in Newfoundland. According to Wernerheim and Long

(2011), lumber prices have been declining every year since 1990, with an unprecedented price spike (in some cases more than 300%) during the COVID-19 pandemic (van Kooten & Schmitz, 2022). According to the authors, this increase is attributed to supply limitations due to labour shortages and increased demand for home construction and improvements due to decreased expenditures in products and services. In the context of the pulp and paper subsector, such as CBPP, the implications of COVID-19 were complex. While packaging materials got a boost in demand due to an increase in online shopping, remote working reduced the consumption of paper in general (Stanturf & Mansuy, 2021). From a broader perspective, prices in the global market may affect the value of forestry products; hence whether the products from CBPP are supplied to the local or international market, their price may affect productivity. In general, the existing market in Newfoundland is still small, hence most of the forest products are sold outside the Province (Newfoundland and Labrador, 2020a).

As previously mentioned, the most significant forestry player in the Corner Brook region is Corner Brook Pulp and Paper Ltd. (CBPP) in Corner Brook, NL. The CBPP is owned by Kruger Inc., a company founded in Quebec in 1904 with production sites throughout North America specializing in traditional sectors such as pulp and paper, container boards, and packaging (Kruger Inc, n.d.). According to 2009 data, Kruger estimated that their direct economic impact in NL is around CA$135 million on goods and services and CA$70 million from direct and indirect employment of more than 1,100 workers (Wernerheim & Long, 2010). Despite being the last pulp and paper mill in the Province after the closure of Abitibi-Bowater's mills in Stephenville (2005) and Grand-Falls-Windsor (2009), CBPP has been decreasing its capacity over the past years. However, research has pointed out promising opportunities over the last years aiming at the diversification of the mill towards greener products with greater added value and following circularity principles such as incorporating residues into innovative products and services. These opportunities result from significant cash investments by the Federal and Provincial Government and CBPP's parent company (e.g., CBC News, 2019; Newswire, 2020) and partnerships with PSE institutes. For instance, these partnerships recently resulted in the Centre for Research and Innovation in a space formerly used as CBPP's human resources building (CBC News, 2020). Examples of research and innovation projects from CBPP and PSE institutions involve the use of fly ash from the mill in the treatment of drinking water (Taghizadehgan, 2019) and as a potential liming material for agriculture (Maheswaran et al., 2019), and the evaluation of repurposing some of the mill's

capacity for the production of lyocell pulp fluff (Gosse, 2019). In addition, the CBPP is also involved in initiatives that utilize its structure to tackle municipality challenges, such as its wastewater (Bird, 2021).

Corner Brook Final Considerations

This report overviews the Corner Brook region in the context of the bioeconomy transition, focusing on the associated opportunities and challenges involving the region's forest assets and human resources. The population size and growth trends in the Corner Brook region offer a unique opportunity in the transition to a bioeconomy society. Notably, the region is considered a hub in western Newfoundland, with the largest population outside the Avalon Peninsula (Newfoundland and Labrador, 2022). Furthermore, the growth rate of 2.5% in the Corner Brook-Pasadena Area signalizes the continued prominence of the region and its exponential opportunities in terms of demand for products and services based on renewable resources, entrepreneurship, and workforce availability. Furthermore, the region stands out for two diverse characteristics that should be explored and addressed. The high representation of people with Indigenous ancestry in the region offers an opportunity to employ a multifunctional perspective on forest assets, thus reflecting one of the pillars of genuinely sustainable forestry (BIC & BioDesign, 2019; Winkel, 2017). On the other hand, there is a deficient representation of visible minorities and immigrants in the Corner Brook region. This is particularly noteworthy considering the region has two campuses of PSE institutes (i.e., Memorial University of Newfoundland and the College of the North Atlantic), both having a successful trajectory in attracting international students to the Province (Kennedy et al., 2021). After these students finish their undergraduate or graduate programs, they may be seek a job in the region with a post-graduate work permit. However, the low percentage of immigrants in the region shows issues in the retention rate of these people, which is a lost opportunity to incorporate the professional and personal skills and networks that these individuals can offer.

The average annual income in the Corner Brook region is close to the Provincial and Federal averages. In fact, the average income in the Corner Brook-Pasadena Area is higher than the Provincial average, which can mean a greater capacity to invest and consume products and services that are not aligned with a linear and primarily fossil fuel-based economy (Newfoundland and Labrador, 2022). A higher-than-average income is also essential for the continuous learning of skills relevant to the bioeconomy transition and the support of the next generations. An associated

positive fact is the relatively lower income gap between male and female workers. Despite the unacceptable fact that men earn about 35% more than women in the Corner Brook region, it is less than the ca. 45% difference in the Provincial average. Further reducing this income gap sets the direction toward a more sustainable and equal society, including the insurance that the perspectives of diverse groups are represented in decision-making positions (Larasatie et al., 2020; Nnoko-Mewanu et al., 2021). Although the rate of unemployment in the region is lower than the provincial average, the fact that 62.1% of unemployed are male individuals and that male workers constitute 82.4% of workers in natural resource industries highlights the necessary work to prepare the region as best as possible to tackle and thrive in a bioeconomy society. Naturally, a population's overall well-being and education level are essential parameters in a region's preparedness for this transition (FAO & UNECE, 2020; Hakovirta & Lucia, 2019).

In terms of well-being, the high percentage of the residents with very good or excellent self-reported conditions is beneficial to the region's socioeconomic as a workforce without good health cannot perform to its total capacity. The CB region also has favourable demographics regarding its inhabitants' highest level of schooling being better positioned than the Provincial average. Nevertheless, the population percentage without a school certificate is still significantly high, for instance, about 4% higher than the Federal average. This is relevant as a high level of education is essential in NRS as they are increasingly adopting modern technologies and at a fast pace (Torfgård et al., 2021). The benefits of a high proportion of inhabitants with at least a high school diploma are numerous. It enables citizens to find jobs more easily, in positions with higher wages and lower layoffs (Kennedy et al., 2021). Additionally, a quality education among potential and current workers is a prerequisite for innovation and entrepreneurship, both essential aspects in the bioeconomy transition (Kuckertz, 2020). Despite the higher average income in the CB region, the costs of updating skills through continuous learning opportunities or supporting the next generation, particularly at the PSE level, are considerably high. Therefore, the accessibility in its multiple dimensions (e.g., diversity of disciplines and the costs and distance to institutes) must be assisted by employers and government representatives.

The CBPP has played a critical socioeconomic role since its inauguration at Corner Brook and indirectly throughout NL. Its importance increased with the closure of the other two pulp and paper mills in the Province, but it does not mean the mill is immune to the negative trend that the sector is undergoing worldwide (FAO & UNECE, 2020). Over the past years, the CBPP significantly

reduced its capacity, inevitably leading to employee layoffs (Wernerheim & Long, 2010). As a countermeasure strategy, the mill has been continuously spending and seeking investments to optimize its efficiency in terms of resources, residues, products, among others. More recently, CBPP's partnership efforts have resulted in notable projects evaluating opportunities to employ the mill's underutilized capacity and residues, therefore closely embedded in circularity principles. Nevertheless, developing those research initiatives into actual changes in the industrial process takes a while, particularly considering the existence of barriers related to current or non-existing policies (e.g., provincial guidelines on using industrial residues). This highlights the importance of broadening partnerships and mobilization efforts to encourage stakeholders to adopt a more proactive approach to supporting the bioeconomy (BIC & BioDesign, 2019; Hurmekoski et al., 2019). A representation of potential outcomes of these partnerships is the Centre for Research and Innovation in Corner Brook, a region's hub for bioeconomy research and development. Finally, an opportunity for higher investments by the forest sector has emerged with the lumber price spikes (and its derived products) in the context of the COVID-19 pandemic. Industry players cannot get comfortable with the increase in prices as they are naturally a time-specific event; thus, investments provided by this revenue increase need to aim for the XXI century forestry instead of solely optimizing current operations and products.

CASE 5: BLOOMFIELD-BONAVISTA REGION: BIOECONOMY OPPORTUNITIES AND CHALLENGES

The following examines the existing assets, potential opportunities, and possible challenges associated with the bioeconomy in the Bloomfield-Bonavista (BB) region. The selected region corresponds to seven of the Local Areas (LA) per Provincial categorization: LA 49 (Chandlers Reach), LA 50 (Southern Bay Area), LA 51 (Black Head Bay), LA 52 (Bonavista Area), LA 53 (Trinity Bay North Area), LA 54 (Trinity, Trinity Bay Area) and LA 55 (Smith Sound-Random Island) (Newfoundland and Labrador, 2022; Fig. 6; see Appendix A for municipalities list). The region was chosen for its relevance to natural resource industries, particularly the forest sector, with a focus on the Sexton Lumber Co. located at Bloomfield, NL. The report will first provide a general overview of the socioeconomic characteristics of the region, followed by its human and natural resource assets, primarily forest-related. Lastly, this work offers comments and suggestions on how the area can participate in the ongoing transition to a circular bioeconomy society.

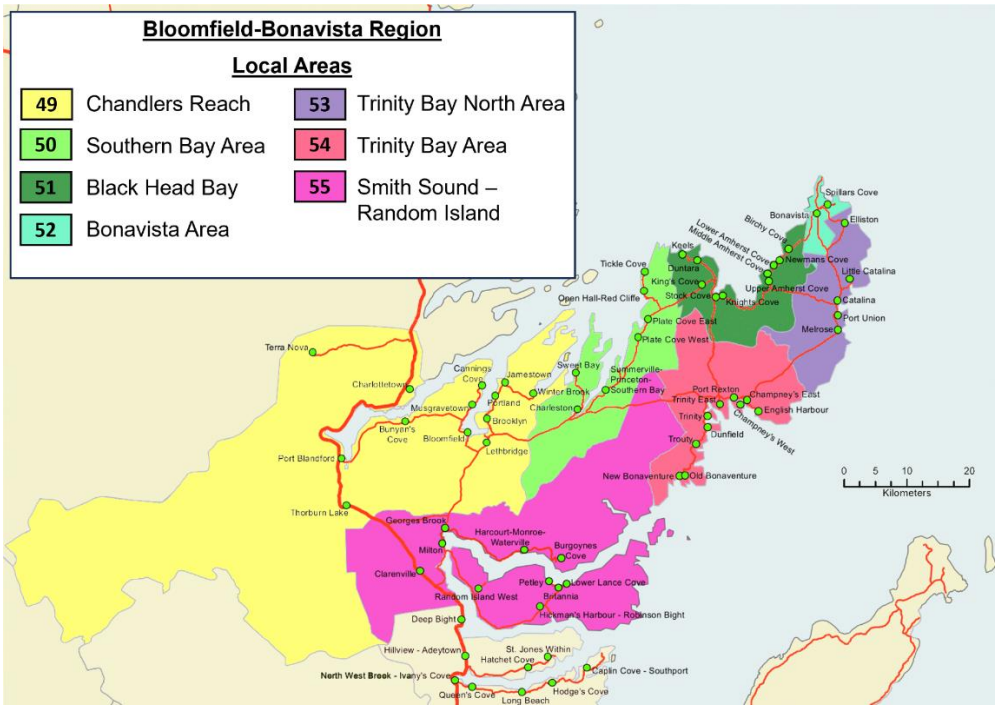

Figure 6. Map representation of the Local Areas that constitute the Bloomfield-Bonavista region. Adapted from Newfoundland and Labrador (2022).

Socioeconomic overview

The Bloomfield-Bonavista region has a series of small communities located approximately 200 kilometres from the province's capital city, St. John's. Regarding its population, the last census (2021) reported that the BB region has 20,410 inhabitants, corresponding to 3.9% of the people in the NL (Newfoundland and Labrador, 2022). Furthermore, the population is largely concentrated in the Smith Sound-Random Island area (LA 55) with 9,090 people or 44.5% of the population in the region. Meanwhile, LAs 50, 51, 53, and 54 individually have less than 10% of the region's population (Newfoundland and Labrador, 2022). Furthermore, there was a -4.1% decrease in the region's population over a 5-year period (2016-2020), which contrast with the average Provincial growth rate of 1% and the Federal rate of 6.2%. However, it is essential to consider the rate differences among the seven LAs in the BB region; specifically, while Black Head Bay (LA 51) had a rate of -12.5%, Smith Sound-Random Island (LA 55) had 1% growth. Of the total population in the region, 545 self-identify as Indigenous (2.7%), which is considerably lower than the

Provincial (8.8%) and Federal (4.8%) proportions of the population. Furthermore, 155 of the region's inhabitants identify as visible minorities, representing 0.8% of the population in the region, and 255 are immigrants, consisting of 1.2% of its people (Newfoundland and Labrador, 2022). Like the comparison regarding Indigenous peoples, these percentages are quite lower than the Provincial population of visible minorities and immigrants (both at 2.3%) and even more if compared with the Federal rates (21.8% and 21.5%, respectively). In terms of labour force size, 57.1% of the region's population (11,650 inhabitants) is within the labour force age category (18-64 years old), thus close to the Provincial and Federal percentages of 63.1% (Newfoundland and Labrador, 2022). Nevertheless, the average population age in the BB region is 56 years old, therefore higher than the Provincial (46) and the Federal (41) population age.

Another essential aspect of evaluating the region's economic opportunities and challenges in the bioeconomy context is its current average income, employment, and general infrastructure. In 2020, the average income in the BB region was CA$31,014.29 per annum, which is lower than the Provincial average (CA$33,500.00) and the Federal average (CA$37,700.00) (Newfoundland and Labrador, 2022). However, it is noteworthy to consider the average income differences among LAs in the region. While the Southern Bay Area (LA 50) average annual income is CA$28,700.00, the Smith Sound-Random Island (LA 55) is CA$35,500.00; a difference of CA$6,800.00. In terms of average income per gender, male workers in BB region earn 1.29 more than female workers (CA$35,700.00 versus CA$27,751.00), which is lower than the Provincial income gender gap of 1.46 (CA$40,700.00 versus CA$27,900.00) and the Federal gap of 1.35 (CA$44,100.00 versus CA$32,600.00) (Newfoundland and Labrador, 2022).

Among the population of 15 years and over in the BB region, 10% is unemployed (2,035 inhabitants), which is higher than the Provincial percentage of 7.7% (40,150 inhabitants) and the Federal percentage of 4.1% (1,442,435 inhabitants) (Newfoundland and Labrador, 2022). Furthermore, 58.7% of the unemployed population are men, thus fairly close to the 61.6% in the Province, and 56% at the Federal level. Among industry workers in the BB region, 7.6% are employed in natural resource sectors[10], which is similar to the Provincial percentage (7.3%) and higher than the Federal (3.9%) percentage of workers in these industries. Of those in the BB region,

[10] Comprising two categories of the North American Industry Classification System (NAICS): "Agriculture, forestry, fishing, and hunting" and "Mining quarrying, and oil and gas extraction".

82.9% of them are men, which represents a higher gender disparity than in the Province (80.1%) and at the Federal level (74%). Finally, the number of dwellings in the region (i.e., houses, apartments, farms, and overall land properties) is 8,885, representing 4.1% of all dwellings in the Province (Newfoundland and Labrador, 2022). Of those, 82.3% are privately owned, thus higher than the Provincial percentage of 81.2%.

Human Resource Challenges and Assets

As a sector that heavily relies on modern technology, the forest industry requires a highly skilled labour force (Borzykowski, 2019; FAO & UNECE, 2020). Not every Local Area in the Bloomfield-Bonavista region had data available on their self-assessment report for physical health and mental health (Newfoundland and Labrador, 2022). For those who did have their data available, the highlight is on the Bonavista Area (LA 52) with 89% of its population self-reporting an Excellent to a Good physical health. On the other hand, 42.6% of the people in Chandlers Reach (LA 49) reported Fair health status, which is a high percentage of the population with a relatively low status compared to the other Local Areas in this and other regions in the Bioeconomy Project (Newfoundland and Labrador, 2022). In contrast, 80.1% of the population from Local Area 49 reported Very Good to Good mental health status. Therefore, only lower than Smith Sound-Random Island (LA 55), with 88.6% of Very Good to Good mental health status.

Regarding the level of schooling, 29% (5,095 people) of the total population aged 15 years and over in the Bloomfield-Bonavista region's do not have a certificate, diploma or degree, 26.7% (4,695 people) have a high school diploma or equivalent, and 44.3% (7,775 people) have a post-secondary education - PSE (Newfoundland and Labrador, 2022). These percentages are slightly different than the Provincial and Federal rates, notably, there are more people with no education certificate and less with a PSE degree than at the Provincial and Federal level. Specifically, 23.4% of NL inhabitants aged 15 years and over do not have an education certificate, 25% have a high school diploma, and 51.6% completed a PSE. At the Federal level, 18.3% of Canadians have no education certificate, 26.5% have a high school diploma, and 55.3% completed a PSE (Newfoundland and Labrador, 2022). There is a significant difference in the level of schooling among Local Areas in the BB region, thus influencing the regional averages. For instance, Southern Bay Area (LA 50) has the highest proportion of its population with no education certificate (38.6%) and the lowest with a PSE degree (30.3%). In contrast, Smith Sound-Random

Island (LA 55) has the lowest proportion of its population with no education certificate (24.6%) and the highest with a PSE degree (51.5%) (Newfoundland and Labrador, 2022). From the gender perspective, the proportion of men and women in the BB region with no education certificate or a PSE degree is fairly equal. The exception is for people with a high school diploma as the highest school level, of which 55.1% are women (Newfoundland and Labrador, 2022).

Natural resource challenges and assets

The Bloomfield-Bonavista region's natural resources are historically split between forestry and fishery. The development and growth of these two sectors have fluctuated over the years, especially with the silviculture program in the early 1980s, an initiative that undertook to renew and revitalize Newfoundland's forests as the Pulp and Paper industry was struggling (CBC News, 2019).

The fishery sector in Bonavista has had its share of difficult times, such as the collapse of the inshore cod fishery in 1992 and the integration of offshore fishery; two mechanisms that considerably impacted the local socio-economic structure (Bradley, 1997). Nonetheless, the fishery sector is growing alongside tourism (if not losing ground to it) in the BB region as the local economy diversifies and younger generations take root in the region (e.g., crab fishery; Bonavista Adventure Tours agency). Unfortunately, both sectors, fishery, and tourism, were considerably impacted by the COVID-19 pandemic, negatively affecting the local economy with unemployment rates skyrocketing (Garrett, 2020).

Significantly, there is an increasing interest in tourism activities closely associated with natural assets in places such as the Dungeon Provincial Park and the Lockston Path Provincial Park, both at the northern portion of the Bloomfield-Bonavista region (Newfoundland and Labrador, n.d.a). Tourism activities in the region are further supported by the proximity to an international airport in Gander, NL.

In the bioeconomy context, tourism involves appreciating ecosystem services and nonmaterial assets, and decreasing demand for natural resources by efficiently utilizing harvested assets - including their residues (Galanakis et al., 2022; Tyrväinen et al., 2017). Such activities can significantly benefit areas struggling with socioeconomic and demographic issues (Lundberg & Fredman, 2012). In this report context, the BB region harbours three ecoregions: the North-Central

subregion of the Central Newfoundland Forest (PAA, 2008o), the North Shore Forest (PAA, 2008p), and the Northeastern Barrens subregion of the Maritime Barrens (PAA, 2008q).

The North-Central is a subregion of the second-largest ecoregion on the island of Newfoundland, the Central Newfoundland Forest (PAA, 2008o). Most of its forests are boreal and the climate in the subregion is continental with some of the warmest summers and coldest winters. Similar to the other ecoregions in the BB, the North-Central subregion's summers are significantly dry, which means its forests are considerably prone to fire events, leading to extensive fire stands of black spruce and white birch (PAA, 2008o). Additionally, one of the rarest conifers (red pine) on the island occurs in this subregion. Overall, this subregion is densely forested, specially in the areas surrounding Bloomfield, where Sexton Lumber Co. is located. In places where fire events and cutovers were particularly severe and frequent, dwarf-shrub heath usually dominates these areas. In terms of wildlife, the subregion has a variety of species from mammals, birds, and fish through its many lakes and rivers.

The North Shore Forest comprises the western portion of the Bloomfield-Bonavista region and has the warmest and driest summers of any coastal area on the island, despite its closeness to the ocean (PAA, 2008p). Consequently, forest fires are even more frequent and extensive than in the Central Newfoundland Forest, leading to sizable fire stands of black spruce. Most of this ecoregion is forested, but trees on the coastline have their growth impaired due to direct exposure to wind from the Atlantic Ocean. The extensive stands of black spruce are quite relevant as it is the most valuable pulpwood species on the island followed by balsam fir (PAA, 2008p). Moreover, the occurrence of white birch in the region is also significant as it is the most important hardwood in the island (Newfoundland and Labrador, n.d.e).

The last ecoregion in the Bloomfield-Bonavista region is the Northeastern Barrens, a subregion of the Maritime Barrens (PAA, 2008q). Located in the eastern portion of the Bonavista peninsula, it is one of the coldest on the island and, unsurprisingly, its landscapes possess widespread barrens. Interestingly, this ecoregion used to be much more densely forested, however, repeated fire events caused by European settlers and then during the 19th-century railway gradually destroyed its forests, giving place to highly competitive shrub species (PAA, 2008q). Albeit small, sheltered spaces still harbour forests that are mostly dominated by balsam fir with patches of black spruce and white birch. In terms of wildlife presence, the subregion has mammals such as moose, caribou,

mink, snowshoe hare, and red fox; a variety of fish in its many rivers, lakes, and ponds; and a population of birds that are mostly migratory.

BB Final Considerations

The forestry industry is one of the most important pillars in the Bloomfield-Bonavista region, being represented by Sexton Lumber Co. (Newfoundland and Labrador, 2017a). Sexton Lumber is the largest integrated sawmill in the province of Newfoundland and Labrador producing a wide range of lumber products for both the markets in Canada and the United States. The company's operations not only enhanced the local economy in terms of job creation but also improved the region's infrastructure through diverse investments. For example, in 2016 Sexton Lumber invested around $2.6 million in a new finger-jointing plant, produced over 50 million board feet, and employed over 140 people through direct employees and contractors (Newfoundland and Labrador, 2017a). Furthermore, Sexton Lumber's employment influence in the region and the Province of NL is even wider if you consider the indirect workers and the report that they generated a sale revenue of USD 7.79 million in 2016 (Dun & Bradstreet, 2020).

An analysis of the impressive influence that Sexton Lumber exerts in the Bloomfield-Bonavista region supports the strategy recently reported on the "Workforce Strategies for NL" by Freshwater and Ward (2022). Notably, adopting a smart specialization strategy in which a region's strengths is primarily considered in policies around public and private investments, therefore preserving current jobs and sunk investments and boosting installed capacity, in this case, the forestry sector. That being said, a smart specialization strategy does not mean deprioritizing innovation and diversification, on the contrary. There are a variety of ways in which investments of capital and broader resources could accompany conditions that fully consider a "forestry of the future" by utilizing examples from across the world and market trends involving alternatives to fossil fuel-based products and services. For instance, a study conducted in Vietnam listed the following key factors in the success of forestry projects they evaluated: funding and equipment, skills mix and time allocation, commitment and collaboration, and capacity building (Bartlett et al., 2017). By emphasizing on the labor force, for instance, there is an opportunity to evaluate current recruitment strategies to promote a diversification of groups, therefore addressing the labour underrepresentation and, most importantly, promoting the broadening of ideas and products in the sector.

IX FOREST INDUSTRY ASSETS AND OPPORTUNITIES

As outlined above, consultations were held with forest industry representatives and associated stakeholders in each of the five case study regions. These discussions centered around identifying forest industry assets, attaching said assets to feasible opportunities related to product or workforce diversification, and identifying possible partnerships to help facilitate the realization of potential opportunities. The sections below include the results of discussions in each of the study regions.

CASE 1: BIOECONOMY ASSETS AND OPPORTUNITIES IN THE GREAT NORTHERN PENINSULA - ST. ANTHONY - PORT AU CHOIX REGION

- Strong desire among forest industry contractors to collaborate to develop a plan to revitalize the forest sector in the region. Suggestion to work with Grenfell Campus / MUN to assist with this
- Extensive timber resource available as contractors are not cutting their full permitted amount
- Interest in finding a market/use of small diameter wood and, if possible, process it locally to support employment in the region
- Possible opportunity to explore shared or centrally located equipment/infrastructure due to some contractors having to decide to either absorb costly repairs, decide to purchase new equipment or get out of the forestry business all together. Related discussion on whether it would be worthwhile to purchase a portable de-barker/chipper
- Willingness to adopt short-term plan for processing small diameter wood elsewhere until a longer-term local processing plan could be put in place
- Desire to enter discussions with Corner Brook Pulp and Paper regarding use of small diameter wood
- Discussion around the value of local port infrastructure and the possibility of international markets for products (e.g. wood chips)
- Desire to determine if there is an adequate local market for residential/domestic pellets if the local pellet plant was restarted
- Possibility of using small diameter wood/dead wood/ pulp wood to generate power to run a saw mill or other forestry related piece of equipment

CASE 2: BIOECONOMY ASSETS AND OPPORTUNITIES IN THE BURTON'S COVE REGION

- Recent investments at the mill will significantly increase the sawmill capacity, including the production of residues that can be used as inputs for other opportunities
- Potential opportunities discussed include utilizing waste heat, sawdust and shavings for potential agricultural or greenhouse applications
- Invitation to consider new uses for the former plainer building on site
- Mine operations in the region are utilizing/demanding a lot of mulch. Further opportunities in this area could be explored
- In the past, a greenhouse consultant evaluated the BC mill site and concluded that there is an excellent opportunity to install a greenhouse there due to access to a large area, an optimum slope for installation, water availability, and multiple resources from the mill
- Participants indicated an interest in a co-located greenhouse due to potential of increased horticultural production, mainly after the food security issues during the COVID pandemic
- Municipal government represented highlighted the mill's role as the town's most significant employer and indicated optimism about the increase in capacity after recent investments
- The Municipality is available to support the industry and opportunities related to a broader bioeconomy
- The production of fiberboard was discussed as an opportunity but at the moment there is not enough material to make this line of products feasible; would require partnership with other industry players
- Participants discussed opportunities involving climate change funding for carbon capture/offsetting that could support initiatives in the mill's region
- Waste heat from kilns could be utilized during periods when not needed for mill operations or captured after mill operation needs are met. Idea of using underground water tanks to store heat energy for later use
- Participant discussed the possibility of increasing the use of sawdust in support of plant cultivation combined with the installation of a co-located greenhouse utilizing the mill's residues to grow tree species seedlings that could be used by the forest sector and in land reclamation initiatives by the mining industry. There is already money available for that service, but probably being used to import those seedlings from elsewhere. It could be produced alternating with general

agriculture depending on the time of the year and the individual climate requirements.

- Suggestions on researching the possibility of laminated products at the BC's mill (currently being produced at Sexton Lumber). If feasible, products made out of laminated material could be used for other outputs other than mass timber buildings.

- Participant mentioned the possibility of offering a lecture on biochar after being asked about the topic by one of the meeting attendees. This would be done through the NL Horticulture Producers Council.

CASE 3: Bioeconomy Assets and Opportunities in the Corner Brook Region

- Hack Forestry & Start-Up Event: such events are focused on solving problems, finding solutions (often digital), and identifying scalable opportunities. Suggestion that CBPPL could act as an investor and partner for local start-ups seeking to address and solve their problems. Similar processes have been used in other settings.

- Centralized Heating & Regional Energy Supplier: discussion on using waste heat (hot water/steam) from CBPP for centralized heating of local district or adjacent infrastructure. Also related discussion around the merits of Deer Lake Power potential as a regional energy supplier.

- Product Diversification Opportunities: questions around how we move past paper as primary product and what the next generation of products might look like. Discussion around the feasibility of retrofitting equipment for additive manufacturing (3D printing) with examples including packaging and even fabric for the arts community.

- Related product diversification discussion on whether mill by-products could be used for new fabric production or if other plant fibres (perhaps from invasive species) could be used.

- Discussion on possibility of wooden cutlery production by retrofitting existing equipment to produce a locally made wooden cutlery and taking advantage of location and established export infrastructure and supply chain.

- Related discussion on feasibility of wood pellet production: exporting pellets and using material to produce energy and heat while utilizing existing supply chain connections and port facilities. CBPP reputation and influence could be used to help with some of the policy barriers

- Possibility of producing blended biofuel to replace diesel generated electricity in Labrador communities.

- Opportunities related to the installation of a bioprocessing plant next to the mill to create high value products and taking advantage of waste heat. Could do trials to develop a scalable model. Similar discussion regarding co-located greenhouse facilities

- Discussion around the opportunities of the carbon economy by earning Carbon Credits and selling surplus credits to those that are deficient

- Industrial tourism opportunities associated with the history and historical structures of CBPP. This would involve using the history, culture and location of the mill as well as the land the mill owns to create memorable visitor experiences

- Opportunities to take advantage of empty 'backhaul' trucks to deliver materials or products to areas outside of the region

- Discussion around the opportunities associated with cutover areas for berry and other non-timber forest product production

- Other regional assets: cruise ship destination; hunting/adventure tourism; film industry; other tourism sectors/businesses in the region, abundance of natural resources / close proximity to fibre supply and strong relationships with MUN/Grenfell, College of the North Atlantic, Centre for Research Innovation, and TechNL

CASE 4; BIOECONOMY ASSETS AND OPPORTUNITIES IN THE COTTLES ISLAND REGION

- Historic tourism: Opportunity to build upon existing regional tourism offerings to highlight the history, culture and location of the mill as well as the land the mill owns to create memorable visitor experiences
- Discussion around the educational value of the machines operating at the mill as well as other processes involving the mill's residues and potential application in agricultural contexts
- Opportunities stemming from the production of biochar: Discussion around biocahar's adsorbent properties when used in response to water contamination and to avoid eutrophication and its use

as a soil amendment to increase nutrients for agriculture (especially in combination with mycorrhiza fungi).

- Opportunities around mulch products: Discussion on merits of ideal mix of bark material and shavings to obtain an ideal mulch particle size. Further discussion on use of a 'hammer mill' (not currently in use at Cottles Island Lumber Co.) for mulch production.
- Research opportunities on types of fungi that could be combined with mulch to optimize decomposition and nutrient cycling.
- New product opportunities related to packaging – replacement of plastics utilizing fibre-based material.
- Workforce shortage challenge (related aging workforce) leading to diversification through recruitment of foreign workers.
- Development of (and previous company experience with) prefabricated house construction kit for exportation.
- Discussion round the merits of Geodesic dome houses – more efficient structures with less heat loss and reduced lumber requirements. Possibility/market opportunity of designing prefabricated kits if machines are precise enough.
- Buried heat system – similar to energy districts in parts of Europe. To take advantage of waste heat from kiln process – could be used for co-located operations near the mill.

CASE 5: BIOECONOMY ASSETS AND OPPORTUNITIES IN THE SEXTON REGION

- Recover heat/energy and use within the mill for other value-added processes/products.
- Suggestion of a greenhouse operation using waste heat to support all-season food production, selling to both residential and restaurant customers.
- Discussion around using excess energy in the production of hydrogen. (Canada has launched its national hydrogen strategy; a NL strategy is being developed; may present an exciting opportunity for the mill to be on the leading of edge of the clean economy.)
- Exploring opportunities for electricity production with the excess steam – a micro-grid electricity system for surrounding area; could be used as an investment attraction asset for the region.
- Pursue an opportunity with Newfoundland Power to produce "green renewable" electricity and sell into the grid.
- A secondary processing facility for food products (e.g., cutting carrots down to size for use in hospitals, etc.) that could use waste energy from the plant and leverage existing skill base in equipment operation and

maintenance.

- Explore developing an engineered wood product partnership to produce glue-laminated timbers or cross laminated timber products.
- Produce component parts for other wood-based industries (add value to commodity lumber).
- Suggestion to produce wood pellets/heating product(s) for residential wood stoves and/or to support distributed heating systems in new subdivisions developments or residential complexes.
- Expand production of mulch for animal bedding using wood/biomass residuals.
- Production of landscaping mulch using wood/biomass residuals.
- Production of compost and soil amendments using wood/biomass residuals.
- Use sawdust for an absorbency material for the oil industry.
- Utilize clean ash (not contaminated by oil) from boiler for soil amendments.

X LEVERAGING POST-SECONDARY EDUCATIONAL INSTITUTIONS FOR A SUSTAINABLE CIRCULAR BIOECONOMY IN NEWFOUNDLAND AND LABRADOR

The following account assesses the future role of PSE institutions in advancing the emerging forest-based circular bioeconomy in NL. The role of PSEs, with particular reference to academic offering and research capacity, in support of an emerging circular bioeconomy is based on work by Arantes-Garcia & Bowers (2022). The work sets a brief context for the emerging circularly bioeconomy and offers 'foresight' based on green economy trends in other parts of Canada and the world. Particular attention is given to recent investments, educational trends, and circular bioeconomy developments in the European Union.

Recommendations are provided to assist PSEs, notably the College of North Atlantic and Memorial University of Newfoundland, in development of their respective programs, including model curricula which draw on best practices in areas where the circular bioeconomy is deemed high priority. It is anticipated efforts will be made to integrate future training in support of the Newfoundland and Labrador forestry sector. Leveraging the capacity of PSEs in building a strong, sustainable circular bioeconomy remains critical to the province's commitment to clean growth strategies, a low carbon economy, and nature-based solutions to combat climate change. As such, findings from this report will be used by the Newfoundland and Labrador Forest Industry Association (NLFIA) to help create jobs, train workers, and promote career paths in the sector. Such activity has particular relevance in rural areas of the province where many communities are highly dependent on forest resources.

Role of Post-secondary Educational Institutions

Promoting education, training, and skills across the forest sector remains a priority for the NLFIA. In their 2020 strategy report, *A Pathway for a Forest-based Circular bioeconomy in Newfoundland and Labrador* (Bowers, 2020), and in their 2022 workforce report titled *Attraction and Retention Strategy for the Newfoundland and Labrador Forestry Sector* (NLFIA, 2022), the Association identified workforce issues, training, and skills development as among the most important issues facing the sector. PSE institutions, in particular, have a unique role to play in advancing the growth

and diversification of the province's forest sector. These institutions include scholars in a variety of disciplines and offer a sizable pool of expertise in many areas of study. A number of workers have examined the central role of higher education and how educational institutions can position themselves in transforming economies and society (Bégin-Caouette et al., 2021; Deem, et al., 2008; Fisher et al., 2014; Gleason, 2018; Harden, 2017; Lebrun 2006; Müller-Chris, et al. 2014; Pritchard et al., 2016; Reichert, 2019; Reimers, 2020; Williams & Savage, 2020; Zilahy & Huisingh, 2009). Several reviews directed specifically to NL public post-secondary education examined future education needs including the nexus between education and society (CARE et al., 2014); Newfoundland and Labrador 2005, 2019; Ludlow & Farrell, 2004; McKinsey, 2019; Batten, 2022). Recently, a review by the Premier's Economic Recovery Team (PERT) reviewed NL's education system in the context of economic recovery, with aspirations to place the province on more sustainable financial footing (Newfoundland and Labrador, n.d.f). These works make clear the positive impact and significance of the province's PSEs. Indeed, few institutions have more to offer in advancing development of the circular bioeconomy, on both a local and national basis, than Canada's technical colleges and universities. As leading institutions in their communities, they serve as technology centers, employers, and enablers. Most importantly, they also serve as regional innovation platforms. Accordingly, PSE institutions fulfill roles that extend well beyond the scholarly boundary of research and education. That is, apart from their teaching and research remit, both university and technical institutions offer their communities economic, cultural, and social opportunities which would otherwise not be available in their region.

In a 'knowledge society' where digital and bio-based economies are rapidly emerging, these institutions remain central to the creation of advanced industrial clusters in their regional areas. The strategic role PSE institutions have on their regional economies including on both technological and social innovation is well documented (Bammer et al., 2020; Bayuo et al., 2020; Benneworth, & Cunha, (2015); CEOs for Cities, 2010; Clark, 1998; Crow & Dabars, 2015; Giammarco et al., 2020; Grillitsch & Sotarauta, 2019; Hall et al., 2014; Hart et al., 2015; Kitagawa, 2005; Westnes, et al., 2009; Wolfe & Gertler, 2004). Highly relevant to the development of NL's forest industry is recent work by Carter (2022) who reported how less favoured regions are struggling to adapt to global competition within the knowledge- based economy. The work integrates key factors of regional innovation systems (RIS), entrepreneurial ecosystems, and less favoured regions to develop an innovation and entrepreneurship model more relevant for rural NL,

particularly where natural resource industries have limited capacity. Underpinning the model is the need for strong institutional capacity, and for a meaningful level of collaboration among elements of the quadruple helix encompassing PSE institutions (academic and research institutes), government, industry, and community. Carter's work also serves as a reminder that, ontologically, energy transitions are often viewed through Schumpeterian, techno-innovation frameworks, effectively placing technology at the center of the transition and transition management. Because such approaches do not necessarily center humans or communities within the transition, Carter (2022) proposes a model(s) to encompass social innovation, social enterprise, and social entrepreneurship more effectively. As such, it helps define viable and acceptable pathways to shape the bioeconomy.

Pathways to shape the Circular Bioeconomy

The bioeconomy is seen by many as an opportunity to strengthen existing traditional industries, such as forestry and agriculture. Further, it offers potential to generate economic growth in a way that solves pressing problem such as climate change, which is strongly linked to fossil fuels. As an emerging research field and policy framework, enabling a shift to more sustainable practices is at the core of the circular bioeconomy. However, the path forward is complicated by a myriad of strategies and interpretations of the circular bioeconomy (International Advisory Council on Global Bioeconomy, 2020; Wei et al., 2022). A number of countries take a narrow focus with great emphasis on biotechnology and conversion processes. Others advocate for more holistic approaches (socio-ecological) and consider the bioeconomy to be a comprehensive societal transition that involves a variety of industries such as forestry, agriculture, fisheries, plant and animal breeding, food processing, the wood, paper, leather, textile, chemical, and pharmaceutical industries, as well as parts of the energy sector. The way forward is further complicated by a broad variety of underlying assumptions, different political strategies and priorities, and alignment with the interest of stakeholders. Sustainable land use (O'Brien et al., 2015), available biomass (Musonda et al., 2021) and other socio-ecological issues pose further challenges to the design and development phase of the intended transformation.

Another issue concerns the question of whether the spatial perspective of the bioeconomy should be local, regional or global. This orientation is influenced by sustainability factors that range from community dynamics and conditions to global commitments and agreements. A number of

workers argue for a 'middle way' to link local and global levels need (Ministry of Employment and the Economy, 2014).

A Strong Foundation

Within both Memorial University (MUN), and the College of the North Atlantic (CNA), a strong foundation on which to build a circular bioeconomy economy has been established. At present, these two institutions form the cohesive substance, the glue, of socioeconomic clusters and collective identity in the province. As 'entrepreneurial institutions', MUN and CNA offer powerful platforms for economic development. Leveraging the capacity of these institutions to integrate circular bioeconomy research into forest sector ventures and further transform the sector provides a unique opportunity for the province. For example, the institutions can play a pivotal role in advancing the concept, development, and skills required to advance the bioeconomy in the province. Moreover, institutional capacity is needed to assist new or existing forest-based industries in prototype, pilot, and industrial scale up. Indeed, it can be argued that the willingness and capabilities of CNA and MUN to promote prosperity and contribute to a provincial bioeconomy agenda, is key to the future success of resource-based industries such as forestry, agriculture, and fisheries.

Institutional Profiles

College of the North Atlantic (CNA) is a public college in Newfoundland and Labrador, Canada. With over 1100 staff and faculty members, and a student population of approximately 7000 per year, CNA is one of the largest colleges in Atlantic Canada. CNA offers a wide range of certificate and diploma programs across multiple disciplines. These include Applied Arts, Business, Health Sciences, Engineering Technology, as well as Natural Resources and Industrial Trades. CNA is known for its practical, hands-on approach to education, providing students with real-world experience and the skills necessary to succeed in their chosen fields. The college has state-of-the-art facilities and equipment and is committed to providing students with a supportive and inclusive learning environment. CNA has a strong partnership with local industry and organizations, providing students with opportunities for internships, co-op programs, and other forms of experiential learning.

The Memorial University of Newfoundland (MUN) is a decentralized comprehensive public university in Newfoundland and Labrador, Canada. Established in 1925, it is one of the largest

universities in Atlantic Canada, supporting 19,000 students from over 115 countries. MUN employs over 3700 faculty and staff across three campuses and ranks in the top ten of Maclean's 2023 Canadian comprehensive university category. The institution offers a wide range of undergraduate and graduate programs across several faculties, including Arts, Business, Education, Engineering and Applied Science, Medicine, Science, and Social Science. Known for its strong commitment to research and innovation, it has several research centres and institutes dedicated to various fields of study. These include the Environmental Policy Institute (EPI), Ocean Engineering Research Centre (OERC), the Grenfell Campus (GC) Boreal Ecosystem Research Initiative, the Labrador Campus' Northwest River Research Station, as well as multiple research units at the Marine Institute. The university also has a vibrant student life, with numerous clubs and organizations, athletic teams, and cultural events, providing a dynamic and supportive environment for students.

Circular Bioeconomy and Sustainability Nexus

A circular bioeconomy can only advance within the context of sustainability. The forest sector is expected to play an increasingly strong role in the development of the bioeconomy and is a major component of the province's sustainability pathway as it hits critical net zero targets in 2030 and beyond. For example, the NL forest industry is placing increased attention on 'climate smart' forestry to sequester carbon to help mitigate climate change impacts. Given the province's high dependence on resource industries, and its commitment to national and global sustainability goals, both MUN and CNA have in the last decades, placed increased attention on environmental issues, most notably, climate change, biodiversity loss, food and water security, and environmental policy. Current programs provide the basis for local and regional capacity building in multiple resource sectors and have particular relevance to a forest-based bioeconomy. As scholars and practitioners grapple with the challenges brought about by a rapidly changing world, transitioning to a more sustainable way of living is no longer an option; it is now an imperative. Coupled with program offerings in the biological sciences, business, information and engineering technology, technical training, and new graduate programs in interdisciplinary and transdisciplinary science, there is growing evidence of a 'sustainability shift' within NL's PSE institutions – one that provides a solid foundation on which to build a viable and productive circular bioeconomy. Sustainability is now an explicit part of most business strategies, and more students are being educated for sustainability (Crofton, 2000; Raivio, 2011; Steiner & Posch, 2006; Sterling, 2004, 2006); it is not by accident

that 90% of S&P 500 companies now publish sustainability reports. To remain competitive, local industries, including forest-based companies, will have to demonstrate their commitment to Sustainable Development Goals (SDG) embedded in international agreements and conventions to which Canada is a signature. Chankseliani & McCowan (2020) report that one of these goals (SGD 4) calls for equal access to tertiary education, including universities, as part of the promotion of lifelong learning opportunities for all. These workers further note that PSE institutions have another important role in the SDGs, as a driver for the achievement of the full set of goals, through their role in human formation, knowledge production and innovation. Currently, Canada ranks 20th globally amongst countries striving to hit the SDGs. The country's availability to improve its record and to be competitive in a global market is in many ways dependent on institutions with a responsibility to educate, train and advance more sustainable approaches to resource development. Consequently, sustainability-oriented programmes are developing at a fast pace throughout Canada and the world (Lambrechts et al., 2013). Interestingly, some of the academic and co-curricular programmes leading the way are faculty professional development and incentive programmes that support the integration of sustainability education into the curriculum including sustainability degree programmes. The establishment of the Environmental Policy Institute and new degree programs in Boreal Ecosystems and Agricultural Sciences, Environmental Policy, Applied Geomatics, and Transdisciplinary Sustainability at Memorial University (GC) are particularly noteworthy, in that they successfully embed sustainability within tertiary curricula and pedagogy, thereby responding directly to sustainability challenges. For sustainability education to come to fruition requires a change in education culture. That is, it requires much more holistic thinking as described by (Boyd, 2017; Grasso & Burkins, 2010; Nicolescu, 2002; Zhang et al., 2022). Moreover, to be effective at engaging students in such long- term and often abstract thinking, sustainability education should rely on transformative learning experiences that allow students and faculty alike to confront the core assumptions and values underlying sustainability as both an idea and a practice (Savelyeva & McKenna, 2011). Further, it can be argued that the efficacy and relevance of a sustainability education is best realized in its ability to encourage more than just knowledge acquisition; it also provides opportunities for personal growth and an evolution in one's thoughts and mind-set toward adopting a more sustainable lifestyle. Evans (2020) suggested that one approach to a sustainability education involves teaching students to slow down, observe carefully, and think critically, deeply, and holistically. More rigorous is work by

Evans (2019) who articulated and described in depth a set of core competencies for the sustainability field and suggests potentially effective pedagogies for teaching them. These competencies include (i) interpersonal communication, (ii) creative and strategic, (iii) critical and normative, (iv) systems, and (v) transdisciplinary competencies.

Of the various pedagogical approaches available, informal, and experiential learning offer high potential for training in the circular bioeconomy because it can provide for transformative experiences. This approach has particular importance in understanding both consumption and sustainability. This implies that in addition to the two traditional missions of teaching and research, PSE institutions have to adapt to changes in social, economic, political, and ecological contexts in order to emerge as key actors for sustainable consumption (Adomssent et al., 2007; Blass et al., 2010; Gombert-Courvoisier, et al., 2014; Karatzoglou, 2013; Martin, 2012; Nejati & Nejati, 2013; Yasin &Rahman, 2011; Yuan & Zuo, 2013).

Forest Centre – MUN-Grenfell Campus, Corner Brook

Academic programming at Memorial and CNA continue to give increased attention to sustainability science. Programs with particular relevance to the emerging circular bioeconomy are listed in Tables 2 and 3. However, as discussed below, there are gaps and specific skill sets that need to be addressed to adequately address learning, training, and the future of work.

CNA Campus, Corner Brook

Table 2. Selected programs offered by CNA deemed to be of high relevance to the emerging circular bioeconomy in the province.

School	Program	Description
Academics, Applied Arts & Tourism	Textile & Apparel Design	Textile & Apparel Design provides students with an opportunity to learn and create one-of-a-kind textile and apparel products through drawing, design, textile and apparel practices. In the program, students will nurture an appreciation for the handcrafted product with the use of natural and sustainable materials.
Business & IT	Business Administration (General)	Students in the Business Administration (General) program will develop interpersonal and organizational skills. They will use the latest computer technology in business decision making and learn practical skills which will help them to be productive members of the workforce.
Business & IT	Accelerated Software Development	Students will learn to use leading-edge processes and methodologies to develop and maintain software for phones, tablets, and computers. This will give them the competencies and approaches required to create, build, and maintain software systems ranging from small to enterprise solutions.
Business & IT	Bachelor of Applied Information Technology: Systems and Network Cybersecurity	The student will learn how to protect against unauthorized access ensuring confidentiality, integrity and availability of resources shielding an organization from internal and external infiltration and attacks. Hands-on activities will prepare students with the skills to safeguard and monitor IT infrastructures, edge devices, networks, and data.

School	Program	Description
Business & IT	Computer Systems and Networking	This program focuses on the skills, competencies and attitudes required to research, design, install and maintain computer systems and network infrastructure in a highly available and secure computing environment.
Business & IT	Cybersecurity for the IT Professional	This program will directly support and strengthen the cybersecurity industry, promoting data and information security for the public and private sectors. The program will enable existing information technology professionals to enter the growing cybersecurity industry for new in-demand roles and fill the emergent skills gap.
Business & IT	Information Management	Students will be able to implement IM best practices in training and consultation to ensure everyone in the organization adheres to regulatory standards, including the security, legal and privacy regulations required.
Business & IT	Project Management	Students will develop strong project management skills enabling them to successfully implement and align projects with organizational strategic plans. Relevant to every industry, the student will acquire the techniques and tools for the application of project management. The student will gain knowledge in managing teams, and projects to ensure a business runs smoothly.
Business & IT	Software Development (Co-op)	This program focuses on the competencies required to design, implement, and maintain software systems that operate in a secure business networked environment containing stationary and mobile devices. The program combines theoretical and practical learning experiences in a team-oriented setting.
Business & IT	Strategic Leadership	Students will develop strong leadership skills to successfully bring out the best in their teams and apply innovative and flexible leadership strategies. Throughout the program, the student will gain a thorough understanding of the appropriate principles, techniques, and tools to apply effective leadership strategies.
Engineering Technology	Chemical Process Engineering Technology (Co-op)	The program equips graduates with both the knowledge and practical skills necessary to begin their career as competent process operators and chemical engineering technologists.

School	Program	Description
Engineering Technology	Civil Engineering Technology (Co-op)	The field of civil design and construction plays a central role in the economic viability of many industries and the province as a whole. The civil field includes such areas as residential, commercial, and industrial buildings; harbours, airports, roads, and other transportation facilities; and municipal infrastructure. Natural resource development projects (hydropower, oil and gas, mineral processing, etc.) will continue to create substantial employment opportunities for Civil Engineering Technology (Co-op) graduates.
Engineering Technology	Computing Systems Engineering Technology (Co-op)	The Computing Systems Engineering Technology (Co–op) program prepares students for the field of scientific and engineering computing. A combination of programming theory and practice, networking, and electronics ensures the graduate will be prepared to work in the fields of cloud computing and mobile device application development, as well as develop the foundation for the emerging fields of machine learning and Big Data.
Engineering Technology	Environmental Engineering Technology (Co-op)	Students will have advanced skills in the use of environmental sampling, monitoring & testing, data analysis, and information technology tools. They have the ability to manage environmental projects from planning through to implementation and the maintenance phase. They have applied knowledge of health, safety and environmental requirements and can contribute to risk assessment and environmental systems management.
Engineering Technology	Environmental Engineering Technology - Advanced Diploma	This program is intended to provide the additional skills and knowledge that engineering, and science graduates require to successfully work on environmental assignments such as contaminated sites, water treatment facilities, sustainability management, contaminant hydrogeology, integrated solid waste management, environmental impact assessment, air quality, climate change, resource management, green energy technology projects and health safety and environmental compliance.
Natural Resources & Industrial Trades	Agriculture Technician Co-op	Students will receive instruction in a broad range of course content aimed at developing good analytical and organizational skills, as well as the ability to work effectively as a team member.

School	Program	Description
Natural Resources & Industrial Trades	Fish and Wildlife Technician	The program reflects the trend towards integrating a wide range of natural resources technology within government departments at Federal and Provincial levels. It provides a balance of field and classroom experiences that include a significant computer-based data collection and analysis component.
Natural Resources & Industrial Trades	Forest Resources Technician	This program provides a strong foundation in the skills and knowledge required for a career in the natural resources industry. Students will be versed in ecosystem management opportunities and challenges, and they will be able to use their acquired skills to evaluate and present sustainable management solutions.

Table 3. Selected graduate programs [11]offered by MUN deemed to be of high relevance to the emerging circular bioeconomy in the province.

School of Graduate Studies	Program	Description
Humanities and Social Sciences	Economics	MUN offers applied economics courses in a wide variety of areas, including fisheries, petroleum and mining, forestry, environmental, international, monetary, public sector, welfare, labor, and health economics.
Humanities and Social Sciences	Environmental Policy	This program is a rigorous, interdisciplinary study of environmental policy in terms of its theory, application, methodology, and approaches with reference to central contemporary debates. It is also an applied program that equips students with practical skills in the field making links to the labour market through a required internship program.
Humanities and Social Sciences	History	MUN's faculty are engaged in research in a wide range of topics in fields such as environmental history, social history, cultural history, military history, and many others, and supervise graduate studies covering periods from the ancient world to the twenty-first century, and regions across the globe.

[11] Listing of MUN programs focused exclusively on graduate programming, as a measure of teaching and research capacity.

School of Graduate Studies	Program	Description
Humanities and Social Sciences; Interdisciplinary	Humanities	Humanities concerns the human condition, past, present, and future. The human condition includes the natural world of which we are a part and from which we have distinguished ourselves, as well as the social, economic, and cultural worlds we create.
Humanities and Social Sciences; Interdisciplinary; Professional Programs; Sciences	Interdisciplinary PhD	This program is intended for students whose academic interests cross multiple academic disciplines. It offers an intimate and varied community in which students bring strong individual initiative together with the shared research concerns and expertise of a diverse supervisory committee in studies that cross traditional disciplinary borders.
Humanities and Social Sciences; Interdisciplinary; Professional Programs	Sociology	This program offers specialties in social theory, criminology and deviance, environmental sociology, social inequality, sociology of gender, sexuality, development, work, culture, and health, including occupational health, political sociology, and maritime sociology.
Humanities and Social Sciences; Interdisciplinary; Sciences	Transdisciplinary Sustainability	This program aims to make a strong contribution to understanding and addressing complex ecological-social-economic-political issues by leveraging the unique strengths of Grenfell Campus and its School of Science and the Environment.
Interdisciplinary; Sciences	Sustainable Aquaculture	Research activities involve the development of new species for aquaculture in the province. Faculty expertise exists in a wide range of scientific and practical areas, including feed development and analysis, marine larviculture, fish husbandry, commercial scale feeding trials, design of grow-out systems for fish and shellfish culture, optimizing shellfish farm production, international links and consultancy, bivalve larvae, and spat monitoring.
Interdisciplinary; Professional Programs	Arctic and Subarctic Futures	MUN's faculty cover a diverse range of Northern-focused research topics, including (for example): Indigenous pedagogies and methodologies; cultural resources management; archaeology; education; governance and self-determination; climate change; Indigenous health and wellbeing; language and cultural reclamation; food security; co-management; and natural resources management.

School of Graduate Studies	Program	Description
Interdisciplinary; Professional Programs	Master of Artificial Intelligence	Students will become specialists who are able to envision how to solve problems with AI technologies, and to develop, understand and maintain AI-based systems.
Interdisciplinary; Sciences	Cognitive and Behavioural Ecology	This program is focused on animal behaviour and behavioural ecology. It is designed to train students in research that integrates cognitive and behavioural studies at the ecological level.
Interdisciplinary; Engineering and Applied Science	Engineering and Applied Science	This program offers various engineering disciplines, including Civil, Communications, Computer, Electrical, Energy Systems, Mechanical, Ocean and Naval Architecture, Oil and Gas, Process, and Safety and Risk engineering. Faculty expertise encompasses a wide cross-section of specialties and backgrounds; many faculty members have broad industrial experience and complement their teaching and research programs with consultancy services.
Interdisciplinary; Professional Programs; Sciences	Master of Data Science	Students will become specialists who are able to structure, analyze and process data. They will learn the foundations of data science and provide them with practical techniques needed to effectively translate data into knowledge, communicate the findings, and help in the decision-making process.
Interdisciplinary; Sciences	Environmental Science	These programs give students an opportunity to build upon their undergraduate science education, to investigate its environmental relevance, to see how it relates to other scientific disciplines important in Environmental Science, and to learn more about these other disciplines.
Interdisciplinary; Professional Programs	Marine Studies	This program provides students with the education, training and management skills required to participate in aquaculture development and production. They will develop current and relevant knowledge combined with technical and practical experience to prepare them for careers in a range of aquaculture and related fields (e.g., aquaculture farm operation and management, aquaculture advisory agencies, federal and provincial government departments, environmental monitoring, fish health suppliers, consulting companies, fish food manufacturers, and aquaculture equipment manufacturers and distributors) in Newfoundland and Labrador, Canada and internationally.

School of Graduate Studies	Program	Description
Interdisciplinary; Professional Programs	Maritime Management	This program will build student's potential to become leaders in the global marine industry. This program will provide them with a broad understanding of the structure and operation of organizations and the factors that influence business decisions in the context of maritime-based organizations.
Interdisciplinary; Sciences	Scientific Computing	These programs train students in advanced computational techniques and in the application of these techniques to at least one scientific area, such as Applied Mathematics, Chemistry, Computer Science, Earth Sciences, Physics, or Physical Oceanography.
Interdisciplinary; Sciences	Applied Science in Software Engineering	Students will become specialists able to develop software, understand and support computer systems architecture and design, and distributed services.
Interdisciplinary; Professional Programs	Technology Management (Online)	This program will provide students with strategic planning and decision-making skills in the context of technology-based organizations. They will gain insight into the nature, structure, and operation of technical operations, and the factors that influence business decisions and success of technology-based organizations.
Professional Programs	Business Administration	Students will become well prepared to make decisions, run organizations and hold leadership positions in public, private and non-profit sectors across the globe.
Professional Programs	Medicine	The programs are designed to provide formal instruction as well as to promote informal exchange in areas of health research. There are ten areas of concentration in graduate studies in the Faculty of Medicine: Applied Health Services Research, Cancer and Development, Cardiovascular and Renal Sciences, Clinical Epidemiology, Community Health, Human Genetics, Immunology and Infectious Diseases, Neurosciences, Public Health, and Health Ethics.
Professional Programs	Pharmacy	This program provides cutting-edge research in an up-close and personal environment. The School of Pharmacy provides graduate students with the opportunity to conduct original research related to Drug Discovery and Delivery, Health Outcomes, and the Scholarship of Teaching and Learning.

School of Graduate Studies	Program	Description
Professional Programs	Public Health	This program will prepare students for practical work in a variety of public health practice settings. The goal of the program is to prepare graduates who are skilled in public health practice to contribute to promoting health and preventing illness and injury in their community.
Sciences	Applied Geomatics	This program will prepare students for any number of careers in environmental fields that require advanced level spatial analysis and its application to research.
Sciences	Mathematics and Statistics	Among the research areas studied by MUN's faculty and graduate students are the following: Numerical Analysis and Scientific Computation, Analysis, Combinatorics, Topology, Applied Statistics, Differential Equations and Dynamical Systems, Mathematical Models and Modeling / Numerical Optimization, Algebra, Mathematical Physics, Mathematical Statistics, and Fluid Mechanics.
Sciences	Biochemistry	MUN's department is both unique and diverse, with expertise in nutrition, human metabolism, the molecular structure and function of proteins and membranes, and food science, as well as a background in physiology and the molecular etiology of normal and disease conditions ranging from obesity, cardiovascular diseases, neurology, and cancer to gastrointestinal tract biology and immune cell function.
Sciences	Biology	This program features approximately 20 researchers from outside Memorial University, many employed in government laboratories (agriculture, fisheries, forestry, and wildlife), hold adjunct appointments with the Department and contribute to the graduate program as co-supervisors and supervisory committee members.
Sciences	Boreal Ecosystems and Agricultural Sciences	This program is designed to train students in high level research in boreal forest ecosystems and agroecosystems. Emphasis is on developing an ecosystem approach to support science-based research on sustainable forest and agriculture systems.
Sciences	Chemistry	This program features faculty members' research whose interests touch on all major subfields of Chemistry, including analytical, physical, inorganic, organic, theoretical/computational, environmental/marine, and materials.

School of Graduate Studies	Program	Description
Sciences	Computer Science	This program provides a solid and rigorous foundation on which systems and applications can be built. It also has a large potential impact on interdisciplinary collaboration.
Sciences	Fisheries Science	Memorial's Marine Institute offers three degree options in the area of Fisheries Science: The degree of Master of Science in Fisheries Science (Fisheries Science and Technology), the degree of Master of Science in Fisheries Science (Stock Assessment), and the Doctor of Philosophy in Fisheries Science.
Sciences	Marine Biology	Students are engaged in a variety of research areas including physiology, biochemistry, and molecular biology; biological and chemical oceanography; behavioural and population ecology; and aquaculture and fisheries.

The Future of Learning, Training and Work

Highly relevant to the advancement of the circular bioeconomy is the convergence of biological systems and digital technologies. Broadly, biodigital convergence will transform the natural resource sector through new ways of making and obtaining raw materials and fuels, as well as new manufacturing techniques. It may also accelerate the transition towards genetic engineering- based biomanufacturing. This biodigital trend is challenging the way we understand ourselves and the world in which we live. For example, biodigital capabilities will increase our capacity to connect with and monitor the natural world and expand our understanding of the interconnectedness of life forms. It will also promote genetic modification and foster new biotechnology techniques for new product development and processes that underpin the emerging circular bioeconomy. This trend has important implication for the forest sector. Demand for forest products is expected to increase in the coming years, as the global population grows, and standards of living continue to rise. International trade is also expected to increase. Given the need to remain competitive and to regenerate, recapture and recycle, the circular bioeconomy offers high potential and opportunities for forest- based industries in the province. Capitalizing on these opportunities calls for substantial capacity building, with emphasis on education, new skills development, training, and research and innovation.

The near future will bring significant changes to the nature of learning, training, and work, including what, how, where, and by whom work will be done. The learning and work environments are expected to be dominated largely by digital technologies, automation, and telepresence. As more technologies mature and combine, changes to the fundamental organizing principles of the economy will occur and the nature of work will be radically altered. Hashim et al. (2021) argue that digital technologies has brought a window of opportunity for universities empowering students and academics. The utilization and integration of digital technologies enable universities to go beyond their conventional virtual borders, influencing the portfolio of courses, regulating the delivery model and the entire value chain of a university. Similarly, digital technologies such as artificial intelligence (AI), robotics, cloud computing, 3D printing, and mixed reality are already transforming the manufacturing sector. As such, the new digital economy is expected to revolutionize global value chains. PSE institutions will need to take advantage of this transformation and build comprehensive programmes and models of cooperation with society within new growing challenge of digital and green transitions (European Commission et al., n.d.). Indeed, in Europe PSE institutions are committing significant funding to the development of new academic programs aimed at promoting education, training, and skills across the bioeconomy (European Commission 2018, 2021). A review of selected programmes relevant to the development of the circular bioeconomy within the European Union is presented below in Table 4. The data presented stratifies information along two primary levels: Higher Education Institutions (**HEI)** and vocational education and training (**VET**). At VET level, the study covers both Initial Vocational Education and Training (**IVET**) and Continuous Vocational Education and Training (**CVET**) programmes. The objective of the latter designations was to recognize the importance of life-long learning, which is acknowledged as a crucial factor in realizing the transition to a sustainable and circular bioeconomy. **EQF** is a lifelong learning framework and covers all types of qualifications ranging from those acquired at the end of compulsory education (Level 1) to the highest qualifications such as a Doctorate (Level 8).

Table 4. Selected programmes relevant to the development of the circular bioeconomy within the European Union.

Programme	Country	Institution	Unit or Department	Education level	Category	Type	EQF Level	Sector Classification	Target Audience (IVET / CVET / both)
Master Innovation Management and The Food Design	Belgium	University of Liège – Gambloux Agro-Bio Tech				HEI			
Entrepreneur in Wood Construction	Belgium					VET			
Entrepreneur and Creator of Green Spaces	Belgium					VET			
Biotechnologist	Bulgaria	Atanas Chengelev Vocational School of Food Technology				VET	Level 4	Agriculture	IVET
Responsible and Sustainable Governance	Bulgaria	Sofia University St. Kliment Ohridski							
Responsible and Sustainable Governance	Bulgaria	Sofia University St. Kliment Ohridski	Faculty of Economics	Master					

Programme	Country	Institution	Unit Department	Education level	Category	Type	EQF Level	Sector Classification	Target Audience (IVET / CVET / both)
Biomanagement and Sustainable Development	Bulgaria	Sofia University St. Kliment Ohridski	Faculty of Biology	Bachelor	Bioeconomy content included	HEI			
Master Economics and Management of Agribusiness	Bulgaria	University of Agribusiness and Rural Development				HEI			
Economy of Food Industry	Bulgaria	University of Food Technologies Plovdiv							
Economy of Food Industry	Bulgaria	University of Food Technologies Plovdiv	Faculty of Economics	Master					
Ecology and Environmental Protection	Bulgaria	Vocational School of Ecology and Biotechnology				VET	Level 4	Agriculture	IVET

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Agroecology	Bulgaria	Vocational school of Mechanization of Agricultural				VET	Level 4	Agriculture	IVET
Biogas Power Plants Operator	Estonia	Järvamaa Vocational Training Centre				VET	Level 5	Production of bioelectricity	IVET
Woody Plants Assessor	Estonia	Luua Forestry School, Vooremaa, Jõgeva County Estonia				VET	Level 5	Forestry	IVET
Forestry Specialist	Estonia	Luua Forestry School, Vooremaa, Jõgeva County Estonia				VET	Level 5	Forestry	IVET
Biological and Chemical Engineering for a Sustainable Bioeconomy	Estonia	Tallinn University of Technology (TalTech)	As a part of Consortium BIOCEB – 5 EU universities from FR, BE, FI & EE	Master	Dedicated Bioeconomy curricula	HEI			
Master Environmenal Engineering and Management	Estonia	TalTech				HEI			
EIT Food Master's in Food Systems	European Union	European Institute of Technology (EIT)							

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target Audience (IVET / CVET / both)
EIT InnoEnergy Master's in Sustainable Energy Systems	European Union	European Institute of Technology (EIT)							
PhD Water and Environmental Engineering	Finland	Aalto University				HEI			
Sustainable energy systems (as part of EIT InnoEnergy programme)	Finland	Aalto University							
Water And Environmental Engineering	Finland	Aalto University	Faculty of built environment	PhD	Bioeconomy content included	HEI			

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Biological and Chemical Engineering for Sustainable Bioeconomy (Bioceb)	Finland	Aalto University	School of Chemical engineering	MSc	Dedicated Bioeconomy curricula	HEI			
Sustainable energy systems (SELECT)	Finland	Aalto University	School of Engineering	Master					
Process manager, water, waste and energy industry	Finland	Helsinki Vocational College				VET	Level 4	Energy, water and waste management	IVET
Vocational qualification in natural and environmental protection	Finland	KSAO				VET	Level 4	Forestry	IVET
Bachelor Environmental Engineering	Finland	Tampere University				HEI			
Risk Management and Circular Economy (Rimce)	Finland	Tampere University	Faculty of Engineering and Natural Sciences	Master of Natural Resources	Dedicated Bioeconomy Curricula	HEI			
Risk Management and Circular Economy	Finland	Tampere University	Faculty of Agriculture and Natural Science	Master					
Master European Forestry	Finland	University of Eastern Finland				HEI			
Master Transatlantic Forestry	Finland	University of Eastern Finland				HEI			

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target Audience (IVET / CVET / both)
Master Forestry	Finland	University of Eastern Finland				HEI			
Wood Materials Science	Finland	University of Eastern Finland	Faculty o Natural Scienc	Master	Bioeconomy content included	HEI			
Forestry and Forest Bioresources	Finland	University of Eastern Finland	Faculty of Science and Forestry	PhD	Bioeconomy content included	HEI			
European Forestry	Finland	University of Eastern Finland	Faculty o Forest Sciences	MSc	Dedicated Bioeconomy Curricula	HEI			
Bioeconomy specialization education	Finland	University of Eastern Finland, Karelia University of Applied Sciences, and Savonia University of Applied Science				VET	Level 5	Manufacture of liquid biofuels	CVET

Programme	Country	Institution	Unit or Department	Education level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Master Agricultural Sciences	Finland	University of Helsinki				HEI			
Master Food Sciences	Finland	University of Helsinki				HEI			
Master Forest Sciences	Finland	University of Helsinki				HEI			
Environmental Change And Global Sustainability (Ecgs)	Finland	University of Helsinki	Faculty of Biological and Environmental Sciences	Master	Bioeconomy content included	HEI			
Sustainable Use Of Renewable Natural Resources (Agforee)	Finland	University of Helsinki	Department of Environmental, Food and Biological Sciences	Phd	Dedicated Bioeconomy curricula	HEI			

1

Programme	Country	Institution	Unit or Department	Education level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Master Food Development	Finland	University of Turku				HEI			
Rural Entrepreneur	Finland					VET			
Specialized Agriculturalist in Renewable Energies – Biomass	Germany	Agricultural Training Centre of the District of Central Franconia in Triesdorf (abb@lfl.bayern.de)				VET	Level 5	Agriculture	CVET
Master Applied Biotechnology	Germany	Ansbach University of Applied Sciences				HEI			
CHP - Introduction with focus on Biomass	Germany	BEW - Das Bildungszentrum für die Ver- und Entsorungs Wirtschaft				VET	Level 4	Production of bioelectricity	CVET

1

Programme	Country	Institution	Unit or Department	Education level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
"...how to lead an agrarian company."	Germany	Landwirtschaftliche Lehranstalten Triesdorf (Agricultural Education Centres Triesdorf)				VET			
Sustainability In Circular Economies	Germany	Mittweida University of Applied Sciences	Fakultät Wirtschaftsingenieurwesen	Master	Dedicated Bioeconomy curricula	HEI			
Biomass Technology	Germany	Technical University of Munich	Campus Straubing für Biotechnologie und Nachhaltigkeit	Master	Bioeconomy content included	HEI			
Bioeconomy	Germany	Technical University of Munich	Campus Straubing für Biotechnologie und Nachhaltigkeit	BSc	Dedicated Bioeconomy curricula	HEI			

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Bioeconomy	Germany	Technical University of Munich	Campus Straubing für Biotechnologie und Nachhaltigkeit	MSc	Dedicated Bioeconomy curricula	HEI			
Sustainable Management and Technology	Germany	Technical University of Munich	Campus Straubing für Biotechnologie und Nachhaltigkeit	Master					
Sustainable Management And Technology	Germany	Technical University of Munich	Campus Straubing für Biotechnologie und Nachhaltigkeit	Bachelor and Master	Bioeconomy content included	HEI			
Sustainable Management and Technology	Germany	TU Munich							
Food Science and Biotechnology	Germany	University of Hohenheim	Faculty of Natural Sciences	Bachelor	Bioeconomy content included	HEI			

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Sustainable Entrepreneurship and Social Innovation	Germany	University of Applied Sciences Eberswalde							
Sustainable Entrepreneurship and Social Innovation (MASESIN)	Germany	University of Applied Sciences Eberswalde	Sustainable Business	Master					
Bachelor Agricultural Sciences	Germany	University of Bonn				HEI			
Bachelor Nutrition and Food Science	Germany	University of Bonn				HEI			
Sustainable International Agriculture	Germany	University of Gottingen	Faculty of Agricultural Sciences	Master	Bioeconomy content included	HEI			
Agribusiness	Germany	University of Gottingen	Agricultural Science, Forestry, and Geoscience	Master					

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Agribusiness	Germany	University of Göttingen							
Bachelor Food Science and Biotechnology	Germany	University of Hohenheim				HEI			
Master Agricultural Sciences	Germany	University of Hohenheim				HEI			
Master Agribusiness	Germany	University of Hohenheim				HEI			
Master Food Biotechnology	Germany	University of Hohenheim				HEI			
Food Systems	Germany	University of Hohenheim							

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Food Systems	Germany	University of Hohenheim	Faculty of Natural Sciences	Master	Bioeconomy content included	HEI			
Bioeconomy	Germany	University of Hohenheim	Faculty of Agricultural Sciences	MSc	Dedicated Bioeconomy curricula	HEI			
Food Systems	Germany	University of Hohenheim	Faculty of Natural Sciences	Master					
Renewable energy project manager with possible additional qualification energy efficiency expert	Germany	WBS Training				VET	Level 4	Production of bioelectricity	CVET

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Business management and renewable energy entrepreneurship	Germany	Weihenstephan-Triesdorf University of Applied Sciences	Fakultät Wald und Forstwirtschaft	Master					
Bachelor Environmental Engineering	Germany	Weihenstephan-Triesdorf University of Applied Sciences				HEI			
Ecological Transition	Italy	Ministry of Education and Friuli Venezia Giulia Region				VET	Level 5	Manufacture of bio- based chemicals, pharmaceutical plastics and rubber	Both
Waste to Energy for the Ecological Transition	Italy	Ministry of Education and Lombardia Region				VET	Level 5	Production of bioelectricity	Both

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Biotech Industrial Applications for Circular Economy	Italy	Ministry of Education and Piedmont Region				VET	Level 5	Manufacture of bio based chemicals, pharmaceutical plastics and rubber	Both
Sustainable Management of Food Production	Italy	Ministry of Education and Puglia Region				VET	Level 5	Agriculture	Both
Bioeconomy of Organic Waste and Biomass	Italy	National Research Council	Biology	Post- graduate Master	Dedicated Bioeconomy curricula	HEI			
Bioeconomy in The Circular Economy (Biocirce)	Italy	University of Bologna, University of Milano- Bicocca University of Naples Federico University of Turin	Department of Biotechnology and Biosciences - Bicocca	Master	Dedicated Bioeconomy curricula	HEI			

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Biotechnology For Bioeconomy	Italy	University of Milan	Agriculture and nutrition	Master	Dedicated Bioeconomy curricula	HEI			
Bachelor Agroengineering	Italy	University of Palermo				HEI			
Bachelor Food System: Sustainability Management and Technologies	Italy	University of Parma				HEI			
Bachelor Agribusiness	Italy	University of Siena				HEI			
Bachelor Sustainable Forestry	Latvia	Latvia University of Life Sciences and Technologies				HEI			

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classificaton	Target audience (IVET / CVET / both)
Agri-Food Business Management	Latvia	Latvia University of Life Sciences and Technologies							
Sustainable Forestry	Latvia	Latvia University of Life Sciences and Technologies		Bachelor	Dedicated Bioeconomy curricula	HEI			
Agri-Food Business Management	Latvia	Latvia University of Life Sciences and Technologies	Faculty of Food Technology	Master					
Biotechnology	Latvia	Olaine College of Mechanics and Technologies				VET	Level 5	Manufacture of bio-based chemicals, pharmaceutical plastics and rubber	IVET

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Environment Protection Technology	Latvia	Olaine College of Mechanics and Technologies				VET	Level 5	Fishing	
Wooden Houses and Eco-building	Latvia	Vidzeme University of Applied Sciences				VET	Level 5	Manufacture of wood-based products and furniture	IVET
Sustainable Business Administration	Netherlands	Aeres Hogeschool				VET	Level 5	Agriculture	Both
Bio-dynamic (Organic) Agriculture	Netherlands	Aeres MBO Dronten Warmonderhof				VET	Level 4	Agriculture	IVET
Biobased Materials	Netherlands	Maastricht University	Aachen-Maastricht Institute for Biobased Materials	Master	Dedicated Bioeconomy curricula	HEI			

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Circle - Erasmus Mundus International Programme On Circular Economy	Netherlands	University of Leiden	N/A	MSc	Dedicated Bioeconomy curricula	HEI			
Bio-Inspired Innovation	Netherlands	Utrecht University	Faculty of Science	Master	Bioeconomy content included	HEI			
Biosystems Engineering	Netherlands	Wageningen University & Research	N/A	Master	Bioeconomy content included	HEI			
Master Biotechnology	Netherlands	Wageningen University & Research				HEI			
Master Plant Biotechnology	Netherlands	Wageningen University & Research				HEI			

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Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Master's Governance of Sustainability Transformations	Netherlands	Wageningen University & Research	N/A	Master					
Master's Sustainable Business and Innovation	Netherlands	Wageningen University & Research	N/A	Master					
Governance of Sustainability Transformations	Netherlands	Wageningen University & Research (WUR)							
Sustainable Business and Innovation	Netherlands	Wageningen University & Research (WUR)							
Living environment and bio-data	Netherlands	Yuverta MBO				VET	Level 4	Agriculture	Both

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Basics of business agriculture, Module III: General aspects of agribusiness, entrepreneurship in the agricultural sector	Slovakia					VET			
Green economy in agriculture	Slovakia (Slovak Republic)	Agroinstitute of Nitra				VET		Agriculture	Both
Agri – Environmental climate measure	Slovakia (Slovak Republic)	Agroinstitute of Nitra				VET		Agriculture	Both
Cultivation, processing and use of hemp	Slovakia (Slovak Republic)	Agroinstitute of Nitra				VET		Agriculture	Both

1

Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Organization and Control of the Manufacture of Pharmaceutical and Related Products	Spain	Several training providers				VET	EQF L	Manufacture of bio- based chemicals, pharmaceutical plastics and rubber	CVET
Waste Management	Spain	Several training providers				VET	Level 4		IVET
Master Computational Biology	Spain	Technical University of Madrid				HEI			
Circular Economy	Spain	Technical University of Madrid	College of Forestry and Natural Environment	Master	Dedicated Bioeconomy curricula	HEI			
Agricultural Sciences And Bioeconomy	Spain	Technical University of Madrid	College of Agronomy, Food and Biosystems Engineering	Bachelor	Dedicated Bioeconomy curricula	HEI			

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Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Forest and Environmental Engineering Environmental Sciences	Spain	Technical University of Valencia		Bachelor		HEI			
Agricultural and Biological Engineering	Spain	Technical University of Valencia		Bachelor		HEI			
Food Science and Engineering	Spain	Technical University of Valencia		Master		HEI			
Molecular Biotechnology	Spain	University of Barcelona		Master		HEI			
Circular Economy	Spain	University of Burgos	Faculty of Economics	Master	Dedicated Bioeconomy Curricula	HEI			

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Programme	Country	Institution	Unit or Department	Education Level	Category	Type	EQF Level	Sector Classification	Target audience (IVET / CVET / both)
Circular Bioeconomy and Sustainability	Spain	University of Cordoba (UCO) & university of Almeria	Dpto. Economía Agraria, Finanzasy Contabilidad	MSc	Dedicated Bioeconomy curricula	HEI			
Applied Molecular Biotechnology Companies	Spain	University of Granada							
Master in Applied Molecular Biotechnology Companies (BioEnterprie)	Spain	University of Granada	Science Faculty	Master					
Master Advances in Agricultural Biology and Aquaculture	Spain	University of Grenada				HEI			
Circular Economy	Spain	University of Zaragoza	Faculty of Science	Master	Dedicated Bioeconomy curricula	HEI			

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Based on this review (above) from the European bioeconomy frameworks, both MUN and CNA might consider new offerings to complement their current programs. The following list takes advantage of a 'global learning ecosystem' where it is possible to partner in adaptable learning, competency-based learning, social learning platforms, etc. These suggested offerings involve a range of personal and digital content and technological devices and software (including AI driven content). Moreover, the programs identified allow for collaborative teaching/learning platforms, and a universal digital micro-accreditation. Specific programs can also involve multidisciplinary professions.

Potential new degree programs and training related to sustainability and development of the circular bioeconomy in NL:

- New undergraduate degree in sustainability (joint between MUN/CNA);
- New undergraduate degree in biotechnology (joint between MUN/CNA);
- New undergraduate degree in biobased materials (joint between MUN/CNA);
- New undergraduate degree in Biology and Eco-innovation (joint between MUN/CNA);
- New undergraduate/graduate degree(s) in Bioeconomy (joint between MUN/CNA); this offering could encompass:
  - Biomass conversion
  - Economic aspects of biomass potential
  - Ethical aspects of using biological resources
  - Bioeconomy services and business models
- New undergraduate/graduate degree(s) in Synthetic biology
- New undergraduate/graduate degree(s) in Green Chemistry
- New undergraduate/graduate degree(s) that shift the emphasis from STEM to STEAM to include ARTS or possibility to STEMED to include Entrepreneurial, Design

Careful attention should also be given to short-term training courses that could include:

- Diploma
- Certificate
- Co-op

- Train-the Trainer sessions
- Apprenticeships

These short-term courses offer various delivery methods and can be tailored to align with the development of the circular bioeconomy. As such, informal/experiential learning is strongly recommended. Among the topics to consider include communication, research management and administration, priority setting, leadership skills, governance/EGS reporting, capacity building, systems thinking, informatics, database management, problem-solving, critical thinking, change management, legislation, cooperation (interdisciplinary and multidisciplinary), facilitation, and teamwork. More detailed offerings could consider a module approach suited to undergraduates. The number of modules can be determined based on current pedagogy and presented as project or work term options. These could include bioeconomy, climate change, project management, audit and performance, energy management, life cycle analysis, carbon management/markets, and certification.

More extensive courses could center on digital tool skills including decision support tools, use of social media and online marketing, data analytics and use of advanced analytics. As noted by Carter (2022) new models and thinking will be required for regional economic development. His call for new models is highly relevant to development of the bioeconomy in NL. The transition from conventional production and processing of biological resources towards a sustainable and circular bioeconomy requires entrepreneurial thinking and action (Kuckertz, 2020). Entrepreneurship education should be considered essential if new bioeconomy initiatives are to succeed. This includes

learning how to start a new business and a means to address the various elements of sustaining a business. Here it would be wise to engage the MUN/CNA Business Schools to promote a range of courses (long or short) with specific focus on natural resource development. To assist in capacity building, MUN and CNA programs as noted above should explicitly involve business management training and make students aware of the importance that employers place on essential and management skills. In the humanities and the social sciences as well, it is possible, and beneficial, to connect programs to the workplace and to employers who hire these graduates, including the forest industry, cultural industries, community services, the Information Technology sector, and governments.

In responding to the emerging circularly bioeconomy, it will ultimately be necessary to take a more holistic approach to education and training, taking into account elementary, junior and high school curricula. While this report focuses on PSE, several other countries, notably, Japan, Portugal, and Finland offer lessons on how learning twenty-first century competences has been implemented. For example, the Finland education system transformed their primary curricula to focus on 'topics' doing away with subject-specific lessons and giving students more flexible learning paths. It is one example of a country getting ready for or adapting to a 21st century economy that calls for a re-examination of assumption about the skills needed for certain positions or industries.

Skill Sets, Competencies, Training

As a complex and highly skilled sector, renewable resource (RR) sectors require a wide variety of competencies from its workforce, depending on the subsector and work position. Furthermore, the global transition toward a circular, bio-based economy brings opportunities and challenges to which these sectors need to adapt. A major component of this adaptation involves resource-use efficiency, which in forestry means a careful and skill-demanding approach from site and tree selection to pre- and post-processing of wood material. Therefore, forestry and other RR workers need to be comfortable with constant adaptation to new technologies and the continuing computerization of their sectors (FPSC, 2011). Hence, it is essential for natural resource (NR) education and training to go beyond typical competencies from STEM and STEAM and include broader/soft skills such as negotiation and market analyses, communication, teamwork, leadership, and entrepreneurship (FAO & UNECE, 2020; FPSC, 2011; Rieckmann, 2012). These skills are needed in tasks like general and specialized management, natural resource regulation, equipment maintenance, and sub-sector-specific skills (FPSC, 2011).

Concomitantly to the need to update NR curricula, there is also the correlated issue in which enrolments in specific programs such as forestry are steadily declining over the past years. Although some authors have argued for broader programs on natural resources, there are important consequences to be considered in this process. On the one hand, there would be a larger pool of potential workers with broader skills that make them eligible for various positions. On the other hand, additional investment may be required when specialized skills/positions are

demanded. However, reports have shown that employers may not afford these training costs due to financial reasons or simple inability to free their employees during working hours. These limitations are particularly severe for small and medium-sized mills and, whenever funding is available to finance education and training of current or prospective workers, it is usually difficult to access (FAO & UNECE, 2018). In addition, mill owners are concerned with the threat of poaching from competing sectors that could offer higher wages and better benefits (FPSC, 2011). Regardless, a report from more than a decade ago argued that students are "more likely to enroll in undergraduate environmental sciences or natural resources management programs than forestry programs" (FPSC, 2011, p. 21).

For all the issues identified here, a natural advantage that needs to be leveraged by RR players in NL is the high-quality PSE institutions in the Province. In this context, two concerted efforts must be implemented to support the required skills for advancing the RR sectors in NL along the circular bioeconomy transition. The first needs to concentrate on increasing the education level of current RR workers and general inhabitants of NL, particularly in rural areas. Concomitantly, there needs to be support for training opportunities and informal (experiential) learning to keep up with the fast- advancing technologies in these sectors, provide a pathway for career growth, and mitigate the effects of early retirements as senior workers could be transferred to other positions. Furthermore, these efforts can foster the additional benefit of opening entry positions for new workers that seek a career in RR industries. In this context, the province of NL had programs that could significantly address some of these issues, but they were discontinued, privatized or are currently not as accessible as before.

The first of these programs was the Adult Basic Education (ABE), which was previously administrated by the CNA and responsible for offering a high school education for adults and facilitating the transition to a PSE program. According to Kennedy et al. (2021), the privatization of the ABE in 2014 was a significant blow to the institution as it decreased CNA's funds and reduced PSE enrolments in this institution. The second program was the Lifelong Learning, which was discontinued on St. John's campus of Memorial University, thus reducing the accessibility in continuous learning/retraining of adults in NL. In fact, Kennedy et al. (2021, p. 106) argued that recent decisions involving education/training have limited the "access of the general public to the… university… and contributing to a sense of disconnection between the university and the community, particularly in rural areas". In this context, we strongly

recommend re-evaluating the decisions involving these programs as such learning opportunities are crucial for the transition and development of a sustainable bio-based industry in NL. Therefore, instead of ceasing the existence of these education programs, efforts should be made to investigate and address the reasons why they did not have enough demand, due to their importance to the development of bio-based economy.

A helpful starting point to address the current and forecasted skill demands is to establish close communications among industry, unions, and education and training institutions involved with RR fields. The collaboration between these players may enable adaptive and comprehensive strategies that consider "formal [and informal] education and training, on-the-job and pre-employment training, and specific skills training and upgrading" programs (FPSC, 2011, p. 16). For instance, in addition to the more straightforward assistance from PSE institutions in programs that match the industry demands, these institutions could also cooperate with tools and techniques (e.g., mentoring, cross-training, apprenticeships) that assist in knowledge transfer between senior and entry workers. A particularly interesting tool is the development of profiles/maps of competencies to inform better recruiters and PSE institutions of which skills are currently in need without going through extensive discussions on updating curriculums (FPSC, 2011). Regarding funding barriers, representatives from the NL government, industry associations, and PSE institutions could assist RR recruiters in acquiring available funds for education and training purposes as small and medium-scale mills do not have this capacity. Lastly, the availability of online or hybrid education/training would improve the access and affordability of a citizen to enroll in such opportunities by themselves or directly supported by their employer.

Improved Access and Student Experience

A PSE system that offers equitable access and support to both early learning opportunities and to higher education is deemed critical to the future economy of NL and thus the well-being of its citizens. Future learners, including life-long learners, must have access to financial aid and to a wider range of programs throughout K-12 and PS programs. Recently, the public post-secondary education system of the province has been the subject of several reviews, notably, the *All Hands on Deck* report (Kennedy et al. 2021) and *the big reset* report (Newfoundland and Labrador, 2021). Numerous recommendations have been submitted to government arguing for significant reform

and investment in the public education system.

Facts positively impacting students access and experience to PSE in NL:

Well distributed location of PSE campuses across the province. The province's PSE system has a large infrastructure footprint. This decentralized system provides valuable capacity to help the transition to a green economy, particularly in rural NL. Both institutions also have a strong online presence.

Memorial - Three primary campuses in the province that offer academic programming - (St. John's, Marine Institute and Grenfell):

- Signal Hill campus which offers housing for graduate students and facilities for public engagement;
- The Labrador Campus (currently housed within the CNA Happy Valley-Goose Bay campus);
- Harlow campus in the United Kingdom;
- Institut Frecker located in St. Pierre, - Department of Modern Languages, Literatures and Culture;
- The Johnson GEO Centre, a geological interpretation centre;
- Bonne Bay Marine Station, a research, teaching and conference centre which houses a public aquarium;
- Holyrood Marine Base, home to a boat launch facility;
- Ocean Sciences Centre, a cold ocean research facility in Logy Bay;
- The Pye farm, a research farm in Labrador.

CNA - 17 campuses throughout the province:

Avalon

- Carbonear
- Placentia
- Prince Philip Drive
- Ridge Road
- Seal Cove

Labrador

- Happy Valley-Goose Bay
- Labrador West

Central

- Baie Verte
- Gander
- Grand Falls-Windsor

Eastern

- Bonavista
- Burin
- Clarenville

Western

- Bay St. George
- Corner Brook
- Port aux Basques
- St. Anthony

Given the wide distribution listed above, both CNA and MUN are ideally located to foster economic activities in small rural communities. As a result of their locations, these institutions have greater appeal for locals to enroll without having to move away from their home communities with its associated costs. Further, the ability to work and build careers in their rural surroundings is attractive. The sense of place remains strong in many parts of rural NL. There is also potential for PSE institutions to tailor their programs to suit the skills and competencies required in the region they are located; this is particularly pertinent for CNA.

Facts negatively impacting student access and experience to PSE in NL:

1) the privatization of the Adult Basic Education (ABE) program in 2014, which reduced CNA's funds and its ability to facilitate the transition from basic to PSE, thus decreasing overall enrolment; and 2) the termination in 2011 of the MUN's division of Life Long Learning in St. John's campus, classified as "limiting access of the general public to the… university… and contributing to a sense of disconnection between the university and the community, particularly in rural areas" (Kennedy et al., 2021, p. 106). "The College of the North Atlantic (CNA) offers

Customized and Continuous Learning to individuals, groups, businesses, and government. Credit and non-credit programming are customized to meet the needs of the target audience" (Kennedy et al., 2021, p. 107).

Lack of clear communication about number of vacant positions in industries across the province creates a dissonance in which there are people not finding a job and employers not finding workers. Improved transportation system would improve PSE access for towns that do not have a campus, particularly important for immigrants without a Canadian driving license and/or low-income individuals without access to their own vehicle. In addition, it is a less pollutant transportation module than a large number of vehicles with single drivers.

Demographic Challenges

The province of Newfoundland and Labrador (NL) has been experiencing a significant population decline over the last two decades. According to Simms & Ward (2017), the scenario that solely relies on NL's natural growth anticipates a population decrease of about 10% by 2036. This decline could cause severe consequences to the province, particularly the labour market of industries like natural resource (NR) sectors. These industries require a local supply of qualified workers to maintain their good functioning and resiliency to adapt and transition towards a circular bioeconomy (BIC & BioDesign, 2019). If a renewed strategy is not implemented, employers may not find workers to substitute retirees, compromising business functioning and the capacity of communities to maintain themselves. As pointed out by Clair (2021, p. 1), although "automation will replace some of the retiring workers, not every job will — or can — be automated". In fact, "there are many businesses in the province — especially in rural areas — that [already] operate with reduced hours, that have turned down work or that are unable to expand operations because of a lack of workers" (Clair, 2021, p. 15). It is estimated that ca. 62,000 job vacancies will be available from 2019 to 2028. Therefore, small rural communities would be disproportionately impacted, potentially ceasing their capacity to preserve their (ageing) inhabitants' well-being due to the lack of essential services in a positive feedback loop. In addition, not only the percentage of retirees is increasing, but also their life expectancy (Statistics Canada, 2019). Therefore, it is natural to expect increased pressure on essential public services such as health and mobility. A

lower percentage of workers and a growing demand for costly support could reduce NL's capacity to afford its increasing debt, influence national discussions, and maintain the pension system (Clair, 2021; Fuss & Whalen, 2021).

In the past, the primary cause of population decline in NL was individuals emigrating to other Provinces looking for employment or higher-paying jobs (Clair, 2021). Notably, the last major wave of emigration happened after the cod moratorium in 1992, which affected communities throughout the whole province, particularly small, rural communities, with prevailing consequences to this day (Davis, 2014). In this century, the major cause of population decline has shifted to an ageing population and low fertility rates, partially due to the continuous emigration that removed people of reproductive age and their children from the population (Clair, 2021). In fact, NL has gone from a fertility rate of 4.9 in 1951 to 1.26 in 2020 (Statistics Canada, 2022c; see also Otis, 2022). The provincial government has tried to reverse this trend through strategies aiming at increasing fertility (i.e., "Baby Bonus") and repatriating residents; however, no significant success has been observed (Clair, 2021). This fertility rate decrease is somewhat expected as it follows a worldwide trend due or correlated to a combination of factors such as costs of living, participation of women in the workforce, changing lifestyles, and climate anxiety (Otis, 2022; Rotella et al., 2021; Skakkebaek et al., 2019). Nevertheless, it is a worrisome scenario for renewable resource (RR) sectors, particularly in the context of a circular bioeconomy transition.

Workforce and Human Resources

The patterns and nature of new businesses in the bioeconomy are strongly influenced by institutions and organizations (Casper et al. 1999; Whitley 1999). Within this context, the development of human capital is recognized as a key element in the development of growth as well as the competitiveness of firms, regions, and nations. According to the OECD et al. (2001, 2007) human capital is seen as the knowledge, skills, competencies, and attributes in individuals that facilitate the creation of personal, social and economic well-being. A diverse and highly skilled workforce (a green-collar workforce in a knowledge-based society) must be a high priority for investment in the bioeconomy. Talent is essential for bioeconomy companies to realize their potential. As such, an abundant supply of skilled,

capable, and available professionals to execute companies' innovation agendas and drive the

commercialization of new products and services is a prerequisite to success.

In NL the overwhelming majority of firms best positioned in the bioeconomy are small and medium- sized enterprises (SMEs). Most have fewer than 50 full-time employees. In most instances, these SMEs seldom have the resources or in-house skills to focus on HR acquisition, training and skills development. In addition to the challenges of product development, taking advantage of the bioeconomy will also entail added attention to corporate functions like marketing, communications, sales and manufacturing. Adequate funding for universities and training programs are essential to help SMEs build a more innovative economy where citizens can be given the opportunity to pursue lifelong learning and on-the job training. Adult participation in on-the-job training is an important measure of how well Newfoundlanders are supported in developing new professional skills.

Moreover, as the bioeconomy expands, the share of science, technology, engineering, arts, and mathematics (STEAM) jobs will increase. While women are generally underrepresented in STEAM fields of study, their representation in a bioeconomy is expected to steadily increase. This trend must continue if NL is to be competitive in an emerging bioeconomy. Further, as discussed below, the Indigenous population in NL must be given opportunities to fully participate in the labour force as meaningful partners in bioeconomy initiatives.

An expanded and robust bioeconomy in the province would also support government's immigration strategy. By increasing immigration and building on skills, fresh perspectives and global connections of immigrants and their families, we grow our economy and support our communities. Attracting specialized skill sets and growing our population will be key to the overall economic health of the province. Research shows that immigrants make significant contributions to local economies and communities and are more likely than their Canadian-born counterparts to establish businesses which employ local workers. A bioeconomy underpinned by innovation and entrepreneurship will act to attract and retain immigrants to NL.

The pace of change and its impact on skills is one of the defining differences between the industrial age and the new knowledge economy. Technical skills, in particular, must be continuously renewed. However, the labour market in NL has become very challenging. The notion of "a job for life" or that of a steady, orderly climb up the ladder of one organization have almost become relics of our industrial past. Today, security comes from anticipating and adapting to new circumstances

and from knowing how to acquire needed skills throughout one's career. In NL and particularly in the resource sectors, in which skills are perceived to be in the shortest supply, such as forest harvesting, and manufacturing, employers will have to train existing staff and/or meet their needs through immigration. Currently, rates of immigration to Newfoundland and Labrador are lower than for the other Atlantic Provinces and the rest of Canada. Rates of retention of immigrants to the province are similarly low. The province has an Immigration Strategy (Newfoundland and Labrador, 2017b) which recognizes that the PSE system is an important partner in attracting and retaining newcomers to the province as students, faculty/instructors, and staff. The province currently has two programs that operate as pathways to permanent residency: the NL Provincial Nominee Program (NLPNP) and the Atlantic Immigration Pilot Program (AIPP). These are complemented by federal programs (primarily Sponsored Family and Resettled Refugees and Protected Persons). Of particular concern for the PSE education system is the decline in population of the largest segment of their potential enrolment, individuals 19 years of age and younger. From a forest-industry perspective, there is concern that a low percentage of immigrants elect to settle in rural NL.

At a global level, green jobs associated with the circular bioeconomy continue to increase (FAO & UNECE, 2021). The United Nations (UN) report on green jobs in the forest sector identified 19 fields of professional activity, reflecting "the broad spectrum of jobs based on the multi-functionality and non-timber benefits of forest ecosystem services and the forest sector" (FAO & UNECE, 2018, p. 64). These activities are centered around managing ecosystem services and consist of seven thematic areas: wood and energy production, agroforestry and mountain forestry, social and urban development, forest management, inventory and planning, biodiversity and ecosystem functioning, health and recreation, and education and research (Figure 7).

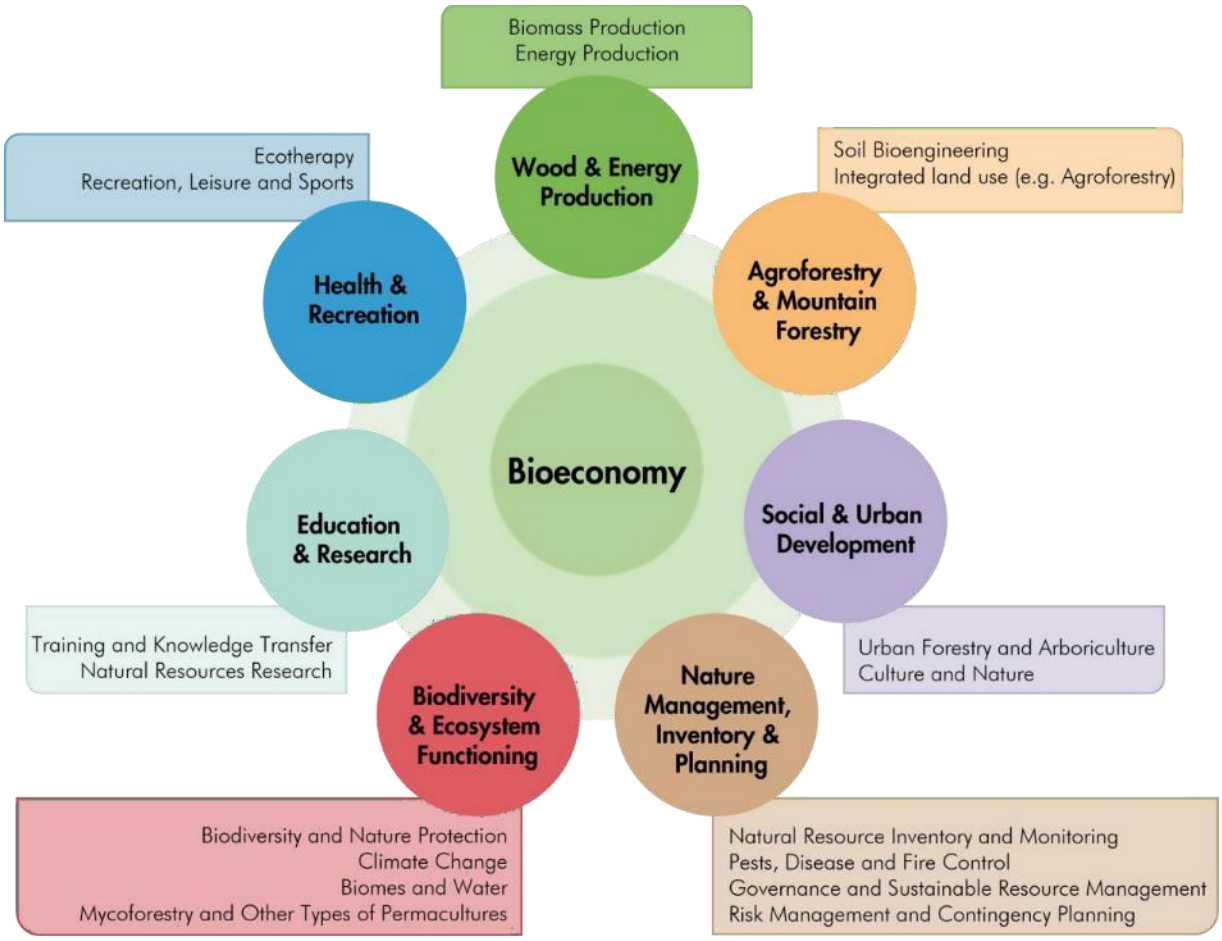

Figure 7. Thematic areas and potential professional activities related to circular bioeconomy. Adapted from: FAO & UNECE, 2018.

This variety of job positions in forestry also applies to other RR sectors and highlights the opportunity to recruit from a larger pool of workers currently underrepresented in such industries (e.g., youth, immigrants, non-male, indigenous). In fact, efforts to recruit these potential workers have the potential to address multiple human-resource-related issues in NL. Some of them include RR sectors' workforce homogeneity (FAO & UNECE, 2020), the declining pool of workers in rural areas, the comparatively older workforce that also tends to retire earlier, and a negative public perception concerning the future of these sectors (NRCAN, 2022). The latter is critical as it affects not only potential workers but also consumer behaviour and the willingness of current employees to recommend a career in RR sectors to friends, next generations, and others (Larasatie et al., 2020). In this context, efforts to recruit more diverse workers would simultaneously (need to) address RR sectors' negative public perception and the misconceptions involving unsustainable practices and fading industries (FPSC, 2011; NRCAN 2022). Nevertheless, if efficient mobilization

strategies are not implemented concertedly by the sectors' stakeholders, the identified opportunities may not be utilized. In other words, the perception of a narrow fit by potential applicants and the declining trajectory of NR sectors built across many years will persist and not sufficient support will be raised for the circular bioeconomy transition. Furthermore, the 2018 Circular bioeconomy report from the European Commission argued for the need for multidisciplinary professionals with cross-sectoral expertise and PSE education (European Commission, 2018). Notably, "graduates… who have an in-depth knowledge in a certain domain…, but also an understanding of the broader circular bioeconomy and supporting and emerging fields (information and communication technology, robotics, remote sensing, new materials, etc.) are needed" (European Commission, 2018, p. 87). Naturally, not every mill owner and decision-maker have moved away from a traditional NR approach in which, for instance, forestry consists exclusively of silviculture and activities centered around timber harvest. However, the emerging prospects for the sustainable management of renewable resources within a circular bioeconomy regime create opportunities for various multidisciplinary human resources, including opportune circumstances for entrepreneurship. To achieve this, NR industries "need to become more innovative in attracting qualified people to fill [and create] these new jobs" while supporting possibilities to foster a higher level of education and training in NL through partnerships with PSE institutions and the provincial government (FAO & UNECE, 2018, p. 65). In fact, one of the significant retainment issues is that workers leave for better wages and benefits in non-renewable resources industries such as oil and gas, mining, and construction, even though some of these jobs are temporary. In this context, developing a "scalable, flexible and timely labour market intelligence platform" is key to analyzing current and future labour demands and informing mobilization strategies and recruiters (FPSC, 2011, p. 23).

Youth Workforce

Recruiting and retaining new workers has been a consistent problem for the forest and other renewable resource sectors in the past few years, particularly for youth (FPSC, 2011). This is especially impactful as these industries are also known to have a relatively older workforce, in fact, the "share of workers [in forestry] aged 15 to 24 is at a historic low compared to the overall labour force (FPSC, 2011, p. 16). Additionally, workers' retiring age is comparably lower, which exacerbates the emergency to attract and recruit youth to join these sectors. Nevertheless,

numerous barriers have been impeding this; key among them are these sectors' "lingering public perception and image problems" of sunset industries held by younger generations, parents, educators, and employment counsellors (FPSC, 2011, p. 16). These players' influence is particularly important as they directly affect the career-making decisions of the young (Kazi & Akhlaq, 2017). Therefore, it is essential to implement effective measures to change these misconceptions by contextualizing forestry and other renewable resource sectors as bio-based industries that can thrive in a transition to a circular bioeconomy society. Furthermore, it is essential to publicize the relevance of the participation of young, skilled, and innovative workers to achieve this transition. Another relevant barrier to recruiting youth to renewable resource sectors is the concentration of most of the population in urban centres, often distant from rural areas where NRs and mills are located.

Concomitantly, some stakeholders argue that Canada's secondary school system prepares students mainly to join a University instead of more applied skills for immediate employment (FPSC, 2011). Concomitantly, there are complaints about a lack of entry-level and apprenticeship positions. As reported by Hakovirta and Lucia (2019, p. 103), "the circular bioeconomy demands special approaches for attracting youth to science, technology, engineering and mathematics [STEM] disciplines" (p. 103) and their corresponding job positions. For instance, forest sector recruiters and associations must establish close partnerships with career counsellors and NL's school system, including secondary and post-secondary education. Through these partnerships, RR sectors will be able to: 1) share the current and foreseen work situation in the industry; 2) demystify some of the notions of an environmentally unsustainable industry; 3) show career paths and positions that are aligned with sustainability trends and technologies; and 4) offer opportunities to visit the mills. Finally, these initiatives need to be supported by long-term social media strategies to multiply the effectiveness of reaching youth and addressing the often-implicit bias of a dirty and dying industry that some share towards these sectors (Bachler, 2017). Some of the topics that need to be communicated in schools and social media are "the high tech and computerized nature of the work… [that] would likely be something youth would find attractive if they were better informed about it" (FPSC, 2011, p. 16). Lastly, these marketing and recruitment approaches need to consider youth among indigenous, women, and new Canadians to address the labour shortage and diversify the sector's workforce.

Internationalization

As established, fertility rates in Canada are on a declining trend, which naturally impacts many societal dimensions, particularly its workforce. Nevertheless, the 2021 Census showed that Canada's population is growing by 5.2% (nearly 37 million people), making it the country in the G7 with the fastest growth rate (Our World in Data, 2015). Notably, the identified growth in the Canadian population is greatly attributed to immigration and the country's success in the "war for talents" (Carter et al., 2008; Chand & Tung, 2019; Guo & Wong, 2018). However, the success of immigration measures is not evenly distributed across Canadian Provinces, on the contrary, the destination for the vast majority of immigrants (ca. 95% of all immigrants between 1996-2006) has been to only a few Provinces: Ontario, British Columbia, Quebec, and Alberta (Carter et al., 2008). In this context, implementing effective immigration strategies in NL to simultaneously address the province's demographic shortcomings and labour requirements is imperative. An influx of immigrants not only increases the Canadian demography but also lowers the population average age as immigrants are about ten years younger than Canadians. Without immigration, the population in NL "will decline, its labour force will decline, its economy will suffer, and its rural areas will empty (Clair, 2021, p.6).

An inherent advantage of pursuing the province's internationalization is that Canada is already among the top-ranked destinations due to political stability, economic opportunities, a good education system, and a culturally diverse society (United Nations, 2020). Hence, achieving the three basic principles of immigration (i.e., recruitment, settlement, and integration/retention) in NL is, to a certain extent, a matter of communication to attract internationals that may not have considered NL their destination. With the proper support from the Federal and Provincial governments, the College of the North Atlantic and Memorial University of Newfoundland can play a crucial role in NL's internationalization strategy (Carter et al., 2008; Clair, 2021; Kennedy et al., 2021).

As renowned PSE institutions, CNA and MUN already have offices dedicated to the recruitment and settlement of international students with growing experience and impressive success (Kennedy et al., 2021). For instance, MUN went from about 500 international students at the beginning of the century to nearly 4,000 in 2021 (Clair, 2021; CBC News, 2021). This growth has been

particularly impressive among graduate students, with an increase of 317% in applications from international students between 2008 and 2019 (Sorensen, 2019). Furthermore, MUN has been ranked first for its support to immigrants, particularly among graduate students (Batten, 2016). This growth is especially promising as graduate students can conduct innovative research and public outreach, apply for substantial external funding and, once they conclude their program, fill specialized job positions or create opportunities through entrepreneurship (Clair, 2021). The CNA also expects a growth in international students' interest, which is essential to support and take advantage of the College's impressive network of 17 campuses (Kennedy et al., 2021). In fact, the location of both PSE institutions throughout the province is crucial to tackling the benefits of distributing immigrants across the Province instead of concentrating in urban areas (Carter et al., 2008; Peri & Requena-Silvente, 2010). In addition to recruitment offices, the enrollment increase of international students in NL's PSE institutions must also be attributed to their internationalization offices. Their services and expertise rely on, among other activities, reducing the everyday friction once international students are successfully admitted and located in NL; in other words, facilitating their settlement and cultural immersion. Ultimately, the influx of international students in NL "help to keep these institutions viable and dynamic. Immigrants bring new ideas, new businesses and new opportunities" (Clair, 2021, p. 26). Concentrating efforts to internationalize NL through PSE institutions is also strategic because they are already an integral part of immigration pathways that involve transitioning from a temporary to a permanent residence status (Newfoundland and Labrador, n.d.f; see also Carter et al., 2008). International students who recently graduated from Canadian Universities are eligible for a post-graduate work permit. Furthermore, immigrants' ideas and perspectives enable them to critically evaluate challenges and opportunities in the Province's workplace by combining their previous experience with the Canadian context (Clair, 2021). This differential perspective is beneficial for an industry's capability to anticipate, adapt, and address crises as well as to undergo its circular bioeconomy transition. In addition, immigration could foster entrepreneurship and promote path- breaking opportunities that are critically needed in long- standing industries such as NR sectors.

Strengthening the province's internationalization also offers the possibility of consolidating existing commercial relationships with international markets and establishing new connections involving the trade of materials, products, services, and expertise (Chand & Tung, 2019; Peri & Requena-Silvente, 2010). These are competitive advantages in a global market where players often

face imbalanced disputes involving practices such as heavy subsidization, low wages, and illegal resource extraction (Hurmekoski et al., 2019; Philp, 2018). In Atlantic Canada, Fang et al. (2021) reported that 88% of employers have had positive experiences after hiring international workers, classifying them as "hard-working, skilled, and reliable." Despite all these potential benefits and the sparse to non- existent alternative solutions to the demographic issue in NL, there is a general resistance to immigration initiatives in Canada (Clair, 2021; Peri & Requena-Silvente, 2010). Some of these anti- immigration discourses are founded on problematic reasoning and overall rely on a perception that the influx of immigrants to Canada is already too large. Other claims involve the concern over increased competition for jobs, depressing wages, and apprehensiveness of immigrants' culture superseding Canadian's, among others. A more detailed exploration of these claims and their counterarguments is required here as they inevitably impact the ability and willingness of public and private players to leverage PSE institutions for a thriving circular bioeconomy transition.

The first argument against immigration is the perception that the influx of immigrants is already overwhelming; however, this argument does not hold up when put into perspective. For instance, in 2021 Canada's immigration target was 401,000 people, representing only 1% of Canada's population (Clair, 2021), thus within strict rationality of the country's immigration targets (Guo & Wong, 2018). In NL, first-generation immigrants only comprise about 2½ percent of the total population in the province, the lowest in any other Canadian jurisdiction and contrastingly lower than the 21.9% for the entire country (Statistics Canada, 2022a). Clair (2021, p. 22) pointed out that "people [that are] least exposed to immigrants who seem to fear them the most" (p. 22). In NL, "38% of people surveyed were satisfied with the current level of immigration, and 34% were in favour of a higher level of immigration" (Clair, 2021, p. 72), comprising 72% of the province's population not carrying negative attitudes toward newcomers. Therefore, if the population of NL is already welcoming to immigrants, internationalization strategies should take advantage of this attitude. This is imperative considering that the Provincial historically cautious approach to immigration is not even close to offsetting the current natural demographic decrease (Statistics Canada, 2022c).

A second argument against immigration is the concern over unfair job competition as immigrants would accept the same jobs for lower payments, thus depressing overall wages in the country. However, Clair (2021, p. 22) argues that the majority of immigrants in Canada (60%) are

"economic migrants who bring the skills and knowledge necessary to participate in the Canadian economy", therefore filling persistent vacancies of high and low-skilled positions that Canadians are unable or unwilling to apply. Furthermore, multiple studies have shown that immigration's effects on wages are either non-existent or modest (Chand & Tung, 2019, p. 334; Ottaviano & Peri, 2012). Another common discourse against strengthening immigration in NL is the highest unemployment rate among Canadian provinces. However, Clair (2021, p. 27) reports that this argument contains various misconceptions that must be carefully considered. Essentially, it does not account for inefficiencies in the job matching mechanism and that "a high unemployment rate can co-exist alongside a high number of job vacancies". This is particularly pertinent if companies with vacancies cannot recruit broadly and if they are far from urban centres that concentrate most of the potential employees. Furthermore, some prefer to work only "part of the year and then receiving Employment Insurance for the rest of the year, instead of working year-round, especially if working year-round would require moving to another community" (Clair, 2021, p. 27); thus, leaving some positions vacant during part of the year or year-round jobs in general. Finally, not only have immigrants been reported to perform comparatively high entrepreneurial behaviour, but they also are responsible for a disproportionate creation of jobs. According to Clair (2021), immigrants created about 17% of new firms between 2003-2013, but they accounted for 25% of all new jobs.

The last anti-immigration discourse concerns the apprehension over cultural differences being a risk to the host population's traditions. This argument does not consider the historical importance that various cultures exerted on forming Canadian and NL cultures (Clair, 2021; Guo & Wong, 2018). It also underestimates the inertia that human societies and their institutions have regarding cultural changes. Besides, the cultural integration process usually involves joint local decisions over a long period until a critical mass is reached. Moreover, a significant level of adaptation inadvertently happens before a custom is integrated into a host society. Finally, a certain degree of xenophobia in the cultural anti-immigration discourse cannot be ignored. Contemporary global immigration often follows a South to North hemisphere pattern with people carrying their "culinary and musical traditions, clothing, religions and — last but not least — skin colours" (Clair, 2021, p. 22). The author further argues that most immigrants arriving in NL before 2011 were from Europe and the Americas. Therefore, immigrants from those regions would be allegedly preferred as they share similar roots to Newfoundlanders and Labradorians. However, this argument ignores the fact

that both host and alien cultures have not stagnated since Europeans' early arrival to the Americas. Ultimately, anti- immigration discourses can be maladaptive for native and non-native people. A contemporary example in which anti-immigration attitudes significantly contributed to societal issues is BREXIT in the United Kingdom. Notably, some of the post-BREXIT consequences are substantial labour shortages (Environment, Food and Rural Affairs Committee, 2022) and conflicts particularly evident in the borders of the island of Ireland (Edgington, 2023). Leveraging PSE institutions as one of the main entry points for immigrants in NL is also a counterargument against the cultural apprehension discourse. That is, these institutions offer the opportunity for newcomers to undergo a cultural immersion during their "formative years… becoming intimately familiar with the country's culture and, in the future, their children as they go to schools and 'learn Canadian values' (Clair, 2021, p. 22; Newfoundland and Labrador, 2017b).

Despite the persistence of anti-immigration discourses, future perspectives of strengthening NL's internationalization are moderate to optimistic. Some indicatives are the creation of the Office of Immigration and Multiculturalism (OIM) in 2005 and the NL Workforce Innovation Centre (NLWIC) in 2017 - based at CNA. Additionally, a strategic governmental report ("The Way Forward on Immigration in Newfoundland and Labrador") was published in 2017 with 36 important recommendations, and a more recent report issued by MUN in 2021 ("Immigration in Newfoundland and Labrador") provided a comprehensive overview of the topic in the Province. However, Clair (2021, p. 80) argues the need for a periodical, "evidence-based, and policy-relevant research" investigating the factors that negatively influence the attraction and retention of newcomers to inform which of them should be prioritized and their complementary approach. "The infrequent nature of these analyses and their delayed publication make it difficult for businesses, educational institutions and other sectors of society to adequately plan for the future" (Clair, 2021, p. 81). The author also recommends selecting and prioritizing a few countries to accelerate the creation of a critical mass of immigrants from a certain nationality. This does not mean excluding countries, as any improvements in the immigration system would benefit everyone. Efforts should also be made to establish a proactive attitude in determining the complex and diverse needs, such as improving the access and quality of the health and transport systems (Carter et al., 2008; Clair, 2021; Fuller & Ballantyne, 2008).

Many of the recommendations indicated herein include improving and maximizing the role of PSE institutions as one of the main entry points of newcomers to NL. Any advancements to facilitate

the process of attracting and admitting international students without compromising their quality are highly recommended. Timing is of the essence, particularly considering the recent and incremental increase of MUN's tuition costs after a 22-year freeze (see CBC News), which will inevitably make the competition with other Universities in the country fiercer. Finally, commitments should be made to facilitate the process of recognizing immigrants' professional credentials by the Canadian and Provincial governments, which currently is a barrier to attracting and retaining highly-skilled workers (CBC News, 2022). In fact, Clair (2021) points out that a similar issue happens with Canadian- born people that obtain a professional certification in different Provinces. Therefore, likewise other improvements aiming to attract and retain immigrants, such as the health and transport system, streamlining the credential recognition process would also benefit Canadians.

In summary, attracting immigrants through NL's PSE institutions is an excellent opportunity and solution to some of the challenges in attracting and retaining internationals in the Province. This does not diminish the importance of providing high-quality, life-long, and informal education programs to Canadians as well as newcomers, particularly in the context of the circular bioeconomy transition. Nevertheless, there is an urgent need to address current labour shortages that are expected to multiply due to the growing percentage of retirees and the advanced skills required in a circular bioeconomy system. We could not stress enough the importance of NL's government in establishing close communication channels with employers and PSE institutions for long-term immigration strategies. Such connections would support the creation/improvement of an official match-making job service that can identify current and forthcoming job vacancies and publicize them to locals and immigrants, reducing friction between employers and potential employees. Such service would also be beneficial to students about to graduate from MUN or CNA, which are precious workers as they receive a high- quality education while immersed in Canadian culture (Chand & Tung, 2019). Since PSE institutions in NL have already shown growing success in recruiting international students, efforts must be made to solidify their methods and address the retainment issue once immigrants graduate. If newcomers undergo substantial negative experiences throughout the immigration process, it could inevitably discourage them from staying and others from coming to NL.

Research and Innovation

Research and innovation are vital to economic growth and development. Through innovation, new products are introduced to the market, new production processes are developed and introduced, and organizational changes are made. While PSE institutions have a major role in fostering innovation (e.g., providing collaborative public space for innovation), they are not the engine of innovation. This typically defaults to business and corporations with a vested interest in investment and future profit. The main objective of PSE institutions is to produce new knowledge. Accordingly, there are excellent prospects for both CNA and MUN to build capacity and produce knowledge through development of academic and research programs in wood chemistry, architectural design, engineered wood products, energy efficient building envelopes, and other customized timber-based building systems. Additional novel products include the use of wood fibre in the textile and cosmetic industries, in fibre cement products, and bio-plastic composites. Likewise, more research and development attention could also be given to supplementary forest goods and services, including NonWood Forest Products (NWFP). The latter emphasizes "secondary", "side-products", or "niche markets"; a developing circular bioeconomy offers potential for an increasing role for NWFPs in future forest-based value chains.

A refocus of our institutions would offer an opportunity for them to align with the emerging circular bioeconomy to complement their current research contributions to the oil and gas and cold ocean sectors. A re-examination of the role, and possible structure of NL's academic and research direction, would be timely given the economic condition of the province and the need for the province to recognize that an oil economy is not sustainable. Similarly, forestry itself is undergoing a radical transformation; it is clear that the future role of forestry in support of a circular bioeconomy will call for adjustments, new ideas, and increased innovation. Indeed, Canada's eight forestry faculties — from the University of New Brunswick in the east to the University of British Columbia in the west have all had to adapt as the forest sector transforms, the industry consolidates, and demand for novel forest products increases. Aligning future training and research with the provincial government's focus on a regional innovation pilot related to forestry and agriculture in the western region, would be a positive step to advancing the circular bioeconomy. One vehicle for this endeavour would be to have the recently established Centre of Research and

Innovation (the Centre), a collaborative effort of MUN (GC), CNA, and Corner Brook Pulp and Paper Limited (CBPPL), spearhead R&D and training related to NL resource sectors. The timing of this new Centre is significant given that innovation is clearly on both the provincial and federal agendas and of big interest to universities and colleges. The latter institutions should strive to not only foster a culture of innovation but also a culture of risk-taking. One approach to this challenge is for PSE institutions to work in partnership with industry and have researchers focus on key industry issues, rather than looking for places where institutional research findings are simply plugged in. Moreover, PSE institutions should play a more active role in the mobilization of knowledge. Experience with industrial firms can allow students gain entrepreneurial experiences, incubate and accelerate new ideas. Finally, universities should fully embrace social innovation, which aims at new ideas that produce value for the world, even if the profit margin is small. That is, research and innovation is not just about natural science, technology, engineering, and math disciplines. To address this blind spot, social sciences and humanities students should have added options and opportunities to embrace research and innovation. This would help shift the culture of graduate education to one that recognizes that the real purpose of post-graduate education is to foster deep thinkers, and creative problem-solvers. Accordingly, the role of social sciences and humanities in addressing 'wicked problems' and policy development including intellectual property rights, startup culture, incubation, design elements, management issues, and land use issues need to be heightened. Indeed, the adoption of technologies is shaped by human behaviour, organizational issues, public policy, and law, all within the social sciences and humanities domain.

Increased Labor Participation

The shortage of labour and exceptionally skilled workers is a significant challenge in NR sectors. Therefore, acknowledging some of the core reasons behind this challenge is essential to propose solutions for a successful transition toward the circular bioeconomy. First, the workforce in NR industries is highly homogeneous and, like other organizations affected by path- dependency, efforts to increase its diversity have often been ineffective (Coutinho-Sledge, 2015; FAO & UNECE, 2020; Martin & Sunley, 2006). In fact, a highly homogeneous organization tends to replicate itself as hiring committees generally recruit candidates with similar traits and skills (Brown et al., 2010; FAO & UNECE, 2020). In addition to its intrinsic issues, a highly homogeneous workforce significantly restricts the supply of potential workers to industries.

Without a continuous inflow of these workers, sectors are bound to undergo an ageing of their workforce with a potential aggravator if continuous or lifelong learning opportunities are not available to update workers' skills (Kennedy et al., 2021). Other characteristics associated with NR sectors' public image may also impair efforts to increase and diversify their labour force (FAO & UNECE, 2020). From an uninformed perspective, individuals perceive NR sectors as environmentally unsustainable and old-fashioned (FPSC, 2011; Larasatie et al., 2020). The public perception of NR image is vital for high school students and their parents when considering a post-secondary education and career for themselves or their children (Bedette, 2022; FPSC, 2011; Kazi & Akhlaq, 2017). As highlighted in this report, this gap between how the general public may perceive the sectors in NR and their enormous potential can be explained by numerous complementary factors (Antikainen et al., 2017; Galanakis et al., 2022; Larasatie et al., 2020).

A simplified example of how a citizen may create or reinforce their preconceptions happens when an individual drives by a forest area harvested recently. In fact, even countries with overall high support for RR sectors tend to disapprove of intensive methods of resource exploration (Hemström et al., 2013; Lindkvist et al., 2012). In this case, the driver's immediate response may not consider the many precautions and planning involved in the harvesting process, including the forthcoming reforestation phase and the efforts to ensure a particular area reaches its previously ecological state. Thus, a negative attitude towards the forest sector may be created or reinforced from this experience. Furthermore, there is a long-standing perception that workers need to fit into a particular stereotype to be a part of these sectors' workforce. According to Larasatie et al. (2020, p. 2), "perceived fit is a direct measure of fit, the degree to which individuals can see themselves fitting into an organization". In the forestry context, the authors refer to a masculine image associated with heavy machines in challenging, sometimes dangerous environments demanding great physical strength. Naturally, none of these characteristics are exclusive to men, nor do they necessarily apply to all positions in the forest sector. However, they certainly discourage the willingness of those who do not associate themselves with these traits to consider a career in NR sectors.

Additionally, Bal & Sharik (2019) reported through a web content analysis that women are rarely portrayed on websites of forestry programs in US universities. The consequence of these cumulative effects is that RR industries, such as forestry "has not attracted sufficient young talent interested in a career in the industry, resulting in a graying workforce" (Larasatie et al., 2020, p.

1). These authors highlight that the diversity increase in NR sectors' workforce could be a broader solution to multiple issues and potential opportunities. For instance, "enhancing gender diversity… is a reliable solution for filling the workforce gap, since women make up nearly half of the labour force in North America" and currently only represent about 24% of the combined workforce of agriculture, forestry, fishing and hunting in NL (Larasatie et al., 2020, p. 1; Newfoundland and Labrador, 2022).

Female Labor Force

As previously discussed, a diverse workforce can foster numerous advantages for an organization, presuming adequate management is concomitantly implemented (Bogdański, 2021; Odrowaz-Coates, 2021; Saxena, 2014). In other words, leading and managing an organization with higher workforce diversity is more challenging. However, if done well, it can be translated into a more resilient industry capable of adapting and thriving in the circular bioeconomy transition (Chen et al., 2021; Duchek et al., 2020). Increasing the participation of women is particularly important as it would address their poor representation in NR sectors while incentivizing the adoption of resource management practices that are more aligned with the Sustainability principles (Muscat et al., 2021; Thomas & Mohai, 1995). Notably, studies in Canada (Reed & Varghese, 2007) and other parts of the world (Nnoko-Mewanu et al., 2021; Sanz-Hernández et al., 2022; Umaerus et al., 2019) have reported that women tend to value natural assets differently than men, often attributing higher importance to a broader range of resources and their uses, directly or not. Some of these broader assets would be hunting/fishing, berries and mushroom picking, biofuel production, tourism activities, provision of higher air quality, intrinsic values, among others. Therefore, one of the potential advantages that a greater participation of women in NR's labour force would be an opportunity to consider the sustainable exploration of nature's products and services that are typically not as valued due to the path dependencies of traditional resource management (Hansen et al., 2016; Martin & Sunley, 2006; Spran & Mansor, 2018).

Unfortunately, the current representation of women in NR sectors in NL significantly impairs their ability to influence decisions that could lead to a multidimensional management of natural assets (FAO & UNECE, 2020; Sanz-Hernández et al., 2022). In fact, women are severely underrepresented, concentrated in a few roles, and under a significant wage gap in NR industries

in NL and other parts of the world. Nevertheless, although this gender unbalance is widespread in NR sectors worldwide, they are not due to immutable circumstances inherent to women. In fact, Salleh (2003, p. 70) argues that labour in such industrial settings "[…] is not necessarily gender-specific. Rather, the gendering is a historically contingent aspect of industrialized societies". For instance, women in forestry and logging represent 16.5% of workers in Canada, 10% in the United States, 13% in Western Europe, and 26% in Balcan countries (FAO & UNECE, 2020). A similar pattern can be found in the province of Newfoundland and Labrador (NL), Canada. For instance, women represent 23% of the labour force in the combined workforce of agriculture, forestry, fishing, and hunting in the province, further decreasing to 19.9% if mining, quarrying, and oil and gas are included. The low participation of women in these sectors and their overall homogeneity not only negatively impact these industries' long-term sustainability but also generates a positive feedback loop that reinforces some of their issues (Larasatie et al., 2020). Further, Reardon (2022) estimates that a minority group within a sector can only start influencing decisions if it constitutes at least 25-30% of an organization's workforce.

Concomitantly, female workers in NR sectors are concentrated in office-based, administrative roles of low decisive power (Coutinho-Sledge, 2015; Thomas & Mohai, 1995). Therefore, the few women currently working in NR sectors are prevented from effectively influencing decisions that affect their workplace participation as well as other potential benefits that a diversified workforce could enable (Lovrić et al., 2021; Saxena, 2014). An aggravating factor is the gender wage gap, which can be particularly harmful in NL as the regions where lumber mills are located also possess an overall lower income than the Provincial and Federal averages (FAO & UNECE, 2020; Larasatie et al., 2020). Hence, the wage gap in NR sectors is an additional factor that discourages women from applying for positions in these industries.

Two other reasons why women are still poorly represented in NL's NR sectors are the general public perception of the sector (FPSC, 2011) and what Larasatie et al. (2020, p. 1) call the "catch-22". In the authors' words, "the solution [to increasing female labour force in NR industries] is denied by a circumstance inherent in the problem". In a more general context, Ahmed (2016) called attention to the social cloning of organizations, referring to how they recruit in their image. Both of these reasons interconnect with the concept of perceived fit. That is, as potential female workers do not see themselves or their values and goals represented in NR sectors, they also do not feel fit to be a part of its workforce (Larasatie et al., 2020). Naturally, the public perception of the sector

cannot be changed quickly as part of its image is embedded in the population's collective perception. For instance, hiring more women through short-term incentives without systemic changes in the workplace can be detrimental (e.g., Coutinho-Sledge, 2015) if those women do not fit in and reinforce the prevailing incompatibility perception. Addressing the complex issue of women's participation in NR sectors requires a comprehensive and long-term marketing campaign compatible with a more diverse labour force. Additionally, a knowledge mobilization plan agreed among major NR players should promote discussions involving their industries' potential to contribute to goals such as mitigating climate change, supporting a circular bioeconomy, and creating greener urban environments. Naturally, these campaigns need to accompany well-informed changes within these sectors so that newly hired workers are retained, thus enabling further diversification strategies (e.g., apprenticeships, mentor programs, informal and continuous learning).

Indigenous Opportunities

As previously mentioned, the (skilled) labour shortage is a major issue affecting all economic sectors in many developed countries across the globe (Beaudoin et al., 2021). Among industries facing this issue, studies report that the natural resource sectors such as forestry are particularly affected (Beaudoin et al., 2021; Proulx et al., 2020). Canada is not an exception among countries confronting these challenges, in fact, the expectation is that the issue will be exacerbated soon due to an ageing workforce and low birth rates (Clair, 2021; Wernerheim & Long, 2010). In this context, increasing the participation of Indigenous peoples in Canadian natural resource sectors can contribute to solving the labour shortage crisis.

With a higher unemployment rate than non-indigenous Canadians, indigenous peoples are among the critical underrepresented groups to be recruited for many reasons (Proulx et al., 2020). To begin with, the average age of indigenous people is lower, and their birth rate is higher than other Canadians. These characteristics indicate a younger and growing pool of workers seeking employment opportunities while sharing a unique connection with nature and its resources. In fact, about 40% of the world's forest-dependent populations are indigenous (Chao, 2012) and, in Canada, more than 65% of indigenous peoples are located in or nearby forested areas (NRCAN,

2022). This proximity to areas where natural resource sectors usually operate offers a unique advantage as mobility to the workplace has been pointed out as an important barrier to recruiting and retaining workers. Beyond the spatial proximity to nature, indigenous peoples also share a strong cultural and spiritual connection with forests, directly influencing their well-being through cultural and subsistence activities (Beaudoin et al., 2021; Lawler & Bullock, 2017). Therefore, the "traditional rights to land, and community-level involvement in forest management is fundamental to their values and way of life" (Chao, 2012). Although the Canadian government has made significant advancements in this regard, progress has been very slow in addressing the impacts of the historical exclusion of indigenous populations from resource development (Lawler & Bullock, 2017). For instance, despite the volume increase of 140% from 2013 under the control of indigenous groups, indigenous ownership of forested lands in Canada is only 2.1%, and their control over the Canadian wood supply is just over 10% (Lawler & Bullock, 2017; NRCAN, 2022). Regarding workforce representation, 4.8% of workers in forestry are indigenous, therefore slightly under the 4.9% of the Canadian population (Lawler & Bullock, 2017). The current control over wood supply and representation of indigenous peoples in Canadian forestry may seem enough for some. However, it does not consider the percentage of their population living near forested areas and their strong connection with nature in many dimensions. Furthermore, Lawler and Bullock (2017, p. 120) argue for the benefits of bringing "indigenous values and beliefs to commercial management systems [and] bridging traditional and scientific forestry knowledge (…) to the development of a community-driven sustainable forest management paradigm. The benefits of greater and deeper involvement of indigenous groups in natural resource industries have only begun, and the corresponding diversity management measures to make this integration possible are still in preliminary stages (Proulx et al., 2020).

Despite the advantages of increasing the participation of indigenous peoples in natural resource industries and their communities' desire for greater involvement in regional economies, "few businesses have a strategy or policy for engaging [them], and minimal financial and human resources are… dedicated to [their] recruitment and retention" (Proulx et al., 2020, p. 2). In addition, several socioeconomic factors hinder indigenous peoples' integration into the workforce, either through indigenous-led companies or as an employee in non-indigenous enterprises (Beaudoin et al., 2021; Lawler & Bullock, 2017). Moreover, when they have access to these labour markets, they are found in lower-paying jobs and are more vulnerable to layoffs. Although Proulx

et al. (2020) reported that organizations led by indigenous people had the highest participation of indigenous workers (40-90% of their workforce), the creation and maintenance of an indigenous-led organization in the natural resource sectors are quite difficult. Using forestry as an example, the required capital volume to support a highly technological and skill-demanding industry is significantly impeditive (Lawler & Bullock, 2017). In addition, vast areas are required to operate competitively in forestry and other natural resource industries, which is incompatible with the scale of most indigenous reserves. When these difficulties are not present, the lack of technical, professional, and institutional capacity at initial stages hinders the ability to develop a management strategy that integrates indigenous rights, values, and needs into traditional forest management (Proulx et al., 2020).

Beaudoin et al. (2021) identified the six most common categories among socioeconomic barriers preventing indigenous participation in NR sectors. The first two barriers are balancing personal/professional life and work/traditional activities. That is, despite the overall proximity to areas where natural resource sectors operate, the requirement of moving and staying away from home for long periods of time influences the decision to join and maintain a job in such sectors. In addition, Beaudoin et al. (2021) reported that some participants complained about an attitude change towards forests and the lack of time to practice activities such as berry picking with their family. A third barrier pertains to mobility in their workplace. For instance, employees are required to have a driver's license and a vehicle capable of operating in areas with challenging terrain. A fourth barrier is the precarity of some of these jobs. Since many are seasonal positions, workers cannot guarantee the same job in the following year, and there may not be enough hours to become eligible for the government's Employment Insurance program. The fifth barrier identified by Beaudoin et al. (2021) involves personal, social or legal problems particular to or exacerbated among indigenous individuals due to higher socio-economic vulnerability. Many of these problems arise from prevailing stereotypes, discrimination, and the lack of inclusion measures; others involve single parenthood and health issues such as the use of drugs and alcohol (Beaudoin et al., 2021; Proulx et al., 2020). While discrimination impacts the willingness of indigenous people to join a particular sector, the higher proportion of health issues among indigenous peoples influences their productivity and capacity to learn (Kalb et al. 2014; Proulx et al., 2020).

The last barrier identified by Beaudoin et al. (2021) is associated with the lack of institutional capacity. That is, the fact that indigenous peoples tend to have lower schooling and training levels

make education the primary concern in improving these groups' involvement in the Canadian workforce (Ciceri & Scott 2006; Proulx et al., 2020). Furthermore, Beaudoin et al. (2021) and Proulx et al. (2020) argue that the overall level of education and insufficient training of potential indigenous workers is a barrier not only to their recruitment but also to their integration and retainment. For instance, it restricts indigenous workers to non-decision-making positions and lower wages.

There has been a long history of indigenous participation in forestry operations (primarily harvesting and mill workers) throughout NL. Indigenous representation should play a heightened role in identifying vital value chains and encouraged to take advantage of potential joint venture opportunities. Currently there are five First Nation communities in Newfoundland and Labrador. In total they comprise over 28,000 members, with distinct communities in Labrador (Innu and Inuit) and Mi'Kmaq on the island portion of the province. The Qalipu First Nation, the most recently recognized Band, represents 24,000 of those members distributed among 67 federally recognized communities spanning from Bay St. George-Port au Port; Corner Brook-Bay of Islands; Grand Falls- Windsor, to Gander Bay north.

Leveraging PSE institutions in NL can substantially contribute to addressing multiple barriers that prevent greater participation of indigenous workers in sectors strongly linked to the circular bioeconomy. Such partnerships need to be broad in terms of learning strategies and target groups, and acknowledge the long-term requirements before fully addressing current labour shortages and achieving the multiple benefits of a diverse workforce. Establishing partnerships between mill owners, indigenous communities, PSE institutions, and governmental instances foster win-win scenarios for the whole society. As a few examples, employers would be able to recruit from a growing pool of workers with a strong connection with nature and potentially high informal experience; PSE institutions would be increasing student enrolments and their corresponding economic gain; and governmental instances would be able to maintain or potentially increase populations in rural areas by fostering industries with high potential in the circular bioeconomy (Proulx et al., 2020). For instance, PSE institutions could intermediate conversations between mills and indigenous communities and further assist potential workers in meeting the present and foreseen skills required by industries. Whenever basic education requirements are already met, training programs can be offered through these partnerships as a successful strategy identified by Proulx et al. (2020). Such training could involve "mentoring, coaching from experienced

employees, on- the-job teaching, observation, and experimentation" (Proulx et al., 2020, p. 6). Nevertheless, the authors reported that cooperation between mill employers and indigenous communities mainly involved medium and large businesses. This suggests that smaller organizations may not have the capacity to coordinate these associations, hence the importance of leveraging PSE institutions' capacity, particularly considering the wide distribution of these institutions in NL through MUN and CNA's multiple campuses. In addition, offering continuous training opportunities is costly, thus typically not affordable by small to medium size companies. Especially considering the concern over losing trained workers to other industries, which discourages direct investment by mill owners (FPSC, 2011).

In this context, Proulx et al. (2020) highlight a participant from a large business that adopted a proactive approach to recruiting and retaining indigenous workers in forestry through effective strategies. According to the authors, the employer offers conventional training programs to indigenous applicants in which experienced workers mentor them. Secondly, they foster a workplace culture where discrimination is not accepted with open channels to report any related problems. Lastly, regular meetings are conducted to further integrate these individuals into their workplace. Such efforts to recruit and create cultural awareness among non-indigenous workers are fundamental for retaining indigenous workers (Ewing et al. 2017; Parmenter & Trigger 2018). Despite its proven efficacy, Proulx et al. (2020) reported that most employers do not have such strategies in place partially because of a lack of resources that cannot be afforded by companies alone. In addition, there is a prevailing idea that adopting such proactive measures would be unfair to non-indigenous workers. Beaudoin et al. (2021) counterargue that such ideas are rooted in a meritocracy belief that does not apply in this context nor assists with the major issues of labour shortages. In fact, the lack of education and training programs for new and current employees only perpetuates stereotypes and undermines managers' capacity to handle identified barriers that are commonly associated with indigenous workers (Proulx et al., 2020).

Improving the participation of indigenous peoples in natural resource sectors can bring multiple benefits to Newfoundlanders, Labradorians, and the broader Canadian society. For instance, it would contribute to the "recognition and protection of treaty rights" and support the sustainable development of indigenous communities (Lawler & Bullock, 2017, p. 120). Furthermore, the incorporation of indigenous values into natural resource industries can be fundamental to a genuine sustainable management of ecosystems and the conservation of areas designated exclusively for

this purpose (Lawler & Bullock, 2017). Integrating such values could also contribute to the skepticism towards sustainably managing natural ecosystems held by parts of society, particularly women and younger populations (FAO & UNECE, 2006).

Nevertheless, Caron et al. (2019) argue that the willingness of employers to make a real effort in recruiting underrepresented groups in their industry such as indigenous peoples is, at best, insufficient. For further advancements, governments are essential in supporting and coercing employers to implement measures that integrate underrepresented groups. Governmental involvement is not problematic; on the contrary, it is in their best interest to oppose systemic discrimination, support reconciliation, and mitigate historic impacts with impacts to this day (Beaudoin et al., 2021; Proulx et al., 2020). The fact that the vast majority of forested lands are publicly owned (91.4%) and that provinces have jurisdiction over natural resources offers a great opportunity to implement a wide variety of strategies and partnerships (NRCAN|, 2022). In addition, substantial efforts need to be made by employers to adopt a more proactive stance in addressing the shortage of labour force while profoundly considering the importance and benefits of workforce diversity to the resilience of their organizations. For instance, Proulx et al. (2020, p. 7) argue that many are still in "early awareness stages and still exhibit signs of cultural hegemony". As argued by Gröschl (2003, p. 98) and more recently reinforced by Proulx et al. (2020), "organizations need to shift their focus from a short-term hiring plan towards a more long-term strategy that includes potential employees' pre-employment training and their education". Finally, once underrepresented groups are recruited, partnerships with organizations such as PSE institutions, employment agencies, and indigenous communities can assist with their integration and acclimatization without surpassing a group's original culture, but actually supporting their respectful coexistence.

Institutional Leadership

As places for creating human capital and social transformations, PSEs require strong leadership that recognizes the value of diverse networks which extend beyond their zones of proximity, familiarity and competence. Within the context of an emerging bioeconomy in NL, academic leaders must strive to better engage the forest sector to rethink existing approaches towards innovation and sustainability. Morawska-Jancelewicz (2021) noted that the importance of

knowledge is not determined exclusively by competitiveness and productivity, but by taking into account the creation of social well-being, the impact on the quality of life and co-creation of knowledge as part of public–private partnerships. Moreover, Almaraz-Menendez et al. (2016; 2021) point out that responding to digital and green transformations requires new future-oriented strategies and organizational change that promotes the understanding of digital culture. Accordingly, organizations need to foster a green and digital culture within their institutions using intelligent, flexible, inclusive, accessible and adaptive learning systems. Further, developing and supporting entrepreneurs provide an important catalyst for new businesses and a flexible, creative, and well-educated workforce.

Leaders of post- secondary institutions need to enhance the role their faculty and students play in the development of the innovation ecosystem, in collaborative research partnerships, in networks of civic and entrepreneurial engagement, and in the wider political and cultural leadership of their regions. Determining which particular mix of teaching and research programs would best underpin the economic development of a region remains a key challenge. Strong institutional leadership is also required to advance the new Centre of forest-based research in Corner Brook to develop new programs, attract expertise, establish regional networks, and identify gaps and opportunities associated with the circular bioeconomy. This Centre should become a forum for leadership and development of practical applications to drive the bioeconomy agenda in support of a forest-based economy. In combination with the Navigate Entrepreneurship Centre, the Centre can support business diversification and a stronger culture of innovation and entrepreneurship. Empirical evidence (Kitagawa, 2005) suggests entrepreneurship education needs to be better integrated into education and training programs with particular emphasis on real- world experience in the workplace and more effective engagement with entrepreneurs.

Given the significance of the forest sector to rural NL, concerted effort and leadership is needed to assist the forest sector in developing joint-venture initiatives in support of a circularly bioeconomy. Opportunities to develop and harness skills for more inclusive growth requires a strong academic and research platform compassing creativity and entrepreneurial capacity (OECD, 2005).

Governance & Policy Challenges for the Circular Bioeconomy

To shape and promote a bioeconomy in NL demands a coherent and strategic policy approach. A major challenge facing policymakers is to design policy schemes that promote innovation and development without locking into particular systems or technologies or locking out future opportunities. A degree of foresight is therefore of great importance in policy formulation for the bioeconomy, so that short-term decisions may be taken without jeopardizing opportunities in the long-term. Staffas et al. (2013) suggest that for the full potential of the bioeconomy to be achieved, a policy framework that considers economic, environmental, technological, social and institutional challenges is demanded. Provincial policymakers should strive for a combined strategy and action plan document to improve the knowledgebase for the bioeconomy, encourage innovation to increase natural resource productivity in a sustainable manner, and assist the development of a profitable and competitive forest sector. Because the bioeconomy is inextricably linked to sustainability, Pfau et al. (2014) argues that consideration should be given to the question of how the bioeconomy could contribute to a more sustainable future. Similarly, Jordan et al. (2007) argues for a sustainable approach to the agricultural bioeconomy as do the European Commission in their recent 2018 bioeconomy strategy (European Commission, 2018). The transition to an energy and materials production regime based on renewable forest resources will be fraught with many setbacks and obstacles, technically and politically. For bioeconomy policy makers, the future is complex and multi-faceted, and the transformation will take time (International Advisory Council on Global Bioeconomy, (2020). All bioeconomy aspirations depend on adequate supplies of sustainable biomass – how to reconcile the competing needs of other land use stakeholders and the forest industry will be challenging.

Moreover, given regional priorities, jurisdictional issues, regulatory issues, and current tenure arrangements, future policies must be coherent and sufficiently flexible. To advance a competitive and sustainable bioeconomy, the forestry sector will need to address participatory governance actively and meaningfully. Full engagement with the general public and key stakeholders in an open and informed dialogue is required to advance the sector. As well, there must be a commitment by government and industry to innovation that drives concerted efforts on sustainable development of the bioeconomy.

XI RECOMMENDATIONS

The following recommendations are provided to assist the NLFIA and PSE institutions in advancing a circular bioeconomy in the province. Attention to these recommendations will assist in planning and priority-setting:

- Establish a circular bioeconomy advisory council so forest industry can provide direct input to development of the circularly bioeconomy in the province. The council can also advise on provincial and federal human resources related policies (e.g. Learning and development; discrimination, bullying and harassment; Occupational safety and Health; Work Sharing, Employment Standards, Temporary Foreign Workers) and programs, including those under Labour Market Development Agreements with provincial governments.

- Seek both industrial and government support to encourage colleges and universities to establish advisory committees of representatives from industry and other appropriate stakeholders, for programs related to bioeconomy development.

- Promote the merits of the bioeconomy, by delivering awareness-raising activities and embedding the bioeconomy within careers guidance for youth and adults.

- An assessment of the training and education needs and adaptation of existing curricula to the skills needed are preconditions for training sustainable forest careers of the future. A systematic, fact-based review of emerging skill needs, and development of relevant training measures will require collaboration between academia and a network of stakeholders from different disciplines.

- The forest sector needs to become more innovative in attracting qualified people to fill new jobs. Working with PSE institutions to revise existing curricula and design of new career paths is fundamental to address the skill gaps. The Open Book of Green Forest Jobs4, developed by the ECE/FAO Team of Specialists on Green Jobs in the Forest Sector (ILO/ECE/FAO Joint Expert Network), can help in this direction.

- Encourage post-secondary education institutions to develop new degree programs (e.g., MUN/CNA 2+2 bioeconomy degree) in support of the circular bioeconomy.

- Strengthen bioeconomy development through skills-related initiatives. Support training on circularity, systems thinking, sustainability and entrepreneurship.

- Emphasize more informal education through conversation, exploration, experimentation, and engagement of experiences while cultivating communities and relationships. Include non-credit continuing professional education, conference or seminar type professional learning and community educational programs. Online and virtual communication (including virtual reality), teamwork and learning forums can be part of informal learning.

- Encourage post-secondary education institutions to develop bioeconomy learning including new paths including certificates and diplomas.

- Promote opportunities for upskilling through individual modules for further training where micro- credentials are offered by PSE institutions.

- Build on and reform where required, existing forest policy frameworks and networks to promote the bioeconomy among multiple natural resource sectors (e.g., forestry, agriculture, fisheries).

- Work with regions and local industry, especially those with high biomass potentials to access provincial and federal funding in support of transition activities that support bioeconomy development.

- Foster activities that bring different stakeholders together to share knowledge and best practices related to circular bioeconomy development, including those from education and training institutions.

- Promote development of an informatics database to monitor workforce development and demand, bioeconomy skills (forecasting), data/knowledge acquisition (developments in other regions and countries).

- Promote practices and programs to make students aware of NL's sustainable forest management practices, including nature-based climate solutions, forest resiliency, biodiversity conservation, and knowledge-based jobs.

- Support NL youth through awareness building efforts that promote 'green' career paths within NL's forest sector.

- Support educational and skills development programs that provide meaningful opportunities for youth through a diversity of forest sector partnerships.

- Increase opportunities for women to participate fully in the circular bioeconomy through capacity building and childcare support.

- With the growing need for a diversity of skills in the forest sector, it is important to provide training and education opportunities that will enable Indigenous people – particularly youth – to consider and pursue forestry-related careers more fully. Specifically, PSE institutions should partner with the Indigenous Forestry program to strengthen opportunities for Indigenous communities.

- Seek a partnership with Forest Products Association of Canada (FPAC) to advance the Outland Youth Employment Program (OYEP), a national network of land-based education, training, and work opportunities for high school aged Indigenous youth. The program takes an inclusive approach to Indigenous education, recruitment, and retention and provides a safe and predictable learning environment that can be tailored to meet the needs of local communities and partners.

- Earnestly engage advocates for underrepresented groups such as Women in Resource Development Corporation, the Association for New Canadians, and the Qalipu First Nation to create forest industry workplaces that are more welcoming and inclusive

- Collaborate with provincial department of Immigration, Population Growth and Skills to facilitate the uptake of forest industry jobs and/or upskilling programs by newly arriving Canadians

- Re-establish 'teacher tours' for secondary school teachers and guidance councillors to learn of contemporary forest industry opportunities and approaches

- Embark upon a targeted rebranding campaign to promote the forest industry's role as a contributor to rural sustainability, attention to environmental sustainability, and carbon management

- The NLFIA should engage a Forest Bioeconomy Business Development Officer to support the development of business cases for new bioeconomy products

- Relevant provincial government departments should introduce new bioeconomy grants for forest industry and partners for feasibility studies, business plans, and start-up funds to encourage the development of bioeconomy products

- Develop guiding policy and plain language guidance documents to facilitate the use of organic residuals (e.g., forest industry residues) as soil amendments. Look to New Brunswick and Nova Scotia for established policies and guidelines

- Incentivize organic waste diversion and more extensive waste management to discourage stockpiling with no added value generation. Landfill ban may not be advisable in favor of incentivizing waste-to-value options

- Encourage industrial synergies (and the clarification of related policy) between forestry, agriculture, and fisheries to take advantage of the benefits of applying wood ash as a soil amendment and other added value when combined with fish waste

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APPENDIX A

Local areas that constitute the Great Northern Peninsula - St. Anthony - Port au Choix Region and its respective municipalities.

- Local Areas 71: includes Castor River and Eddies Cove.
- Local Areas 72: Cook's Harbour, Goose Cove East, Great Brehat, Hay Cove, L'Anse-aux-Meadows, Noddy Bay, North Boat Harbour, Quirpon, Raleigh, Ship Cove, St. Anthony, St. Anthony Bight, St. Anthony East, St. Carols, St. Lunaire-Griquet, Straitsview and Wild Bight.
- Local Areas 73: Conche, Croque, Englee, Main Brook, Roddickton-Bide Arm and St. Julien's.
- Local Areas 74: Barr'd Harbour, Eddies Cove West, Hawke's Bay, Port Saunders, Port au Choix and River of Ponds.

Local areas that constitute the Burton's Cove Region and their respectives municipalities.

- Local Area 38: Cormack, Deer Lake, Georges Cove, Hampden, Howley, Jack Ladder, Pynn's Brook, Reidville, St. Judes and The Beaches.
- Local Area 41: Jackson's Arm, Pollards Point and Sop's Arm.
- Local Area 58: Baie Verte, Brent's Cove, Coachman's Cove, Fleur de Lys, Harbour Round, La Scie, Ming's Bight, Pacquet, Purbeck's Cove, Seal Cove, Tilt Cove, Westport, Wild Cove and Woodstock.

Local areas that constitute the Cottle's Island Region and their respectives municipalities.

- Local Area 62: Notre Dame Bay South comprises: Includes Baytona, Birchy Bay, Boyd's Cove, Campbellton, Comfort Cove-Newstead, Loon Bay and Michael's Harbour.
- Local Area 63: New World Island: Includes Cottlesville, Summerford and all other communities on New World Island.
- Local Area 64: Twillingate Island: Includes Black Duck Cove, Crow Head, Kettle Cove, Purcell's Harbour, Ragged Point and Twillingate
- Local Area 67: Fogo Island: Includes Deep Bay, Fogo, Fogo Island Centre, Island Harbour, Joe Batt's Arm-Barr'd Islands-Shoal Bay, Seldom-Little Seldom, Stag Harbour and Tilting.

Local areas that constitute the Corner Brook Region and its respective municipalities.

- Local Area 39: Corner Brook, Gillams, Hughes Brook, Humber Village, Irishtown-Summerside, Little Rapids, Massey Drive, McIver's, Meadows, Mount Moriah, Pasadena, Pinchgut Lake and Steady Brook.
- Local Area 40: Cox's Cove, Humber Arm South, Lark Harbour and York Harbour.

Local Areas that constitute the Bloomfield-Bonavista Region and its respective municipalities.

- Local Area 49 (Chandlers Reach): Bloomfield, Brooklyn, Bunyan's Cove, Cannings Cove, Charlottetown, Lethbridge, Morley's Siding, Musgravetown, Port Blandford, Portland-Jamestown-Winter Brook, Terra Nova, and Thorburn Lake.
- Local Area 50 (Southern Bay Area): Charleston, Open Hall-Red Cliffe, Plate Cove East, Plate Cove West, Summerville-Princeton-Southern Bay, Sweet Bay, and Tickle Cove.
- Local Area 51 (Black Head Bay): Birchy Cove, Duntara, Hodderville, Keels, King's Cove, Knights Cove, Lower Amherst Cove, Middle Amherst Cove, Newmans Cove, Stock Cove, and Upper Amherst Cove.
- Local Area 52 (Bonavista Area): Bonavista and Spillars Cove.
- Local Area 53 (Trinity Bay North Area): Trinity Bay North (includes Catalina, Little Catalina, Melrose and Port Union), and Elliston.
- Local Area 54 (Trinity, Trinity Bay Area): Champney's East, Champney's West, Dunfield, English Harbour, New Bonaventure, Old Bonaventure, Port Rexton, Trinity East, Trinity, and Trouty.
- Local Area 55 (Smith Sound-Random Island): Burgoynes Cove, Clarenville, Clifton, Georges Brook-Milton, Smith's Sound (Gin Cove, Harcourt, Monroe, Waterville), and all of Random Island.

APPENDIX B

Dissemination Plan:

- Submit manuscript entitled "Forest-based Bio-economy Development in Newfoundland and Labrador" for publication in *Canadian Journal of Forest Research*. To be submitted for publication in 2023.
- Submit manuscript title "TBD" to the journal *Shima*. This paper will outline the merits of the photo documentaries used in this research project in fostering collaborative discussions with forest industry stakeholders. To be submitted for publication in 2023.

Sensitivities with respect to Dissemination of Final Report and Deliverables:

- None