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Examining Carbon Challenges in the Western Canadian Forestry Industry: A Review of Current Forest Carbon Accounting Practices and Forest Management Issues.

by

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Abstract

Considering the increased international emphasis on the role of forests in climate change mitigation efforts, it is important to examine the challenges facing forest management regimes as they begin integrating regulations for forest carbon and climate change values. Large-scale natural disturbances and a business-first regulatory approach have contributed to forests in British Columbia and Alberta devolving from perennial carbon sinks into net carbon emission sources. An examination of provincial forest management regulations and policies suggests that current forestry regulations in western Canada don't adequately consider forest carbon issues and may fall short of international sustainable forest management standards. This issue is highlighted by the permissive regulation of slash burning, a practice which simultaneously destroys usable forest fibre while significantly contributing to forest sector emissions. Potential regulatory solutions to slash burning are examined, and potentially misleading transparency issues regarding carbon accounting practices in the LULUCF sector of Canada's National Inventory Report are discussed.

Acknowledgement

To my Mom and Dad, thanks for always supporting me. I love you both. Part of this project is yours.

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I would like to dedicate this project to the men and women of Shunda Firebase. “Full tilt or no tilt”

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AAC – Annual Allowable Cut

BDMT – Bone Dry Metric Tonnes

CAP – British Columbia's Climate Action Plan

CanFi – Canadian Forestry Institute

CBM-CFS3 – Carbon Budgeting Model for the Canadian Forest Service Version 3.0

CFS – Canadian Forestry Service

CH_4 - Methane

CLT – Cross-Laminated Timber

CLP – Climate Leadership Plan (Alberta)

COP21 – Conference Of the Parties 21 (Paris Agreements)

CO_2 – Carbon Dioxide

CO_{2eq} – Carbon Dioxide Equivalent

CRF – Common Reporting Format

ECCC – Environment and Climate Change Canada

eNGO – environmental Non-Government Organization

FA- Forest Act (British Columbia)

FAO – Food and Agriculture Organization of the United Nations

FCI – Forest Carbon Initiative

FESBC – Forest Enhancement Society of British Columbia

FFT – Forest For Tomorrow

FL – Forest Licence

FLNRO – Ministry of Forests, Lands, Natural Resource Operations and Rural Development

FMA – Forest Management Area

FMP – Forest Management Plan

FMU – Forest Management Unit

FPC – Forest Practices Code (British Columbia)

FPInnovations – Forest Product Innovations

FPPA – Forest and Prairie Protection Act (Alberta)

FPPR – Forest Planning and Practices Regulation (British Columbia)

FRIAA – Forest Resource Improvement Association of Alberta

FRPA – Forest and Range Practices Act (British Columbia)

FSP – Forest Stewardship Plan

GHG – Greenhouse Gases

Ha – Hectare

HFC - Hydrofluorocarbons

HWP – Harvested Wood Product

IEA – International Energy Agency

IPCC – Intergovernmental Panel on Climate Change

ITSL – Innovative Timber Sales Licence

Kt – Kilotonne

Kt CO_{2eq} – Kilotonnes of Carbon Dioxide Equivalent

LULUCF – Land Use, Land Use Change and Forestry

MBF – Mega-Board Feet (1000 Board Feet)

MLP – Managed Land Proxy

MPB – Mountain Pine Beetle

MPBFRP – Mountain Pine Beetle Forest Rehabilitation Program

Mt – Megatonne

Mt CO_{2eq} – Megatonnes of Carbon Dioxide equivalent

MWh – Mega-watt hours

NEB – National Energy Board

NF_3 – Nitrogen Trifluoride

NIR – National Inventory Report

NRCan- Natural Resources Canada

N_2O – Nitrous Oxide

ODT- Oven Dry Tonne

OGR – Timber Harvest Planning and Operating Ground Rules (Alberta)

OSB – Oriented Strand Board

PIR – Provincial Inventory Report

PFC- Perfluorocarbons

PCF – Pan-Canadian Framework on Climate Change

RFP – Regulated Forestry Professional (Alberta)

RPF – Registered Professional Forester (British Columbia)

SEDV – Sustainable Energy and Resource Development program

SFM – Sustainable Forest Management

SF_6 – Sulfur Hexafluoride

TFL – Tree-Farm Licence (British Columbia)

TMR – Timber Management Regulations (Alberta)

TSA – Timber Supply Area

TTP – Transformative Technologies Program

UNCED – United Nations Conference on Environmental and Development

UNFCCC – United Nations Framework Convention on Climate Change

VOIT – Values, Objectives, Indicators, Targets

WRP – Wildfire Reclamation Program

3D – Three Dimensional

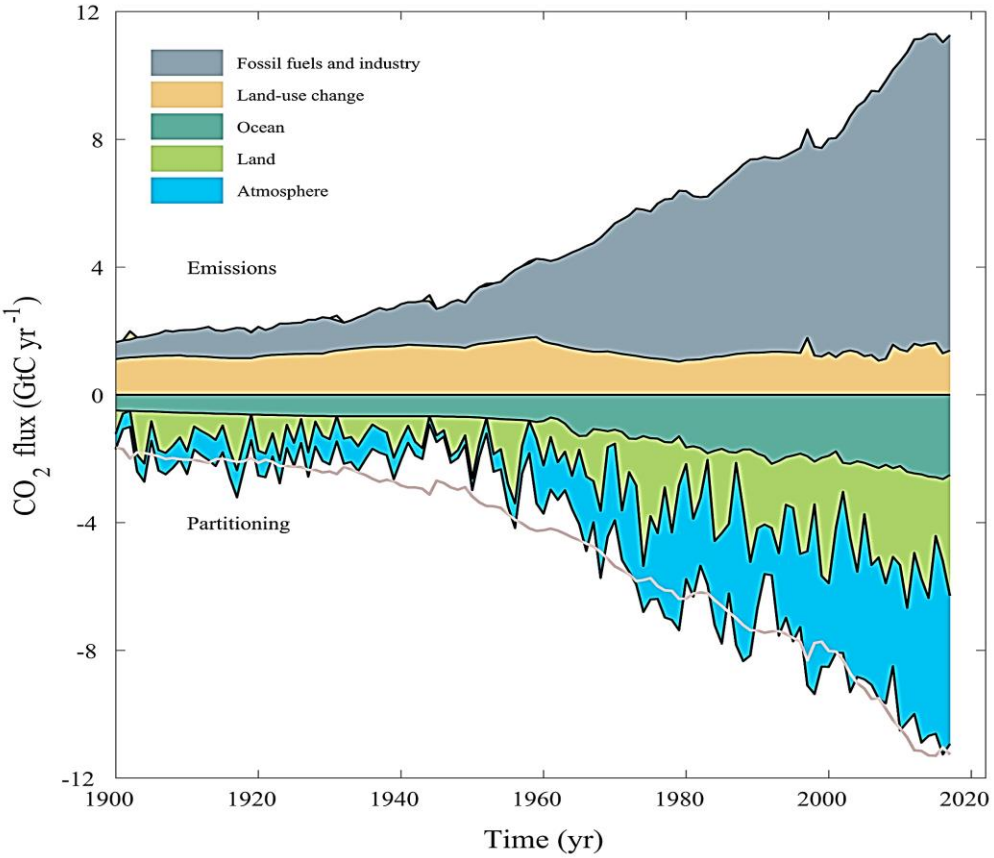
Chapter 1: Introduction

Climate change is the most formidable challenge facing the global population today. Rising Greenhouse Gas (GHG) concentrations in the atmosphere and their effect on increasing global temperatures have been well documented. While the majority of anthropogenic GHG's are emitted through the combustion of fossil-fuels and cement production, global forests have an increasingly important and complex part to play to as the world attempts to shift towards a low-carbon future.

Global forests have long been a significant carbon sink and assist in mitigating carbon emissions by intaking carbon from the atmosphere and sequestering this element throughout the duration of their lifecycle, and potentially for longer than that depending upon the end-usage of Harvested Wood Products (HWP) through the supply chain. It is estimated that up to 30% of anthropogenic GHG's were captured and sequestered in global forests between 1990-2007 (Pan, Piao, Rautiainen, Sitch, & Hayes, 2011). With the recent Intergovernmental Panel on Climate Change (IPCC) report (SR15), indicating the potential risk to global communities if climate change rises 1.5 °C above pre-industrial levels, it is important to consider the role that forests can play in assisting global climate change mitigation efforts (IPCC, 2019).

Carbon emissions from Land Use, Land Use Change and Forestry (LULUCF), primarily stemming from land-use change resulting from large-scale deforestation, contributed to a mean average of 18% of total global carbon emissions from 1959-2017 (Le Quere, 2018). The overall percentage of global carbon contributions from land use change has been declining in recent years, but this is due to increasing emissions from fossil-fuels, and not decreasing contributions from forest biomass removals.

Figure 1 - Global Carbon Flux



(Le Quere, 2018).

A report from the Climate and Land Use alliance has indicated that global forests contain greater amounts of carbon than exploitable oil, gas and coal deposits, and that improving the management of existing forests is a critical component of climate change mitigation, that provides additional co-benefits, including conserving biodiversity, reducing air pollution and buffering against flooding (Wahlen, 2018). Additionally, harvested wood products (HWP) derived from forest timber harvests also have the ability to enhance climate change mitigation efforts through carbon sequestration, although the duration of sequestration can vary significantly due to product lifespans and usage.

In 2015, the global HWP carbon pool resulted in a net annual sink of 335 Megatonnes of CO2 equivalent (Mt $CO_{2\,eq}$), with the potential to increase to 441 Mt $CO_{2\,eq}$ per year by 2030 assuming certain socioeconomic developments (Johnston & Radeloff, 2019).

Although forests have the potential to store large amounts of atmospheric carbon, the cumulative effects of deforestation and climate change have been turning many of the world's forests from net carbon sinks, into sources of significant carbon emissions. Forest fires and insect infestations, due in part to drought conditions and rising global temperatures, have been increasing in size and severity over the past 30 years and the rapid release of sequestered forest carbons have drastically increased the amount of carbon released to the atmosphere resulting in a positive feedback loop that increases both the severity of climate change and the potential increase of carbon emissions stemming from natural disturbances in forests (Harvey, 2017). These trends have been evident in western Canadian forests over the past decade, and this trend is expected to increase in the first half of the 21st century (Natural Resources Canada, 2017).

With the potential for forests to be a net GHG/carbon emission source, as well as a net carbon sink, carbon accounting measures within the LULUCF sector and emphasis on sustainable forest management practices are becoming increasingly relevant to world-wide climate change initiatives. The United Nations Framework Convention on Climate Change (UNFCCC) directed 2015 Paris Agreement established a framework encouraging ratifying countries to "*implement and support, including through results-based payments…policy approaches and positive incentives for activities relating to reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks*" (UNFCCC, 2015, p. 1). The Paris Agreement has also requested in-depth forest carbon reporting protocols for both developing and developed nations. Partially due to this agreement, various countries worldwide are adopting and implementing forest carbon mitigation strategies and polices aimed to increase sequestered carbon levels and limit sector related GHG emissions.

Countries like Finland and Sweden have begun to focus on carbon mitigation through forest-related-activities and have implemented regulations and policies regarding harvesting practices, bio-energy production, reforestation, afforestation, forest waste management and carbon sequestration in HWP (Makkonen, Huttunen, Primmer, Repo, & Hilden, 2015); (Lundmark, et al., 2014). Other jurisdictions, including New Zealand (Carver & Kerr, 2017), Australia (Buizer & Lawrence, 2014), and Canada (Government of Alberta, 2018a) are exploring and implementing various forms of forest carbon offset incentives, and carbon market trading schemes in order to mitigate climate change. Given the current global climate initiatives regarding GHG emissions

from LULUCF and Canada's international climate change commitments, such as the Paris COP21 agreement it is essential to examine current forest carbon challenges facing the western Canadian (British Columbia and Alberta) forestry industry relating to forest carbon accounting practices, and relevant forestry regulations and policies and examine potential ways to alleviate these issues through effective sector-targeted regulations and policies and sustainable forest management techniques.

This project will investigate the current methods of GHG accounting in western Canadian forests and evaluate the performance of regulations and policies that inform forest management practices in Alberta and British Columbia through a climate change mitigation lens. Special attention will be paid to the burning of collected forest harvest residuals, also known as slash pile burning.

Forest harvest residuals, also known as slash piles, are the cast-off portions of timber that are left on harvesting blocks after primary forest operators have removed the stem of the tree. These discarded pieces, generally consisting of the small-diametre top, branches and needles, and often times bottom cut-offs can represent 30% of the total tree volume and thus represent a significant waste of forest fibre especially in light of the large-scale harvest operations employed in British Columbia and Alberta. Large amounts of slash left on blocks after harvest operations create logistical problems for forest operators within Alberta and British Columbia and represent significant potential sources of GHG emissions.

The practice of slash-pile burning is highly prevalent within the forestry industry in both British Columbia and Alberta. Since there are currently very limited markets for these harvest residues in Canada, and thus little incentive to retain them, most forest harvest operators use machinery to pile the residual debris and burn it to clean the block which increases the efficiency of government mandated reforestation practices. Beyond increasing the efficacy of reforestation operations, this practice is reinforced for forest operators by forestry regulations in both British Columbia and Alberta. Both provinces have installed regulations and policies that demand the complete removal, or partial spreading, of forest harvest debris as a method of fire-mitigation control as loosely dispersed (broadcast) slash poses a significant fire-risk to newly reforested blocks, and large slash piles, which can sometimes reach heights of 10+ metres, tend to dry rapidly increasing fire risk

and fuel loading within harvest blocks (Government of Alberta, 2017b); (Government of British Columbia, 2019d). Currently there is no precise quantitative data, beyond high-level estimation methods, to determine how frequent the practice is or to accurately describe its impact on forest carbon emissions and ecosystems. Estimations are provided by provincial industry experts (Government of Canada, 2019a) and are not specific enough to properly encompass the associated emissions within the province. Questions regarding how misleading these industry estimations are and if they are in fact greatly underestimating the scope of emissions (Voices for Good Air, 2017).

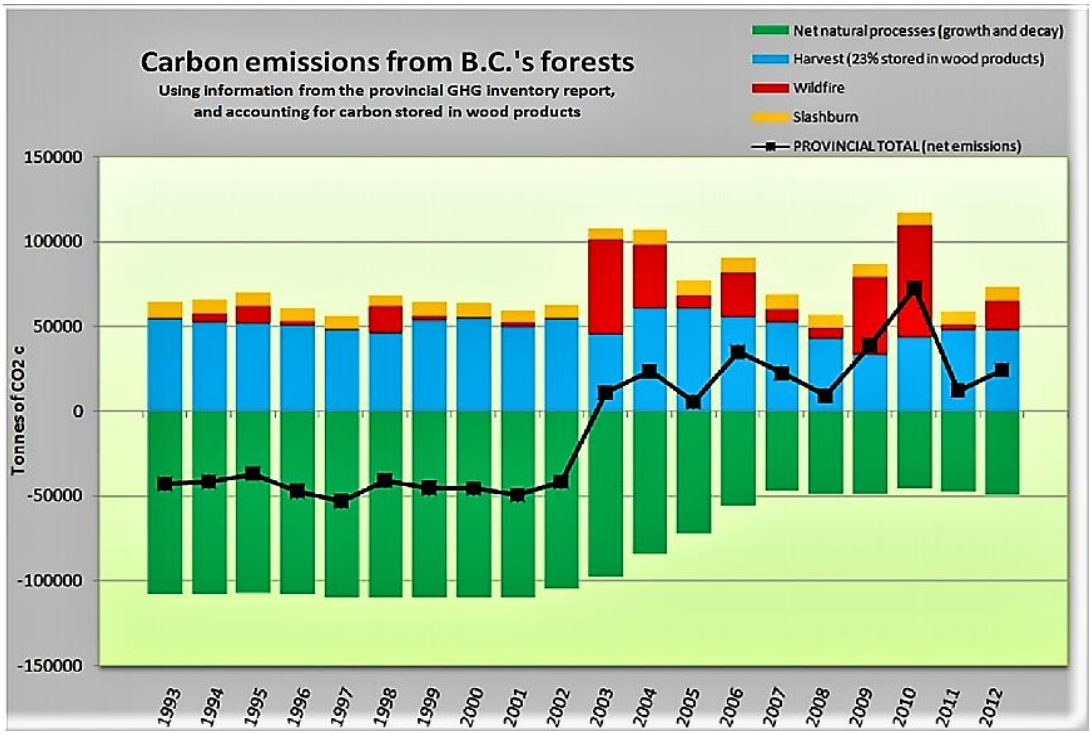
British Columbia's 2016 Provincial Inventory Report (PIR) estimated that slash pile burning emitted 4,634 kilotonnes of $CO_{2\ eq}$ which would represent 14% of British Columbia's LULUCF sector emissions and 7.2% of the province's total GHG emissions (Government of British Columbia, 2018b). **This emissions total is greater than those associated with light duty gasoline fueled transportation and residential energy emissions for the entire province**

Figure 2 - Slash Piles being burnt in British Columbia

(Vice, 2015)

It is estimated that from 2003-2012 emissions from slash burning practices in British Columbia contributed 82 Mt $CO_{2\ eq}$ to the atmosphere, and these figures may underestimate the practice (Wieting, 2015). Since Alberta, unlike British Columbia, does not compose or publish a PIR and provincial emissions from the LULUCF sector are not disclosed in national inventory reporting, there is even less available data regarding the actual scope of slash-pile burning and the emissions that result from their combustion within the province. However, given the similarities between forest management practices in both provinces, and Alberta's debris removal policies, it is safe to assume that the emission profile is similar, albeit on a smaller scale due harvest volume difference.

Figure 3 - British Columbia, Forest Carbon Emissions 1993-2012



(Wieting, 2015)

Considering the large emissions profile associated with the practice, and the waste of potentially useful fibre, it is important to consider other forest management practices that deal with harvest residuals. Notably, other forestry countries such as Sweden and Finland have embraced alternative utilization techniques for their forest residuals and have created secondary markets for their previously waste forest fibres that have resulted in increased economic opportunities for the

industry, and significant decreases to forest carbon emissions (Kallio & Leinonen, 2005); (IRENA, 2018); (Bostrom, 2015).

Collection and utilization of forest harvest residuals is a practice that has been growing over the past decades in countries like Austria, Finland and Sweden (Hoyne & Thomas, 2001). Finland and Sweden have prioritized the harvesting of forest residuals in order to support their development of the bioeconomy in their countries (Bostrom, 2015); (Ministry of Agriculture and Forestry of Finland, 2018). The bioeconomy is a way decreasing humanity's reliance on non-renewable resources in order to meet our needs. The European Commission defines the bioeconomy as *"the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy"* (European Commission, 2012, p. 1).

The increased utilization of harvest residuals could provide numerous opportunities for Alberta and British Columbia to begin fostering a bioeconomy through the forestry industry. Residual forest fibres have the potential to assist with industry diversity that could help revitalize stagnant aspects of forestry industry in western Canada as they can feed into multiple existent industries, including pellet plants, pulp facilities, OSB plants, and bioenergy plants (Graff & Henderson, 2018). For example, wood pellet manufacturing is an emerging production option that offers opportunities for growth. In 2017, British Columbia exported 1.78 million tonnes of wood pellets worth $311 million (Barnes, 2018). These numbers are expected to grow over the coming years and British Columbian companies have signed recent long-term supply deals with Japan and the United Kingdom suggesting this will be an economically viable industry in the long term (Pacific BioEnergy, 2019).

Although British Columbia faces challenges integrating bioenergy into its energy mix due to the prevalence of hydroelectricity as a renewable energy source (Lindroos, Nilsson, & Sowlati, 2011), Alberta still relies on coal and natural gas fired energy plants for much of its electricity and heat production, so there is greater potential for bioenergy production to contribute meaningfully to greenhouse gas reductions in Alberta, though this depends on spatially specific application sites (Niquidet & Friesen, 2014). There are also companies such as FPinnovations, a Canadian non-profit with a strong history of working with government and industry, that focuses on developing

tangible options for competitive HWP manufactured from residual fibres (Favreau & Ristea, 2016). FPinnovations is currently partnered with the British Columbian government on their forest fibre action plan and are working are creating secondary products that will drive demand in the residuals market (Kozuki & Stewart, 2019).

Both Alberta and British Columbia have ambitious climate change goals but little to no regulatory framework in place to enhance climate change mitigation efforts through the forestry industry. Carbon taxes directed towards slash burnings have been discussed (Chipeniuk, Duerichen, Hart, & Imhof, 2017); (Britten, 2018), but more effective options could potentially be realized via incentivization policies, such as those utilized in Finland and Sweden, which have increased economic prosperity within their forestry industries. It is important to note that the re-direction of residual forest biomass into the energy sector in both Sweden and Finland was made viable by the installation of favorable environmental taxes on fossil-fuels and the provision of credits towards bioenergy (Extension, 2013). British Columbia is making significant strides towards increasing utilization of harvest residuals within their forests through government sponsored initiatives, but Alberta has relatively few in comparison. A strong first step towards enhancing climate change mitigation and preserving forest carbon within the western Canadian forest sector could start with progressive regulations surrounding the practice of slash pile burning. Increased collection and utilization of this previously wasted fibre would greatly decrease sector emissions and could potentially create new income streams within the forestry industry.

1.1. Project Scope:

This project will focus on the British Columbia and Alberta forestry sectors, considering that western Canada is the primary region for forestry, logging, and support activities in the country, accounting for over 50% of Canada's forest sector jobs with British Columbia accounting for 40% of the overall total (Government of Canada, 2019b). Additionally, given the amount of research that has been dedicated to British Columbia's forest carbon initiatives, more attention will be directed towards the challenges facing Alberta, as the province currently has less developed carbon-mitigation policies regarding the forestry sector. Projections regarding the impact of climate change on Alberta's forests past the 2020's suggest that increased water scarcity may cause instances of drought, and that extreme weather patterns may drive increased instances of natural

disturbances which have the potential to seriously alter the carbon balance in Albertan forests (Cerezke, 2009). With these threats in mind, it is pertinent to begin examining ways that forest management regimes can begin to foster resilience within western Canadian forests to preserve crucial forest values such as forest carbon and the maintenance of forest carbon sinks.

In order to provide a thorough background context with which to examine potential solutions to the carbon challenges facing western Canadian forestry, a literature review will be conducted reviewing the current regulations and policies that inform "on-the-ground" forest management practices in Alberta and British Columbia, and evaluate the extent to which they support Canada's global climate commitments. Relevant global examples of effective forest carbon policy and forest management techniques will be discussed to determine whether these practices could be effective in alleviating western Canada's forest carbon challenges. In addition to evaluating the current regulatory and policy framework concerning the enhancement of forest carbon, climate change mitigation, utilization of forest harvest residuals, and reforestation efforts aimed at increasing the overall forest carbon sink, this project will investigate the current methods of western Canadian and national forest GHG accounting and suggest how improvements could be made towards greater transparency in forestry GHG inventory reporting. Alternative utilization options to slash pile burning will be examined as this unnecessary practice directly contributes to sector GHG emissions and if properly managed, could contribute to immediate GHG reductions through production of bioenergy and potentially increase the economic viability of the forest industry (Ter-Mikaelian, Colombo, & Chen, 2015).

This research project addresses three significant sustainability pillars: <u>Environment, Economics and Energy</u> through the examination of national and provincial forest GHG accounting and western Canadian forest regulations and management practices. Forests are one of the few viable natural climate change mitigation options as they actively sequester carbon throughout their lifecycle. Significantly, bioenergy derived from forest biomass has been identified as renewable energy source that can aid climate change mitigation efforts. The climate change mitigation potential of western Canadian forests is currently undermined by the anthropogenic impacts of large-scale industrial forestry operations which extract carbon in the form of merchantable timber which drives the forestry industry. In the face of declining profitability, forest regulations and policies in western Canada have

prioritized the economic health of the forestry industry over the health of the forest itself, resulting in non-sustainable forest management practices which have contributed to the transition of the forests from a carbon sink to a carbon source. The complex relationship between regulations/policy, climate change mitigation potential and industry economics in western Canadian forestry will be highlighted by an examination of current forest management practices regarding forest harvest residuals in western Canada and the economic and environmental potential of integrating forest harvest residuals in Canada's renewable energy mix will be examined.

In order to inform further discussion and gain a nuanced perspective about the carbon challenges facing the western Canadian forest industry for this project, 13 interviews were conducted with various stakeholders and policy actors identified as influential to forest carbon initiatives and forest management operations. The scope of conducted interviews includes researchers, government representatives, industry professionals from forestry and bio-energy fields, and environmental Non-Government Organizations (eNGO's). The purpose of these interviews is to establish stakeholder views on the topic of western Canadian forest carbon challenges and elucidate the concerns and priorities of the different groups. All interviews were conducted in accordance with the interview ethics guidelines approved by the SEDV program and the University of Calgary Ethics Board. All interview participant information can be found in Appendix A.

Chapter 2: Slash Pile Burning and Climate Change

2.1. Perspectives on the Practice of Slash Pile Burning:

"For me, I spend a lot of time in the forest and I see so much wood going to waste. It's pathetic, and we're not just talking residues. We're talking actual saw log material. So, until [the government] get[s] with the program, there's not much we can do. We'll just keep stumbling along doing what we're doing." – Retired British Columbia RFP and Owner of Sunshine Logging – Jeff Mattes, (Interview Participant K, 2019).

I think that bringing increased awareness to slash pile emissions as a line item in national forest carbon accounting or incorporating them into the provincial inventory would be a positive step towards ensuring that forestry is always considering effective emission reduction programs. And quite often it is not right now. – Climate Change Policy Analyst, (Interview Participant C, 2019). (Statement paraphrased by Report Author)

"I think that there is certainly a way to utilize the fibre, but whether it's economically feasible or not, so far, it's just no. They tried to put a bio-energy plant up in Drayton valley and they were looking at bringing all those tops in, but someone has to pay to pick the things up and truck them in. If someone delivered them or paid for the delivery it would have been viable. But otherwise it's just a no." - Kevin Gagne, Forest Area Manger in Alberta.

2.2. Tenure systems, merchantable timber and slash pile burning:

When tenured licensees harvest timber in western Canadian forests, one way that the timber is valued is via volume-based stumpage fees (Luckert, Haley, & Hoberg, 2011). These fees are determined both by the type of tree and the area the timber was harvested from as certain forest management areas may have different stumpage agreements in place and are usually calculated in cubic metres. In order to be sold or processed, the harvested tree is stripped of its branches and the thin portion of the top of the tree is also removed leaving a thick trunk or log that can be easily loaded and transported for sale or processing. In order to be sold or processed further these log

cuts must meet size and quality standards that are regulated for by the province under the determination of "merchantable timber" (Luckert, Haley, & Hoberg, 2011).

To be deemed merchantable timber, i.e. timber that can be sold or processed, the timber must meet certain minimum requirements set out by the individual provinces in terms of quality and size. Both Alberta and British Columbia have definitions of merchantable timber within their harvesting regulations and guidelines with certain minimum measurements are set for base and top diametre, minimum quality values also apply and serve to limit the amount of rot and decay that can be present in a merchantable timber log (Government of Alberta, 2019d); (British Columbia Timber Pricing Branch, 2011). Unless a secondary license is granted for timber sales off hog fuel or chip wood, the removed portions of the tree are essentially valueless for the forest harvest operator who possesses a primary harvesting license due to the lack of market for this lower quality wood and the regulated merchantable timber assessment. The pre-determined value of the timber relies on solid merchantable timber saw logs and pulp logs that can be turned into valuable Harvested Wood Products (HWP) such as construction materials or pulped in pulp and paper mills. Studies of forest harvest residuals in British Columbia have suggested that between 14 to 55% of the original stand biomass remained on the harvest block after harvest operations were completed (MacDonald, 2006). As such these harvest residuals are traditionally left in the harvest block (Kamp, 2013).

I believe there is a root cause problem, which is the gatekeeper approach that tenure holders have and until this tenure problem is solved by increasing access to fibre or guaranteeing access to fibre for secondary users, there will not be sufficient market to take the residual fibre, so it's a chicken and egg thing. There must be a significant change in the legislation to give access to others. Emissions from slash piles are an externality, which is not currently accounted for, but it comes down to the root cause, this issue has been around for 15-20 years. – Canadian Climate Policy Analyst, (Interview Participant E, 2019). (Statement paraphrased by Report Author)

Estimates describing the scale of harvest residuals/slash in forestry cut-blocks vary, depending upon the species harvested, forest ecosystem collected from, harvesting techniques and other factors. Some have suggested that for every cubic metre of merchantable timber that is removed a cubic metre of slash is produced (Enters, 2001), while others have suggested that for every million

cubic metres of merchantable timber harvested nearly 160,000 cubic metres of slash is produced (Morgan, 2009). The large amounts of slash that left on blocks after harvest operations have taken place create significant problems for forest operators within Alberta and British Columbia.

Due to reforestation requirements, many primary harvest operators prefer clean, slash-free, blocks in order to conduct their reforestation operations efficiently (Interview Participant A, 2019). This is because many tree species in western Canada, including the commonly harvested lodgepole pine, regenerate best under open-canopy conditions as they are used to cyclical fire seasons that open up the forest canopy and allow sunlight and rain to foster growth of seedlings (Government of Alberta, 2017d). As such, large areas of slash may block seedlings from receiving adequate sunlight and moisture requirements and impact regeneration rates in reforested areas. Simultaneously, a clean block enables for effective and rapid reforestation operations to occur without being encumbered by large piles of loose slash. Forest harvest operators generally rely on manual planting of seedlings to ensure density and stocking requirements and large accumulations of slash significantly decreases both the speed of reforestation activities and also the area of land available for replanting. *"[Fulfilling] regulatory requirements to [remove] the slash is part of it, but I think a lot of companies do burn [slash] because it makes their site preparation easier for silviculture… the big companies, like West Fraser, they want it clean so that they can go in and do whatever they want."* – Alberta Forest Area Manager Alberta - Kevin Gagne, (Interview Participant A, 2019)

Since there are limited markets for the harvest residues, and thus little incentive to retain them, most forest harvest operators machine pile the residual debris and burn it to clean the block. Beyond increasing the efficacy of reforestation operations, this practice is reinforced for forest operators by forestry regulations in both British Columbia and Alberta. Both provinces require the complete removal or partial spreading of forest harvest debris as a method of fire-mitigation control as loosely dispersed (broadcast) slash is a danger during the fire season to newly reforested blocks, and large slash piles, which can sometimes reach heights of 10+ metres, tend to dry rapidly and significantly increase fire risk and fuel loading within harvest blocks. Alberta's *Forest and Prairie Protection Ministerial Regulation* requires harvester operators to facilitate the removal of forest debris from harvest blocks no more than 12 months after harvest operations have taken place and give specific regulatory guidelines that operators must follow regarding the disposal of this

debris (Government of Alberta, 2017b). Similarly, British Columbia's *Wildfire Act* requires licensees to conduct fire hazard assessment activities every 6 months and conduct fire hazard abatement activities "when necessary to reduce fire hazards" when operating on public lands within 12 months of completed harvest activities (Government of British Columbia, 2019d). As a result of these regulated time spans for removal, there are few options available for tenured forest harvest operators, the hazard simply needs to be abated or removed. As such, they either pile it and burn it, spread it and burn it via broadcast burn, or spread it and pile it to create windbreaks, ecological nutrient reserves, and habitats for small mammals as the regulations dictate. Enforcement of residual debris regulations is strict in both provinces and forestry officials may be sent to harvest blocks to ensure that fire hazard reduction requirements are being adhered to and may impose fines on offending operators at their discretion. There are also significant liabilities at stake for forestry companies when it comes to removing residual debris. If a wildfire can be proven to have started from a slash pile or is determined to have caused increased damage as the result of improper pile disposal methods, the government reserves the right to charge the companies for the cost of fire-fighting operations and resulting timber losses (Government of British Columbia, 2019d); (Government of Alberta, 2017b). These costs can quickly amount to millions of dollars for large-scale fires and as such the majority of forest operators take disposal regulations very seriously and choose the lowest cost option for disposal, which is often burning.

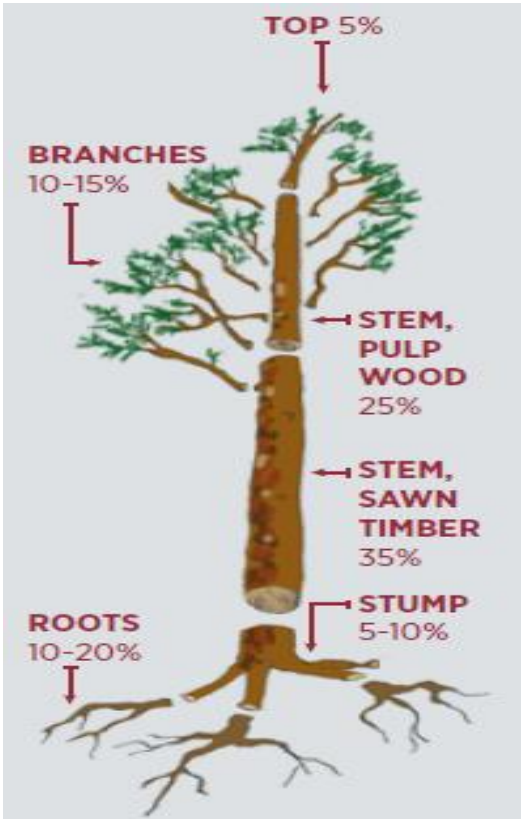
"In the early 2000s… there was a there was a lot of energy, across North America, put into slash and what [could] be done, including in Alberta… Weyerhaeuser itself did some analysis around that, but nothing ever came of it. As long as operators were allowed to… pile slash up and burn it, they base every [option] compared against that cost… When something is the [accepted] best practice that everybody thinks is OK, [and] it's cheap. Nothing else is going to compete, right?" – Former Residuals Manger Weyerhaeuser – Stuart McCormick, (Interview Participant B, 2019)

When it comes down to economics of forest residual removals, the most cost-effective method of disposal is often to burn it. These burning operations are conducted in the winter or spring months, when the forest is still snow-covered or frozen and the odds of fires spreading to create wildfires in other forest areas are low. The practice of slash-pile burning is highly prevalent within the forestry industry in both British Columbia and Alberta. Although currently there is no precise

quantitative data, beyond estimation methods, to determine how often the practice is employed and accurately describe its impact on forest carbon emissions. Although forest management activities are tracked and documented by Canada's National Forestry Database, supplementary data regarding specific practices is often provided by provincial management agencies (Environment and Climate Change Canada, 2019b). Data regarding emissions stemming from the burning of harvest residues is collected the Canadian Forestry Institute (CanFI) and is generally informed by provincial industry expert opinion. Details of this estimation procedure and individual provincial emission contributions are not available for Alberta at this time. British Columbia is the only province that relies on its own collection data. For British Columbia industry experts estimate the prevalence of the practice to be 15% in coastal FMA's and 50% in interior FMA's (Environment and Climate Change Canada, 2019b).

These estimations are arbitrary and are not specific enough to properly encompass the scope of the practice and associated emissions within the province. Details are not given regarding the estimated volume of timber burnt nor the specifics of the burning practices or details as to what is considered "slash". This is significant as estimated harvest residual levels can increase significantly depending upon the method used to construct the piles and the composition of the slash itself. Muraro conducted a study in Merritt British Columbia examining the weight of slash piles in a lodgepole pine cut-block. The parameters of the study only considered the cut-off non-merchantable top-portion of the tree as slash and even this limiting factor determined that 52.6 tonnes of slash were generated per hectare of harvested forest (Muraro, 1966). The number would increase significantly if the branches and oft-discarded bottom ends were included in the slash definition. Significantly, a study looking at Finnish residual biomass determined that beyond non-merchantable timber material (tops, branches, cut-off bottoms), 36% of slash-piles consisted of surface vegetation, soil hummus and organic litter due the use of machines to construct the piles (Virkkula, et al., 2014). Although machine piling is the most common piling technique in western Canada, these additional components are currently not mentioned in the residual fibre definitions provided in Alberta or British Columbia's relevant forestry regulations which consider only the tops, branches and rotting or dead trees as harvest residuals (Government of Alberta, 2019d); (Government of British Columbia, 2012).

Figure 4 - Timber components.



(IRENA, 2018)

Although estimates of emissions from the burning of slash piles likely underestimate the scope of the practice due to a lack of available quantified data, the practice still strongly affects emissions in the forestry sector. A Canadian forest researcher, interviewed for this project, has estimated that for British Columbia, at least 8% of British Columbia's provincial emissions come from slash pile burning (Interview Participant I, 2019).

There is a growing recognition that something needs to be done, but frankly, not much has been. Given the state of forestry and Canada's climate change commitments, the goal needs to be to eliminate slash burning in the very near future, probably within the next 24 months or so. – Canadian Forest Carbon Researcher**,** (Interview Participant C, 2019). (Statement paraphrased by report Author)

The estimation methodologies currently employed in western Canada poorly represent the scope of emissions resulting from slash burning practices and this can negatively affect mitigation efforts. Slash pile emissions are reported in British Columbia's PIR, but they are not included in the provincial total, this lack of inclusion undermines the significance of the impact that these emissions have on the environment.

For Alberta, there is even less data regarding the actual scope of slash-pile burning and the emissions that result from their combustion. Data collected by the Canadian Forestry Service through CanFI and information provided by industry experts informs Canada's national GHG accounting estimates (Environment and Climate Change Canada, 2019c), but data is not available on a provincial or territorial level. Kevin Gagne, a Forest Area Manager in Alberta summarized that although "*not all of the companies burn the slash, [but] most do"* (Interview Participant A, 2019)

Figure 5 - Unburnt Slash Pile near Rocky Mountain House Alberta

(Author, 2019)

In 2014-15 Alberta harvested an estimated 83,785 hectares of timber (SFM Canada, 2016). Using crude estimation techniques taken from Muraro's study (Muraro, 1966), this would conservatively estimate that 4.4 million tonnes of slash was produced. This estimate could increase by as much

as 40% if other non-merchantable timber aspects like branches and cut-off bottoms were included. An estimation benchmark of 30% forest residuals from harvesting operations has been used in estimations of western Canadian harvest debris before (Layzell & Ralevic, 2006), and applying this benchmark to Alberta's forest harvest results in ~25,000 hectares of harvest residual debris for 2014-15. If all this material was combusted, it would result in significant carbon emissions similar to those seen from wildfire disturbances. Dr. Werner Kurz, of the Pacific Forest Research Centre, has suggested that wildfires in Canadian boreal forests emit approximately 150-170 tonnes of $CO_{2\ eq}$ per hectare (Cruickshank, 2016); (Riley, 2018). Applying this approximate emission baseline to the ~25,000-hectare estimation number applied earlier would suggest that emissions from slash pile burning in Alberta for 2014-15 could contribute emissions of 3.7 to 4.2 Mt $CO_{2\ eq}$. Even if the estimated amount of slash was significantly reduced representing only 10% of harvest totals, this would still represent 1.2 to 1.4 Mt $CO_{2\ eq}$ of emissions in a given year.

Although these estimation methodologies are extremely rudimentary, the resulting numbers underscore the significance of slash emissions within western Canadian forestry operations. Unlike British Columbia, Alberta does not produce a provincial inventory report and there are no sub-category estimates for the LULUCF sector that provide provincially specific data for forest management activities. Although Canada compiles a national estimate for emissions and removals of GHG's in the LULUCF sector, it does not provide jurisdictionally specific data sources for forest management activities within ECCC's official GHG inventory, or Canada's NIR despite the good practice guidelines recommending transparency of reporting within the LULUCF sector suggested by the IPCC and UNFCCC (IPCC, 2008).

One of the more compelling things to consider when evaluating the combustion of harvest residuals in western Canada is that the practice is unnecessary. Both Alberta and British Columbia's regulations regarding the practice emphasize the mandatory removal of forest debris, but do not specify that it must be burnt. They simply allow for the practice as method of disposal. Considering the large emissions profile associated with the practice and the waste of potentially useful fibre, it is important to consider other forest management practices that deal with harvest residuals. Notably, other forestry countries such as Sweden and Finland have embraced alternative utilization techniques for their forest residuals and have created secondary markets for their

previously waste forest fibres that have resulted in increased economic opportunities for the industry, and significant decreases to forest carbon emissions.

Finland, through their National Forest Strategy, have rapidly increased collection rates of harvest residuals since the mid-90's when systematic national research and development plans were launched to explore the utilization of forest harvest residuals for fuel. It is estimated that 65-75% of harvest residues are recovered and processed in Finland through progressive forest management techniques that involve integrated primary and secondary harvesting methods (Kallio & Leinonen, 2005). The collection of harvest residuals is incentivized through their sale to co-gen heat plants and bioenergy plants that, in 2016, supplied 26% of the country's electricity and 42% of the countries heat for that year. Through Finland's National Energy and Climate strategy, renewable energy, primarily based from harvest residuals is expected to assist with phasing out coal power plants and is expected to provide 90% of the country's energy supply by 2040 (IRENA, 2018).

Similarly, Sweden has also committed to reduce emissions from fossil-fuel combustion through increased utilization of forest residuals for both biofuels and bioenergy. In 2013, bioenergy production in Sweden reached 128 terra-watts, up from ~ 60 terra-watts in 1990, and this number is expected to increase in coming years (Bostrom, 2015). In 2014, an estimated one third of all renewable energy in Sweden came from bioenergy (IEA Bioenergy, 2017). One of the reasons for this increase is the integration of bioenergy and increased utilization of HWP from Swedish forests to supplant the use of more energy intensive substances within Sweden's national climate change policies (Bostrom, 2015). The substantial increases in bioenergy utilization in Sweden are supported in part by the countries carbon tax on fossil fuels. Sweden's carbon tax was first installed in 1991 and is based on the polluter pays principle, the tax has steadily increased since it was introduced and has opened up the marketplace to renewable energy providers (IEA Bioenergy, 2017). These ambitious policies have resulted in increased utilization of harvest residuals for both energy and HWP uses through effective forest management practices resulting in decreases in sector related GHG emissions.

"I just can't, for the life of me, figure out in the province of B.C… why we're not using it as power generation. When I was in Sweden and did a tour there, you look at… what they do there. There must be government buy in because the pulp mills are small, or the operators

must have agreements. Their forestry has evolved to the point where Joe Farmer can pile his half a cord of sticks at the gate of his farm and a porter comes along and picks it up and he gets paid by weight. We just don't have that in B.C. That's why the utilization there is far superior to what it is here. I don't know what the tenure system is [like] there compared to here, but I'm a firm believer that our tenure system should go to a different format rather than stumpage and cruising and… that type of thing, we should be in land rent, and… all the major [operators] should only have 50 percent of their [timber] needs under license" – Retired British Columbia RFP and Owner of Sunshine Logging – Jeff Mattes, (Interview Participant K, 2019).

Finland and Sweden have found better ways to utilize their forest harvest residues. These two countries are suitable for comparison to British Columbia and Alberta as their forest resources are similar in terms of size and composition, and their forestry industries produce comparable amounts of exported material. The example set by these two countries regarding the increased utilization of harvest residuals involved incentivization of collection by creating markets for their utilization. Although bioenergy produced from timber residuals does exist in Alberta and British Columbia it is limited to providing heat and electricity to lumber mills and pulp and paper operations as they already have large sources wood residuals on hand as a result of their processing. These are products such as energy efficient insulation for homes, flooring tiles made from compressed wood pulp and even wood-based cellulose that can be used in 3D printers. The research is suggesting that these are competitive products, the development is done, the trick is getting them into commercial operation (Interview Participant C, 2019). Although utilization potential is strong on the supply side, unless the demand side is addressed eliminating the practice of slash pile burning won't happen organically.

The problem of slash pile burning is one that could be addressed through effective and progressive regulatory and policy frameworks. Both Alberta and British Columbia have ambitious climate change goals but little to no regulatory framework in place to enhance climate change mitigation efforts within the forestry industry. Carbon taxes directed towards slash burnings should be considered, but more effective options could potentially be realized via incentivization policies, such as those utilized in Finland and Sweden, which have increased economic prosperity within their forestry industries.

There are nearly 5 million tonnes of carbon dioxide being released from slash pile burning in British Columbia every year. That for an equivalent amount, other industries are having to pay 30 dollars a tonne. Whether or not the tax will actually achieve the desired outcome is unclear. For one reason, there could be under reporting by companies that are doing the burning. Secondly, paying the penalty may be the cheapest solution for them. Discussion surrounding a carbon tax for slash pile burning is a good way to open up the discussion, but whether or not it is the most effective policy instrument is to be determined. – Canadian Forest Carbon Researcher**,** (Interview Participant I, 2019). (Statement paraphrased by Report Author)

British Columbia is making significant strides towards increasing utilization of harvest residuals within their forestry industry through government sponsored initiatives, but Alberta has relatively few in comparison. Although debates can be had regarding the most effective regulatory framework or policy applications, a strong first step towards enhancing climate change mitigation within the western Canadian forest sector could nonetheless start with progressive regulations surrounding the practice of slash pile burning. Increased collection and utilization of this previously wasted fibre could decrease sector emissions and could potentially revitalize the industry economically.

"There needs to be a change [made] that gives the option to forestry companies to get revenue from this material. Or, if they're not going to use it, then they have to be able to provide that material to others who want it." – Director of Operations and Engineering for Steeper Energy – Bob Moll, (Interview Participant J, 2019).

In order to increase slash pile utilization, you've got to increase the economics of it, explore what prices work and maybe look at incremental changes to slowly change management practices. It won't happen quickly. Increased utilization has been discussed in the past, but the economics of it have yet to make sense for the majority areas. – Forest Analyst for Alberta Government, (Interview Participant G, 2019) (Statement paraphrased by Report Author)

The question of increasing the utilization of these materials is an economic one. We need to focus on the economic performance of these residuals first. Once the incentives for reward are there, the companies will follow through with actions. We shouldn't limit the application of residuals to just energy, it might make financial sense to pursue higher value products;

maybe jet-fuels or specialized wood products. Higher end prices may increase utilization and make transportation and collection more viable. – Bioenergy Businesswoman - Maryam Mkhani, (Interview Participant L, 2019).

Chapter 3: Forest Carbon Accounting Challenges in Canada

3.1. Perspectives on Forest Carbon Accounting in Canada

"[LULUCF emissions] should be included in the NIR, it is not enough to report them if they do not make it into the final total. Governments will not do anything to curtail these emissions if there is no evidence of them occurring. It doesn't matter where the GHG source is coming from, it should be quantified. Maybe Canada has to reset its goals in order to include emissions from natural disturbances, if we continue to exclude emissions from wildfires/insect infestations the government will consider this as natural, and of little concern. If included, it will be a motivating force to reduce emissions to meet the new benchmarks" – Bioenergy Businesswoman - Maryam MKhani, (Interview Participant K, 2019).

Two major concerns are that they're not actually counting all of the emissions that are going in the atmosphere because they're not counting our unmanaged lands and they're not counting the natural disturbances… So, from the vantage point of what the atmosphere sees and whether our emission targets are actually sufficient for dealing with climate change, they could be really underestimating the amount of effort that we should be making to reduce our emissions. – Director of Canadian eNGO – (Interview Participant D, 2019). (Statement paraphrased by Report Author)

"I don't really go along with the whole… prognosis on GHG's and carbon emissions…I look at the forest itself. I look at stuff that I harvested 30 years ago and it's better for us today than it was then. I think today we have more trees today than we had at the turn of the century. People play the tune on climate change. Well, I look out the window every day. The climate changes, whether it's a micro way or in a macro way." – Retired British Columbia RFP and Owner of Sunshine Logging – Jeff Mattes, (Interview Participant K, 2019).

First of all, I think everything [the government does] should be as transparent as possible. I'm completely opposed to some provinces trying to hide their emissions. I think that's totally counterproductive and Alberta is one of the worst, frankly. If you can expose that [province], do it. – Canadian Forest Carbon Researcher, (Interview Participant I, 2019). (Statement paraphrased by Report Author)

3.2. GHG Accounting Background

One of the strongest global initiatives aimed to mitigate climate change is the United Nations Framework Convention on Climate Change (UNFCCC) which was negotiated during the United Nations Conference on Environment and Development (UNCED) in Rio De Janeiro in 1992. This framework is an international treaty with the stated objective to *"stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".* (UNFCCC, 2019e, p. 1) The UNFCCC entered into force on March 21, 1994 and, as of 2019, has nearly universal membership with 197 countries which have ratified the convention and signified their commitment to global climate change mitigation efforts. Recent extensions of the UNFCCC such as COP21 – aka as The Paris Agreement, have aimed to foster increased adherence to emission reduction commitments by establishing GHG reporting guidelines and emission reduction goals that are measurable on country-specific basis (UNFCCC, 2019e).

In order to achieve these objectives, the UNFCCC has developed a series of guiding principles to direct ratifying countries to reduce their emission profile and meet their commitments. Membership within the UNFCCC requires countries to gather and share information on GHG emissions, national emission reduction policies and best practices; to launch national strategies aimed at reducing GHG emissions and adapting to expected impacts of climate change; and to cooperate in adapting to those impacts (UNFCCC, 2019e). Although the treaty provides a framework for further negotiations of environmental protocols, the treaty itself is legally non-binding and contains no enforcement mechanisms for ratifying countries if they fail to reach set emission targets. As technology and climate change goals fluctuate over time, member nations of the UNFCCC meet annually at Climate change conferences in order to discuss emission trends and share research and ideas as part of their commitment to the treaty. Out of these international conferences, certain extensions of the original UNFCCC treaty have been ratified and have increased environmental commitment levels, GHG emission reporting standards, and climate change mitigation strategies. Important extensions of the UNFCCC treaty are the Kyoto Protocol, ratified in 1997 and put into force in 2004, and the Paris Agreement ratified in 2015, and rapidly put into force in 2016. The Paris agreement was ratified by 175 parties including Canada, which had originally ratified the Kyoto Protocol and then pulled out of the treaty extension in 2011. The

emission reduction agreements detailed in the Paris Agreement are the current standard for all UNFCCC ratifying Parties, with the most recent conference of the Parties to taking place in Bonn Germany in June of 2019 (UNFCCC, 2019e). It is important to note that since the Kyoto Protocol has applied the only binding commitments for Annex I Parties, legal enforcement of emission targets currently only exists for Annex I parties that have ratified and committed to the first and second commitment period of the Kyoto Protocol (Iverson, Lee, & Rocha, 2014). This distinction is significant in the treatment of Canada's emissions and removals in the LULUCF sector as Canada backed out of the Kyoto Protocol in 2011 and as such is not legally bound to meet its initial commitments. More information on the Kyoto Protocol and its connection to Canada's LULUCF emissions can be found in Appendix C.

As an industrialized nation and active member of the United Nations, Canada is an Annex I and Annex II Party under the UNFCCC. Canada has committed to work internationally to combat climate change through the United Nations. Canada's obligations under the UFCCC as an Annex I, and Annex II country include:

- Providing greenhouse gas emissions data on an annual basis;
- Reporting on national progress in reducing net greenhouse gas emissions;
- Providing financial and technical resources to developing countries, especially the poorest and most vulnerable, to assist them in combating climate change; and
- Conducting scientific observations of the world's climate system and research on climate change and its impacts (Government of Canada, 2015).

Annex I reporting Parties are responsible for installing stringent national emission reporting standards that document Greenhouse Gas (GHG) emissions over multiple anthropogenic sectors, and to meet this obligation Canada submits an annual inventory of its GHG emissions, reporting removals and emissions of direct GHGs (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3)) from 5 distinct sectors, (Energy, Industrial processes and product use, Agriculture, Land Use, Land Use Change and Forestry (LULUCF) and Waste) to the UNFCCC. The GHG inventories include all years from the base year (1990) until two years before the report

is due (UNFCCC, 2019c). Additional information on Annex I and Annex II parties to the convention can be found in Appendix Q.

3.3. UNFCCC and IPCC Good Practice Reporting

In order to ensure quality reporting standards, the UNFCCC requires transparent data, documented in Common Reporting Format (CRF) tables and in-depth documentation of the underlying assumptions, calculations and procedures undertaken by each reporting country to be included in the final document. To ensure reliable and internationally comparable formatting and report standards, NIR's submitted to the UNFCCC by Annex I countries are required to follow the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse gas Inventories under Decision 24/CP.19 (UNFCCC, 2019c).

The IPCC is an independent reporting body that was founded under the United Nations Environmental Programme and is known primarily for creating comprehensive global climate and environmental reports. The IPCC aggregates internationally derived data and co-operates fully with the UNFCCC on multiple reporting fronts (UNFCCC, 2019b). Reports from the IPCC have been formational in constructing the goals of the 2015 Paris agreement, and the IPCC has the full support of ratifying Parties of the Convention. The IPCC *"Good Practice Guidelines for National Greenhouse Gas Inventories"*, first published in 1996, has been refined several times, most recently in 2019, and is a methodological guide to estimating and reporting anthropogenic GHG emissions and removals which aims to provide a sound scientific basis to support the preparation and continual improvement of national emission inventories (Buendia, et al., 2019). This includes the installation of methodologies and procedures in compiling emission inventories that ensure that any reporting country, regardless of their experience level or lack of resources can compile a scientifically valid emissions inventory based on the IPCC definition of *"Good Practice"* defined as: *"a set of procedures intended to ensure that greenhouse gas inventories are accurate in the sense that they are systematically neither over- nor underestimates so far as can be judged, and that uncertainties are reduced so far as practicable"* (Buendia, et al., 2019, p. 10) The IPCC considers *"Good Practice"* to be a key concept for inventory compilers to follow when preparing national emissions inventories. As a result of the 2015 UNFCCC requirement that Annex I reporting countries must follow IPCC guidelines (United Nations, 2015), NIR's have become

increasingly uniform in terms of delivery format from all reporting countries, and have improved reporting transparency and accuracy. Canada fully supports the IPCC and has been an active IPCC member since its establishment in 1988 (United Nations, 2015).

The stated purpose for the construction of NIR's for the UNFCCC is to provide annual reporting data from national reporting parties on the ***anthropogenic*** GHG emission and removal estimates across all reporting sectors for their respective country (UNFCCC, 2019a). Quantifying the impact of anthropogenic activities on the atmosphere is especially important as knowledge of human influenced activities, and their subsequent emissions or removals, assist in determining the drivers of these emissions, can inform mitigation policies and serves to highlight changes stemming from mitigation activities (Kurz, et al., 2018).

When considering the emission data provided to the UNFCCC by the reporting parties, it is important to understand the difference between the terms *Reporting* and *Accounting* as they are applied under the UNFCCC. *Reporting* only provides data for anthropogenic GHG removals and emissions in the year that they occur and does not require the use of a baseline reference level. Whereas *Accounting* utilizes this reported data against the baseline to determine whether reporting countries are meeting their commitments (Iverson, Lee, & Rocha, 2014). As such emissions may be reported for, but not accounted for. This is the case for LULUCF emissions. They are included for transparency purposes, but do not impact the final GHG accounting total.

3.4. Canada and LULUCF Sector Reporting

This report will be investigating reporting of the LULUCF sector in Canada's most recent NIR submitted on April 15th, 2019 to the UNFCCC. This report includes all emissions and removals quantified under the various subcategories for the entire LULUCF sector. The LULUCF sector is one of the most significant sectors that emissions are quantified for in the National Inventory Reporting framework. Forests play a key role in the planet's terrestrial ecosystem, land and sea-based biomass both emit and sequester large amounts of biological carbon in a continuous exchange cycle of GHG's between the atmosphere and terrestrial biomass. This cycle takes place naturally but can also be profoundly affected by anthropogenic activities and large-scale natural disturbances (Iverson, Lee, & Rocha, 2014). Anthropogenic influences in the LULUCF sector have the potential to alter the natural exchange dynamic of the ecosystem through human actions

that increase or decrease the land-based reservoir of carbon. This is due to the significant role that forests play in the global carbon cycle. Between the years 1990-2010, the Global Carbon Project estimated that global forests contributed an average 9.3 ± 3.8 Gt CO_2/year of carbon sequestration ability and absorbed an estimated 30% of global anthropogenic emissions (Global Carbon Project, 2018). This estimate includes gross emissions from the Land Use sector of 10.8 ± 1.7 Gt CO_2/year from 1990-2007.

The substantial mitigation potential inherent within the LULUCF sector suggests that proper management of forests could provide as much mitigation potential as other major carbon accounting sectors such as Industry or Transportation. For Canada, the ability to impact carbon fluxes through forest related mitigation activities could prove more impactful relative to many reporting countries to as Canada has the third largest forest area on the planet with over ~347,575,760 hectares (ha) (Global Forest Resources Assessment, 2015). This expanse of forest coverage, quantified in the NIR under the sub-category forest land, contributed -210 to -150 Mt $CO_{2\ eq}$ /year of sequestration potential between 1990-2017 while the net flux within the entire LULUCF sector fluctuated between -240 to +66 Mt $CO_{2\ eq}$ /year.

Table 1 - Canadian LULUCF Carbon Flux

Sectoral Category		Net GHG Flux (kt CO_2 eq)[2]							
		1990	2005	2012	2013	2014	2015	2016	2017
Land Use, Land-Use Change and Forestry TOTAL[1]		**-68 000**	**-21 000**	**-36 000**	**-33 000**	**-32 000**	**-25 000**	**-25 000**	**-24 000**
a.	**Forest Land**	**-210 000**	**-160 000**	**-160 000**	**-160 000**	**-160 000**	**-150 000**	**-150 000**	**-150 000**
	Forest Land remaining Forest Land	-210 000	-150 000	-160 000	-160 000	-160 000	-150 000	-150 000	-150 000
	Land converted to Forest Land	-1 100	- 950	- 650	- 590	- 540	- 500	- 440	- 390
b.	**Cropland**	**8 300**	**-11 000**	**-11 000**	**-10 000**	**-9 500**	**-8 600**	**-7 800**	**-6 800**
	Cropland remaining Cropland	-1 300	-15 000	-14 000	-13 000	-12 000	-11 000	-10 000	-9 600
	Land converted to Cropland	9 600	3 900	2 700	2 800	2 800	2 700	2 700	2 800
c.	**Grassland**	**0.6**	**0.9**	**1.6**	**1.9**	**0.8**	**1.2**	**1.2**	**1.2**
	Grassland remaining Grassland	0.6	0.9	1.6	1.9	0.8	1.2	1.2	1.2
	Land converted to Grassland	NO	NO	NO	NO	NO	NO	NO	NO
d.	**Wetlands**	**5 300**	**3 100**	**3 000**	**3 000**	**3 100**	**2 900**	**2 900**	**3 200**
	Wetlands remaining Wetlands	1 500	2 600	2 500	2 400	2 400	2 500	2 600	2 800
	Land converted to Wetlands	3 800	470	540	670	710	420	340	330
e.	**Settlements**	**3 800**	**3 800**	**3 700**	**3 800**	**3 900**	**3 900**	**3 800**	**3 500**
	Settlements remaining Settlements	-2 400	-2 400	-2 400	-2 400	-2 400	-2 400	-2 400	-2 400
	Land converted to Settlements	6 200	6 200	6 100	6 200	6 300	6 300	6 200	5 900
f.	**Other Land**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**
g.	**Harvested Wood Products**	**130 000**	**140 000**	**130 000**	**130 000**	**130 000**	**130 000**	**130 000**	**130 000**
	Forest Conversion[3]	***22 000***	***16 000***	***15 000***	***15 000***	***15 000***	***15 000***	***14 000***	***14 000***

(Environment and Climate Change Canada, 2019c)

Canada's reporting of the LULUCF sector is described in Environment and Climate Change Canada's Greenhouse Gas Reporting inventory. *"The Land-Use Land-Use Change and Forestry (LULUCF) sector reports net greenhouse gas fluxes between the atmosphere and Canada's managed lands, as well as those associated with land-use changes. The assessment includes emissions resulting from human-induced fires and controlled burning, and conversion to cropland. For the purpose of the inventory, managed forests are those managed for timber and non-timber resources (including parks) or subject to fire protection.* ***All emissions from and removals by the LULUCF sector are excluded from the national total****"* (Government of Canada, 2019a, p. 1). The trend in Canada's LULUCF sector clearly indicates that the two most influential sub-categories that influence the overall LULUCF emissions trend are the Forest Land and Harvested Wood Product (HWP) categories. The included components of these two sub-categories are very important in the composition of Canada's LULUCF reporting inventory as they are the two largest drivers of uncertainty when included into the national inventory. The other reported categories; Croplands, Grasslands, Wetlands, and Settlements, do contribute to the overall removals and emissions in the sector but are nearly negligible in terms of their overall effect on the sector and do concern the scope of this project.

In Canada's 2019 NIR, the Forest land category containing Forest land remaining forest land and the land converted to forest land category, resulted in estimated removals of - 150 Mt $CO_{2\ eq}$, and the HWP category contributed +130 Mt $CO_{2\ eq}$ in emissions. The remaining LULUCF categories contributed to the remaining - 4 Mt $CO_{2\ eq}$ removals estimated in the final sector totals. With the cropland remaining cropland sub-category contributing the most significant removals at - 9.6 Mt $CO_{2\ eq}$ (Environment and Climate Change Canada, 2019c).

3.5. Forest Land Category Methodology Canada 2019 NIR

Reporting for the forest land category in Canada is currently informed by CBM-CFS3 (Environment and Climate Change Canada, 2019b). This is the most recent modeling approach that integrates forest inventory information, curves merchantable timber volume over time, provides equations to convert merchantable stand timber into total biomass, provides data on anthropogenic and non-anthropogenic activities and disturbances and simulates carbon transfers

between carbon pools and exchanges with the atmosphere associated with natural ecosystem processes and other events (Environment and Climate Change Canada, 2019b).

Forest management activities estimated for under the forest land reporting framework are: Clear-cutting, shelterwood harvesting, seed tree harvesting, selection harvesting, commercial thinning, pre-commercial thinning, salvage cutting, residential firewood harvesting and the burning of harvest residues (slash burning). Different practices of forest conversion are also simulated for estimation purposes included controlled (prescribed) burning (Environment and Climate Change Canada, 2019b). Considering that the stated goal of national inventory reports is to show the impact of anthropogenic activities on GHG emission levels, it is important to note that emissions from the mentioned anthropogenic activities are not quantified on an individual activity basis, nor on a jurisdictionally specific basis.

Although slash burning and other specific forest management activities that may have large impacts on emissions in the forest land category such clear-cutting, salvage cutting and controlled burning are reported for under Canada's carbon budget modelling approach, there is no breakdown of these emissions or removals on an activity specific basis, and it is thus difficult to isolate the effects that these individual activities have on the final emissions total. The absence of specific data for slash pile burning and other anthropogenic activities within this model is notably absent from inventory disclosure. This may be a result of the entire LULUCF sector being excluded from the final national inventory total, however this is not explicitly stated within the NIR.

Canada's Provincial and Territorial GHG emissions tables are broken down by sector in Part 3, Annex 11 of Canada's 2019 NIR (Environment and Climate Change Canada, 2019b). Although activity specific data is shown and divided into numerous categories and subcategories for the other reporting sectors; Energy, Industrial Processes and Product Use, Agriculture, and Waste, the LULUCF sector is not represented at all in these jurisdictionally specific reporting tables. Alberta and British Columbia's documented provincial emission contributions by sector for 2019 are located in Appendix L.

Provincial and Territorial LULUCF emission totals are similarly not available through any publicly published source. The government of Canada provides their UNFCCC emission spreadsheets for download by year for Canadian emission reporting from 1990-2017 and document

activity specific sector emissions (Government of Canada, 2019d). Reporting tables for the national LULUCF total however, are not activity specific and all forest management activity is assumed to be estimated and quantified under the forest land category. Significantly, the total LULUCF emissions for each Province and Territory, for each year of reporting all have values of zero reported for every year of national reporting (Government of Canada, 2019d).This is a significant transparency issue that should be addressed in future iterations of the inventory.

A research scientist interviewed for this project mentioned that they know of the Canadian intergovernmental committee that decided that the emissions from forestry will not be provided on a provincial basis to the public. This is a national decision to not provide LULUCF emissions on a jurisdictional basis. (When they were asked why this decision was made, they mentioned that they couldn't reveal that information.) – Climate Related Scientist - (Interview Participant C, 2019). (Statement paraphrased by Report Author)

Table 2 - Canada's Official GHG Inventory without Provincial LULUCF Emissions

	A	B	C	D	E	F	G	H	I	J	K	L	M
26296	2017	Alberta	530	Agricultur	TRUE	0	0	0	20.29963	6049.29	0	0	
26297	2017	Alberta	600	WASTE	TRUE	26.9445	70.9009	1772.523	0.300057	89.41685	0	0	
26298	2017	Alberta	700	LAND USE	TRUE	0	0	0	0	0	0	0	
26299	2017	British Col	0	TOTAL	TRUE	49785.19	350.0328	8750.82	6.147407	1831.927	1623.922	64.77609	20.24
26300	2017	British Col	100	ENERGY	TRUE	47475.46	145.4596	3636.49	3.000332	894.0989	0	0	
26301	2017	British Col	101	Stationary	TRUE	20428.15	26.26028	656.507	1.006318	299.8827	0	0	
26302	2017	British Col	140	Manufactu	TRUE	4823.439	0.642091	16.05226	0.478116	142.4786	0	0	
26303	2017	British Col	200	Transport	TRUE	25457.64	5.123402	128.085	1.989114	592.7558	0	0	
26304	2017	British Col	220	Road Tran	TRUE	17059.16	1.069383	26.73456	1.368027	407.672	0	0	
26305	2017	British Col	250	Other Trar	TRUE	4536.326	3.79436	94.85899	0.186444	55.56042	0	0	
26306	2017	British Col	300	Fugitive S	TRUE	1589.67	114.0759	2851.898	0.004901	1.460372	0	0	
26307	2017	British Col	320	Oil and Na	TRUE	1589.67	78.42421	1960.605	0.004901	1.460372	0	0	
26308	2017	British Col	400	INDUSTRIA	TRUE	2281.227	0	0	0.233026	69.44188	1623.922	64.77609	20.24
26309	2017	British Col	410	Mineral Pr	TRUE	1088.676	0	0	0	0	0	0	
26310	2017	British Col	420	Chemical	TRUE	0	0	0	0	0	0	0	
26311	2017	British Col	430	Metal Pro	TRUE	729.783	0	0	0	0	0	63.41593	0.935
26312	2017	British Col	500	AGRICULT	TRUE	28.49709	64.02342	1600.586	2.553929	761.0709	0	0	
26313	2017	British Col	530	Agricultur	TRUE	0	0	0	1.769586	527.3367	0	0	
26314	2017	British Col	600	WASTE	TRUE	0	140.5498	3513.744	0.360119	107.3155	0	0	
26315	2017	British Col	700	LAND USE	TRUE	0	0	0	0	0	0	0	
26316	2017	Yukon	0	TOTAL	TRUE	495.0592	0.404976	10.12439	0.029771	8.871898	18.21434	0.002207	

GHG_IPCC_Can_Prov_Terr (1)

(Government of Canada, 2019d)

Although the CBM-CFS3 informs Canada's national inventory by modeling anthropogenic carbon fluxes at various scales, including for the forest land category, the overall generation of national estimates for LULUCF involves the integration of large quantities of data from numerous sources. Forest management activities are tracked and documented in Canada's National Forestry Database and supplementary data for specific forest management activities is provided by provincial and territorial forest management agencies and experts (Environment and Climate Change Canada, 2019b). Canada relies upon provincial and territorial governments, whose jurisdiction includes the management of natural resources, to provide essential information on their individual forest management activities. This includes detailed forest inventory data, detailed descriptions of forest management activities and practices, information on natural disturbances, including prevention and control methods, forest harvest yield tables (volume / age curve), specific site indices and regional expertise (Environment and Climate Change Canada, 2019b). General estimation data from Canada's National Forest Inventory (CanFI) can be applied for any province or territory but many, including Alberta and British Columbia, have provided more recent, higher-resolution data.

Data regarding forest management areas in Alberta is provided by Alberta's Provincial Forest Inventory database and CanFI data provides the rest of the data for managed forest areas. Significantly, activity data for the burning of harvest residues (slash piles) were obtained using the CanFI for all provinces and territories apart from British Columbia where expert opinion was used to quantify estimates. For British Columbia, expert opinion suggests that the prevalence of slash burning is ~15% in coastal areas and ~50% for all other harvest areas (Environment and Climate Change Canada, 2019b).

Due to computational limitations, and inefficiencies in large-scale data collection for forest areas in Canada, it is currently considered impossible to accurately quantify uncertainties for managed forest areas. For the 2019 NIR the uncertainty about biomass increment is assumed to be 50% and reflects the lack of available data sources and computational limitations (Environment and Climate Change Canada, 2019b). Similarly, managed forests are annually affected by natural disturbances which influence forest carbon dynamics as a whole as they impact emissions and removals in the short term and impact decay and decomposition rates and forest regeneration rates in the long term. Uncertainties for natural disturbances in managed forests annually is assumed to be 10% for wildfires and 25% for insect infestations respectively. For forest conversion a 30% uncertainty

was applied (Environment and Climate Change Canada, 2019b). These uncertainty estimates are developed for both emissions and removals from anthropogenic drivers and non-reported emissions and removals resulting from natural disturbances. For both categories it is expected that future increases in computational capacity, greater data collection rates for forest areas, and refined procedures when increase the accuracy of accounting measures for these sources (Environment and Climate Change Canada, 2019b).

Canada's revised CBM-CFS3 carbon budget model for the LULUCF sector now has been retroactively designed to partition anthropogenic emissions and removals in managed forests from the influence of natural disturbances that have obscured the effects of human management and diminished the commercial value of the stand (Environment and Climate Change Canada, 2019b). Although the IPCC has recognized the difficulties associated for many countries in separating anthropogenic from non-anthropogenic emissions and removals in the LULUCF sector, there is currently no default methodology for separating these sources. The IPCC has encouraged countries that implement tier 3 reporting methodologies (see Appendix B) to develop new methods to improve the identification of anthropogenic emission sources and removals in the sector (Environment and Climate Change Canada, 2019b). Canada's NIR separates managed lands from unmanaged lands, managed lands are considered any forest area where there is direct human management activities for either timber or non-timber resources, as well as areas that are anthropogenically protected against natural disturbances such as insect infestations and wildfires including national and provincial parks and environmental protection areas (Environment and Climate Change Canada, 2019b).

Managed lands in Canada as of 2016 encompass 226 million hectares, which accounts for approximately 65% of Canada's total forest area, with the remaining 35% considered as unmanaged lands (Government of Canada, 2018). All emissions and removals from unmanaged lands are also not considered in the compilation of Canada's LULUCF sector inventory. Another issue with the carbon accounting framework currently in place relates to HWP. Current emission calculations assume all harvested forest carbon is immediately emitted to the atmosphere ignoring the significant amounts that will be sequestered for variable time-lengths in harvested wood products which if accounted for would significantly reduce net emissions (Dymond, 2012).

3.6. Harvested Wood Products (HWP) carbon pool methodology in Canada's 2019 NIR

Canada's LULUCF sector includes an estimate of the GHG emissions associated with the utilization and disposal of HWP manufactured from wood obtained from forest harvest and related conversion activities occurring in Canada (Environment and Climate Change Canada, 2019b). These HWP may be consumed in Canada or elsewhere in the world according to the Simple Decay Approach presented in the 2006 IPCC Guidelines. However, the simple decay approach assumes instant oxidization of carbon derived once wood enters the HWP pool (IPCC, 2008). Canada has decided to not assume the instant oxidization of the wood in the year of harvest, as that approach does not consider the large amount of wood that remains as long-lived HWP and has significant carbon sequestering capacity. Canada's approach is to treat the HWP pool as carbon transfer related to forest harvest and tracks all woody biomass that is domestically harvested and is transferred off-site (Environment and Climate Change Canada, 2019b). Emissions of CO_2 deriving from HWP use and disposal are estimated and reported by the LULUCF sector, whereas other emissions related to combustion of HWP or decay and decomposition (CH_4 and N_2O) are estimated and reported on in the Energy and Waste Sectors (Environment and Climate Change Canada, 2019b).

The calculation and determining of Carbon flows for HWP is informed by the CBM -CFS3 in order to ensure that there is no loss of carbon flow from forest harvesting to product and that emissions and removals are not double counted (Environment and Climate Change Canada, 2019b). The CBM – CFS3 takes in carbon inputs and assumes the export of some of the harvested roundwood, the conversion of all harvested wood into commodities (i.e. saw-wood, wood-based panels, pulp and paper, residuals from these processes referred to as "milling waste", exports an estimated percentage of the produced HWP and tracks additions and removals for domestic HWP in-use and estimates a percentage of milling waste is turned into bioenergy (Environment and Climate Change Canada, 2019b). The CBM – CFS3 incorporates 18 separate export networks, one for each Province and Territory (excluding Nunavut) plus one each for Japan and the United States, with the final network combining all other importers of Canadian HWP (Environment and Climate Change Canada, 2019b).

In the CBM – CFS3 model, all on-site decay of harvest residues (slash) is captured under the forest land category. This model uses recent statistics from the Food and Agriculture Organization of the United Nations (FAO) tracking of trade flows to estimate the amount of HWP that remain in Canada for processing, and the amount of manufactured HWP that are subsequently exported or remain for domestic utilization (Environment and Climate Change Canada, 2019b). All manufactured HWP are assumed to be produced in the same year as the harvest and are considered for the In-use pool. Applying the IPCC good practice guidelines for LULUCF (Penman, et al., 2003), allows for the determination of the amount of HWP transferred out of the in-use pool and upon being transferred out of the in-use pool all carbon is assumed to be instantly oxidized (Environment and Climate Change Canada, 2019b).

Uncertainties for the HWP category are heavily influenced by the uncertainty of the carbon pool inputs, specifically the estimates of carbon in forest products from forest harvest and forest conversion from the CBM – CFS3 model, available statistics from commodity production prior to 1990, and the volume of residential firewood provided by estimates from the Energy sector (Environment and Climate Change Canada, 2019b). Product allocation and utilization factors as well as the half-life of carbon emissions associated with certain products are sourced from published data in the IPCC good practice guidelines for LULUCF (Penman, et al., 2003). As with forest management, in years of no substantial change, no in-depth uncertainty analysis is performed, instead confidence intervals for each category are extrapolated on based on the previous year's estimate submission (Environment and Climate Change Canada, 2019b). The application of confidence intervals in lieu of annually quantified data, or estimations based detracts from the accuracy of reporting in the HWP reporting category. Additionally, many countries employ country-specific methodologies when compiling their HWP emission inventories and this lack of comparable standards undermines the accuracy of the accounting process (Johnston & Radeloff, 2019).

3.7. Partitioning Emissions: Canada and the Managed Land Proxy

"The reason we don't count our forest emissions, is that if we count the sink, we have to account for the emissions from the forest fires. So, for that reason, we don't count either

side of them"- Director of Operations and Engineering for Steeper Energy – Bob Moll, (Interview Participant J, 2019).

Considering that many countries rely on emission removals from the LULUCF sector to achieve their emission reduction targets, the emphasis placed on LULUCF reporting by the 2015 Paris agreements puts pressure on the entire sector to contribute to climate change mitigation strategies (Krug, 2018). This includes the utilization of forests as reservoirs of carbon or carbon sinks, and the greater integration of forest products into bio-based economies that may rely on HWP to further increase carbon sequestration potential. However, core requirements of the carbon accounting approach within the LULUCF sector such as the separation of anthropogenic and non-anthropogenic emissions and providing universally applicable accounting standards to ensure accounting integrity are not sufficiently secured for by currently applied accounting practices within the LULUCF sector (Krug, 2018).

The inherent difficulty in accurately partitioning anthropogenic and non-anthropogenic emissions in the LULUCF sector was recognized by the IPCC, and in 2003 they stated that the *"scientific community cannot currently provide a practicable methodology that would factor out direct human-induced effects from indirect human-induced and natural effects for any broad range of LULUCF activities and circumstances"* and introduced the Managed Land Proxy (MLP) as a default reporting approach. (Eggleston, Srivastava, Tanabe, & J., 2010, p. 8) In light of this concession, the IPCC subsequently adopted the Managed Land Proxy (MLP) into their good practice guidelines for the LULUCF sector. The MLP requires that all emissions and removals from all sources occurring on managed lands be classified as anthropogenic and thus must be reported. For countries like Canada, who are subject to large areas of interannual natural disturbances, adoption of the MLP can significantly misrepresent the actual anthropogenic influence on emissions from managed forest lands (Kurz, et al., 2018). If the MLP were to be applied in Canada, anthropogenic-derived GHG emission trends and fluxes have the potential to be distorted due to the variability of large-scale natural disturbances, predominantly due to wildfires and insect infestations.

Table 3 - Impact of Natural Disturbances on Managed Land GHG Emissions

Subcategories	1990	2005	2012	2013	2014	2015	2016	2017
Total Managed Forest Area (kha)	**230 000**	**230 000**	**230 000**	**230 000**	**230 000**	**230 000**	**230 000**	**230 000**
Areas with Anthropogenic Impacts	170 000	170 000	170 000	170 000	170 000	170 000	170 000	170 000
Areas with Natural Disturbance Impacts	56 000	56 000	55 000	56 000	56 000	57 000	56 000	57 000
Net Flux (kt CO_2)[2,3]	**-240 000**	**-110 000**	**-50 000**	**-120 000**	**-3 000**	**76 000**	**-39 000**	**66 000**
Reported Estimates	-210 000	-150 000	-160 000	-160 000	-160 000	-150 000	-150 000	-150 000
Emissions from Natural Disturbances	-26 000	43 000	110 000	40 000	150 000	230 000	110 000	220 000
Wildfires	500 000	430 000	460 000	390 000	500 000	580 000	460 000	560 000
Insects	4 100	130 000	130 000	140 000	140 000	140 000	140 000	140 000
Other natural disturbances[4]		59	32	12	12	12	12	12
Post-disturbance regeneration[5]	-530 000	-520 000	-490 000	-490 000	-490 000	-490 000	-480 000	-480 000
Carbon Transferred to HWP (Mt C)[6]	***45***	***55***	***42***	***43***	***42***	***44***	***44***	***44***

(Environment and Climate Change Canada, 2019c)

Yearly variability in GHG emissions from wildfires alone between 1990-2016 have contributed direct annual emissions ranging from 11 to 242 Mt $CO_{2\ eq} \cdot year^{-1}$ (Kurz, et al., 2018). For example, if natural disturbances were applied under the MLP to Canada's Managed GHG emissions, it would have added 220 Mt CO_2e to the Forest Land Remaining Forest Land category, even with taking into account estimated post-disturbance carbon sink of 480 Mt $CO_{2\ eq}$ (Environment and Climate Change Canada, 2019c).

While using the MLP as a default approach may be practical for many countries, countries with significant forest coverage that are often affected by large-scale natural disturbances like Canada, Russia and Australia can be significantly impacted by natural disturbances that occur on managed lands. If these emissions were counted towards Canada's emissions total it could significantly misrepresent the true degree of anthropogenic influence in the LULUCF sector. However, despite what were defined as "*valid concerns*" the IPCC concluded, during a 2010 review, that although further scientific work was needed, "*the managed land proxy remains a globally applicable, assessed and approved method for separating anthropogenic emissions and removals*" (Eggleston, Srivastava, Tanabe, & J., 2010, p. 19).

Given the established difficulty in partitioning emission sources in the LULUCF sector, the 2006 IPCC reporting guidelines for national GHG inventories encouraged Annex I reporting countries to refine LULUCF emission accounting standards through various country-specific approaches and techniques. These methodologies must be transparently documented and follow the existing base requirements of the IPCC (UNFCCC, 2019a). As of 2019, Canada and Australia are the only

two reporting countries that have instituted and applied their own partitioning systems. (Kurz, et al., 2018) Canada's country-specific approach was designed to more accurately represent the anthropogenic GHG contribution of Canada's managed forests and sector-related climate mitigation strategies and was integrated into Version 3 of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) (Kurz, et al., 2018). This partitioning approach was first applied and reported for transparency purposes in Canada's 2018 NIR (Environment and Climate Change Canada, 2019c).

In previous iterations of Canada's NIR, GHG emissions in Canada's managed forests were heavily driven by large natural disturbances which had no direct correlations with anthropogenic activities in those areas. If the MLP default approach was applied for Canada's 2018 NIR, the net flux of emissions would still be largely driven by natural disturbances, however, when refined approach for quantifying partitioned emissions for managed forests was applied, trends in emissions and removals in this category were more closely related to anthropogenic activities than when natural disturbance emissions were included in reporting estimates (Kurz, et al., 2018).

The ability to partition anthropogenic from non-anthropogenic emissions in Canada's managed forest lands is a very significant step towards increasing the transparency of reporting within the LULUCF sector. The goal of emissions reporting to the UNFCCC is to quantify categorized anthropogenic emissions in order to identify areas that need to be addressed to meet emission reduction goals. With this in mind it is clear that emissions from anthropogenic sources in Canada's LULUCF sector should ideally be counted both in sector reporting, but also towards the overall accounting total. However, although Canada now has developed the ability to partition anthropogenic from non-anthropogenic emissions within the LULUCF sector and has demonstrated this capability, LULUCF emissions are still only reported for and do not count towards the final accounting total. It is important to ask the question as to why this is occurring. If the total estimated anthropogenic emissions and removals for LULUCF were included in Canada's 2019 final inventory total, representing the year 2017, it would have resulted in -24 Mt $CO_{2\ eq}$ of emissions removals and decreased Canada's total emissions by ~3.3%. Similar removals would have been realized for most years from 1990 to 2017, with removals of ~11% in 1990, and ~2.9% in 2005 (Environment and Climate Change Canada, 2019c). There is a possibility that UNFCCC is worried about opportunistic countries taking advantage of the inherent carbon sink of their

forests in order to meet their emission reduction targets without making significant mitigation efforts in other sectors. However, that type of restrictive accounting system does not provide any emission mitigation incentives for country's that make quantifiable improvements in their sustainable forest management practices.

3.8. Reporting Challenges in LULUCF sector

Reporting in the LULUCF sector is a significant challenge for countries like Canada that possess vast forest resources, and significant forest industries. Emissions are estimated based off complex methodologies and modeling systems developed by national scientists, governmental research institutes and through international methods developed by the IPCC (Environment and Climate Change Canada, 2019c). In Canada, emissions reporting for all sectors is compiled by the Pollutant Inventories and Reporting Division of Environment and Climate Change Canada (ECCC) with input from relevant experts and scientists from across the country as well as collaboration with provincial and territorial governments (Environment and Climate Change Canada, 2019c). Since 2005, ECCC has delegated the responsibility for the compilation of the key components of the LULUCF sector NIR submission to the Canadian Forest Service of Natural Resources Canada (CFS) (Environment and Climate Change Canada, 2019c). The CFS develops Canada's NIR submission by compiling estimates of GHG removals and emissions from forest land, harvested wood products, afforestation (conversion of land to forest land) and deforestation (forest land converted to other land).

Although Canada has provided emissions data for the LULUCF sector, and compiled inventory emissions for sub-categories within LULUCF on an annual basis and submitted them to the UNFCCC, GHG emissions for the LULUCF sector, save for minute contributions from deforestation and afforestation, are excluded from the national total. This decision is made by Canada's GHG reporting body at ECCC, although it is not explicitly stated as to why the sector is excluded. The reasons for this exclusion have to do with the interannual variability of natural disturbances, the MLP, and inaccuracy of the estimating methodologies employed. A uniformed politician, or policymaker would not implicitly understand the UNFCCC defined differences between GHG *Reporting* and *Accounting,* or the intricacies that go into the MLP or the CBM-CFS3. The lack of inclusion of LULUCF emissions in the final total significantly misrepresents

Canada's true anthropogenic emissions. Although the LULUCF sector relies heavily on estimation which makes accurate quantification difficult, this representation could lead to misinformation being utilized by national and provincial policymakers, leading to ineffective regulatory decisions surrounding climate change mitigation and carbon sink enhancement in Canadian forests.

Part of the explanation for exclusion of LULUCF sector emissions was provided by a forest carbon researcher who was interviewed for this project. Their statement is summarized here:

It is already very difficult to separate natural from human-caused carbon fluxes but for a large country like Canada that is heavily affected by vast emissions from natural disturbances it could significantly misrepresent the anthropogenic emissions stemming from managed land. As an example, the 2017 and 2018 wildfire season created emissions that were two to three times larger than the emissions from all other sectors combined. So, Canada could spend hundreds of millions of dollars reducing emissions in other sectors, and another fire season like 17-18 would reduce all that effort to naught. I think that Canada, as a country that is subject to these large instances of natural disturbances, needs to protect itself against the risk that the cumulative impacts from climate change could completely overwhelm the emissions from all the other sectors. This is why we need partitioning of anthropogenic and non-anthropogenic emissions in the LULUCF sector. - Canadian Forest Carbon Researcher, (Interview Participant I, 2019). (Statement paraphrased by Report Author)

Accounting for forest carbon through National Inventory reports is a critical tool in international efforts to reduce climate change. However, forest carbon accounting is complex and as a result many policy makers, who are not technical specialists with detailed understanding of forest carbon inventories or carbon accounting methodologies, may find it difficult to integrate forest carbon accounting data into legislation (Andersson, Evans, & Richards, 2009). Clear, concise reporting regarding forest carbon trends is essential to inform the development of forest carbon and climate change mitigation policies. Reporting for forest carbon emissions and removals allows for the formation of forest policy as a climate change mitigation tactic and accurate reporting standards allow for implemented policies to be evaluated against previous emission levels (Andersson, Evans, & Richards, 2009). Facilitating communication between scientific reporting and policy makers within the forestry industry is essential if effective mitigation strategies are to take place.

There exists a distinct need to clarify the forest carbon accounting process and disseminate the emissions data, as best determined, to relevant policy actors in Canada's forestry provinces such as Alberta and British Columbia.

Jurisdictionally specific Provincial and Territorial estimates for LULUCF emissions and removals are not provided within Canada's NIR. It could be argued that this is a violation of the UNFCCC reporting guidelines and good practices standards. *"Good annual inventories should include transparent documentation and data to enable the reader to understand the underlying assumptions and calculations of the reported emission estimates".* (UNFCCC, 2019a, p. 1). However, although transparent documentation is a good practice guideline, it is not a legally binding provision for Canada after backing out of the Kyoto Protocol and thus no penalties or corrective action will be taken by the UNFCCC. Notably, British Columbia is the only province that compiles LULUCF data in a Provincial Inventory Report (PIR) and disperses this information publicly, however, LULUCF emissions are still not applied to the province's final accounting total as they follow Canada's national reporting standard which is set by ECCC through Canada's NIR (Government of British Columbia, 2016).

Meaningful progress has been made in the partitioning of anthropogenic from non-anthropogenic emissions in Canada through refinements to the CBM-CSFM3 however, with these improvements there should be a push made to include anthropogenic emissions from the LULUCF sector into Canada's final accounting total. The inclusion of these estimates on a jurisdictional and activity specific basis could increase public perception of climate change risk and could raise awareness for the challenges and sequestration ability of forests and the role they play in the global carbon cycle. Similarly, anthropogenic emissions from preventable or emission intensive management practices such as slash burning should be reported on in visual sub-categories to draw attention to the practice and directly quantify its effect on GHG emission totals.

Chapter 4: Forest Regulations in Western Canada

4.1. *Perspectives Forest Regulations in Canada*

I think we're probably not even really thinking about GHG emissions from the forestry sector. I think that's a problem. I think for sure we should be looking at more of those climate impacts from our forest management and incorporate that into the way we're calculating our emissions and then the types of mitigations they're putting in… I think that has to be on top of… the [regulatory] actions we're taking around fossil fuels. – Canadian Climate Change Policy Analyst, (Interview Participant C, 2019). (Statement paraphrased by Report Author)

I think there is a huge opportunity to use BC forests, especially in light of the current economic circumstances, as a carbon sink. The management requirements are simply huge though, and the forestry industry in BC is very resistant to change. This is because you have to operate on these long timelines. You replant, and you don't come back for 80 years. Foresters want the regulations to be consistent, so anytime there is change it is definitely not welcomed. – Forestry Consultant in BC **–** (Interview Participant F, 2019)**.** (Statement paraphrased by Report Author)

"I think very clearly, we need to take a wholistic approach to a more ecosystem-based management [framework], which we're not doing now… we can't be only placing the value of timber as the highest value [in the forest] We need to think about conservation. So, whether it's slash or fire or beetle kill it's really choosing the [best] approaches and regulating for pressures that are going to be most in line with a different ecosystem-based management approach." – Conservation Director for Canadian Parks and Wilderness Society (Southern Chapter) – Katie Morrison, (Interview Participant M, 2019).

"I think the regulations, they're there to ensure a [economic] return to the crown, to protect the park, the environment. The regulations are also there to protect the economic development of the companies. So, in general, I think they're fine." – Alberta Forest Area Manager - Kevin Gagne, (Interview Participant A, 2019)

4.2. Forest Carbon Regulation and Policy Background

Canada's most recent emissions reduction commitment under the auspices of the UNFCCC has come with the ratification of the Paris Agreements at the 21st Convention of the Parties (COP21) in 2015. Canada's emission reduction commitments stemming from this agreement aim to reduce GHG emissions to 30% under 2005 levels by 2030 (Davidson & Shah, 2015). In order to implement and achieve these 30% reduction target Canada established the Pan-Canadian Framework (PCF) in 2016. The PCF is constructed on 4 pillars: Pricing carbon pollution, undertaking complementary actions to reduce emissions across the economy, increasing adaptation climate resilience initiatives, and the creation of clean technology innovation and jobs (UNFCCC, 2019a). Under Article 5.1 of *Adoption of Paris Agreement*, the UNFCCC has given broad directives aimed at emission reductions in the LULUCF sector specifying that *"Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases as referred to in Article 4, paragraph 1(d), of the Convention, including forests."* (United Nations, 2015, p. 23)

It furthermore encourages parties to implement and support policy approaches and incentives that support the existing framework set out in guidance and decisions previously agreed to under the convention and expands this support to future emission reduction approaches in the LULUCF sector under Article 5.2 including; *"reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks…"* (United Nations, 2015, p. 23) By ratifying the Paris Agreement Canada has pledged on an international stage to implement climate change adaption and emissions mitigation approaches related to the sustainable management of forests, including the incentivization of the non-carbon benefits associated with alternative policy approaches that have yet to be realized.

Despite Canada's progressive attitude towards ratifying global climate change commitments, implementation of regulatory frameworks to successfully meet Canada's emissions targets have consistently fallen short of their goals. Canada has missed two separate emission reduction targets thus far, the 1992 Rio target and the 2005 Kyoto protocol target and, on the basis of current policy approaches is currently on pace to exceed the 2020 Copenhagen target by nearly 20% (Office of the Auditor General, 2018). Meeting the 2030 Paris agreement emissions target will require

substantial increases in regulations and policies aimed at climate change mitigation within the country. However, the Canadian auditor general has determined that the current status of climate change regulations and policies in Alberta and British Columbia have not fully assessed for the risks associated with climate change and have yet to develop sufficient adaptation plans and climate change mitigation strategies currently consist of high-level aspirational goals with little guidance on how to implement regulatory actions (Office of the Auditor General, 2018).

In order to evaluate Alberta and British Columbia's forest management practices against international standards, it is important to set a benchmark for comparison. Although definitions of sustainable forest management vary considerably depending on country or organization, this report will consider the definition contained within the Forest Principles developed at the 1992 Rio Earth Summit (UNCED, 1992).

> ***"Forest resources and forest lands should be sustainably managed to meet the social, economic, cultural and spiritual human needs of present and. future generations. These needs are for forest products and services, such as wood and -wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks and reservoirs, and for other forest products. Appropriate measures should be taken to protect forests against harmful effects of pollution, including air-borne pollution, fires, pests and diseases in order to maintain their full multiple values"*** (UNCED, 1992).

Considering the mitigation potential provided by forests in Canada, it is important to investigate whether current regulation and policy frameworks for Canadian forestry are directed towards the enhancement of Canada's overall climate goals, and what opportunities exist for improvement in this area.

In the most recent national update on progress made under the PCF, the government of Canada has renewed its focused aimed at enhancing carbon sinks and reducing emissions through sustainable land management policies (Environment and Climate Change Canada, 2018). The federal government has approved 5 proposals under the framework that specifically target the enhancement of carbon sinks including increased promotion of forest regeneration programs aimed at forest land areas that have been slow to recover from natural disturbances such as insect infestations and wildfires. These proposed projects include partnering with British Columbia on

the Forest Carbon Initiative, aimed at regenerating over 300,000 hectares of forest land affected by natural disturbances in the province (Environment and Climate Change Canada, 2018). The Green Construction through Wood program was introduced by the federal government in 2018 and aims to increase carbon sequestration through increased domestic usage of long-lived HWP in construction projects (Environment and Climate Change Canada, 2018). Alberta began to implement significant incentive laden opportunities aimed at the reduction of GHG emissions in the forestry sector through the emission offset system under the 2015 Climate Leadership plan, but it is uncertain how these programs will progress as a result of recent political change in the province (Government of Alberta, 2016).

"Moving forward, I am concerned. The climate action plan looks good and the goals seem very reasonable, but we are falling behind, quite rapidly. The carbon tax is not responding as it should be, this is due to industry concerns, but frankly their concerns shouldn't matter in light of the crisis we are facing" – Bioenergy Businesswoman - Maryam Mkhani, (Interview Participant L, 2019).

Various jurisdictions internationally have begun to implement forest carbon mitigation policies and explore policy applications for the utilization of forests as climate change mitigation opportunities. Finland has significantly altered their forest management policies and practices while attempting to increase the impact of the bioeconomy. Finland's National Forest Strategy has the stated vision *"Sustainable forest management is a source of growing welfare"* (Ministry of Agriculture and Forestry of Finland, 2019, p. 6) and has increasingly integrated carbon sequestration initiatives with increased utilization of forest derived products to support both their forest products and energy sectors. Finland also has robust forest carbon incentivization system that offers grants and subsidies for private companies that take on afforestation projects and has managed to increase its overall forest carbon sink profile through afforestation efforts. Finland's forest carbon sink in 2017 was 38% greater than it was in 1990 and 10% greater than in 2016 (Ministry of Agriculture and Forestry of Finland, 2018). Sweden has also begun implementing significant policy actions directed towards forest carbon and its role in climate change mitigation. Sweden's National Forest Program has determined that sustainable forest management strategies, instituted through sector-targeted policy directives, have the ability to enhance the value of forest resources to society both economically and by enhancement of climate change mitigation efforts

(Bostrom, 2015). Although the aggressive policy programs implemented in Finland and Sweden have been scrutinized in terms of their long-term effects on biodiversity and questionable emissions reduction claims in the face of a rapidly advancing bio-energy industry (Romppanen, 2017). International examples like these show that comprehensive forest policy strategies can function without detrimentally affecting the economics of the forestry industry and may in fact increase economic viability within the sector.

Canada has plans to institute a carbon tax under the Pan-Canadian Framework. As of 2018 any province or territory that have not instituted a jurisdictionally specific carbon reduction framework will be subject to federal backstop carbon pricing starting at $20/tonne and this will rise $10 per year as Canada attempts to meet their global climate obligations (Environment and Climate Change Canada, 2018). British Columbia has had a carbon tax since 2008 as part of its Climate action plan and is currently pricing carbon at $30/tonne (Government of British Columbia, 2018a). However, neither of these carbon taxes apply to emissions in the forestry industry beyond the extra costs associated with transportation requirements. Theoretically, the application of a carbon tax towards emissions derived from forest carbon could reduce the utilization of non-sustainable forest management techniques by applying financial pressure to forest operators. However, the complexity of forest carbon fluxes, interannual variability of natural disturbances, and uncertainties regarding emission quantification procedures create challenging design problems for potential forest carbon taxes. However, application of carbon pricing to certain specific aspects of forest management such as slash pile burning may be more manageable (Hoberg, St-Laurent, Schittecatte, & Dymond, 2016).

Carbon tax is the most efficient economic tool that there is. So other programs, offsets etc., especially an industry like forestry where there are huge differences in operation. It would be incredibly hard to use the benchmark approach for something like that. Because every facility is something different. A carbon tax provides a very simple fiscal incentive, which is extremely easy for companies to understand. The companies understand exactly what their exposure is, and it means they're much more likely to move forward on emission reductions. – Canadian Climate Change Policy Analyst, (Interview Participant C, 2019). (Statement paraphrased by Report Author)

Although a carbon tax may be simpler to administer as policy option, some international jurisdictions have approached the complex issue of regulating for forest carbon through the implementation of carbon offset pricing, or cap and trade solutions. California opened up their forestry industry to carbon cap and trade emission projects when they passed the *Global Warming Solutions Act* in 2006 (Climate Action Reserve, 2019). Since its inception this program has successfully incentivized improved sustainable forest management projects that have demonstrably increased carbon sinks and reservoirs within the state. Similarly, the *New Zealand Emissions Trading Scheme* has allowed forest owners and operators within the country to claim and trade carbon credits derived from the carbon sequestration potential of their forest land (NZ Forestry, 2019). These carbon credits can be used by companies to offset emissions from other business activities they may be involved in or may be sold to generate increased revenue from their forest lands. The success of international carbon incentives and carbon offset programs represent a significant opportunity for the Canadian forestry industry that should be investigated further.

Policy actions directed towards forest carbon, or forest climate change mitigation experience significant design problems; a lack of heterogeneity between forest zones, significant uncertainty issues pertaining to carbon flux data-streams and interannual variability within natural forest carbon cycle due to natural disturbances (Gren & Aklilu, 2016). Another significant aspect contributing to uncertainty within forest carbon policy efforts is the uncertainty of permanence regarding harvested wood products. Though these have the potential to increase carbon storage capacity, different usage requirements across jurisdictions and uncertain treatment within the literature have led to difficult policy design problems (Gren & Aklilu, 2016). Research examining regulatory and policy approaches to forest carbon mitigation has been limited thus far and more is needed to inform practices and actions of countries who wish to successfully implement this kind of policy into their legislative framework. Although the general opportunities surrounding forest carbon mitigation strategies have been discussed elsewhere, there exists an opportunity to examine the potential of these strategies in a specific jurisdictional context in Canada (Hoberg, St-Laurent, Schittecatte, & Dymond, 2016).

Direction for the governance of Canada's natural resources was first mandated under the Constitution act of 1867, jurisdiction over the resources contained in the Provinces and Territories while the federal government retained small amounts of power to direct the utilization of these

resources (Natural Resources Canada, 2017). In 1982, the constitution act was amended and explicitly recognized the authority of Provinces and Territories to manage and regulate their own non-renewable resources, forestry and electrical energy. Section 92A of the 1982 amendment stipulates that each provincial legislature has the power to enact laws that relate to non-renewable resources and developing, conserving and managing non-renewable resources and forestry (Natural Resources Canada, 2017). Canada is rich with forest resources and there are ~347 million hectares of forested land in the country. Up to 90% of this land is provincially owned and presided over by the various provincial and territorial governments. ~4% of forests are owned and looked after by the federal government with the majority of this being made up by national parks and indigenous reserve lands. The remaining 6% of forest land is privately owned with the majority of this being owned by large private forestry companies and a small portion being held by private woodlots owners (Natural Resources Canada, 2017).

Considering a significant majority of forests fall under provincial jurisdiction, provincial powers and responsibilities relating to the direction of their own forest management regulations and policies inform the majority of managed forest land in Canada. Among the responsibilities and powers held by the provinces and territories with regards to forest land is the ability to develop and enforce forest laws, set up timber licenses and supply agreements with forest companies, monitor activities of forest companies given access to public forests, collect royalties from operating forest companies and manage protection areas such as provincial parks and conservation areas (Natural Resources Canada, 2017). Provincial forestry laws in Canada differ from one jurisdiction to the next but all of them should be grounded and based on sustainable forest management principles, developed through proper consultation with the public and relevant stakeholders and informed by scientific research and analysis (Natural Resources Canada, 2017).

Proper land planning and forest management practices must be developed and followed by forest industry who would operate on public lands. In Canada, public lands owned by the Province are referred to as crown land or public forests. Provincial governments grant forestry companies the right to harvest timber on public lands and can thus stipulate the responsibilities that are tied to those rights to operate. These arrangements between the provincial government and operators are called tenure, but the existence of a tenure agreement does not immediately give an operating company access to harvest timber. In all provinces and territories there is a law that requires the

development and approval of a forest management plan or forest stewardship plan that the government must authorize and approve before any harvesting rights are transferred to an operating company (Natural Resources Canada, 2017).

"A forest tenure can take the form of an agreement, license or permit. Each is a legally binding contract that provides the contract holder with specific rights to use public forests over a specific period of time, in exchange for meeting government objectives, including forest management obligations and the payment of fees including stumpage" (Government of British Columbia, 2019c, p. 1).

If a company fails to live up to aspects of the forest management plan or tenure agreement, the government can impose fines, warnings, penalties or even prosecute offending companies who have violated the law under forest management acts or regulations. Although provinces and territories have the constitutional power to make their own regulations and management plans regarding the use of their natural resources, federal laws and international agreements that have been ratified by the federal government can influence forest management decisions and provincial regulations and policy.

4.3. The Tenure System.

The forest act is the federal government of Canada's overarching set of forestry regulations. Although it only applies to very small amount of Canadian forests its fundamental structure is what the majority of provincial forestry regulation and policy is based on. The concept of the Canadian forest tenure system is described in the Forest Act and the institution of tenure agreements has shaped much of Canadian forest policy and regulation as it relates to provincial and territorial governance. Considering that the vast majority of forestland in Canada is owned publicly (90+%) (Natural Resources Canada, 2017) the governments of Canada have an obligation to the public to utilize and manage these forests in the public trust. As the amount of capital necessary to operate large forestry operations and process harvested timber is most often in private hands, the question of how to transfer utilization rights from the public to private sector falls upon forest policy makers to ensure the publics best interest is represented (Luckert, Haley, & Hoberg, 2011).

The Crown forest tenure system addresses this policy question for both federal and provincial governments. This system has been in place since the earliest days of forest management in Canada and has remained the primary instrument through which jurisdictions address the question of how to treat private companies operating in publicly owned lands and profiting from publicly owned resources (Luckert, Haley, & Hoberg, 2011). Essentially, the private companies who wish to operate on public lands are required to pay various fees to the government, rents, and most commonly stumpage fees, which the government then collects on behalf of the public. The government can then disperse the revenue generated through various government initiatives that benefit the community. In additional to collecting operational fees from private operators in the forestry sector, governments are also entrusted to protect the public interest by setting regulations that set the operational conditions that operators must adhere to in order to exercise their rights to harvest and process the timber collected (Luckert, Haley, & Hoberg, 2011).

The tenure system is a staple of Canadian forest operations and allows private forests harvesters to extract resources while ownership of the land remains with the public. Once a tenure agreement is signed, the forest harvest operator owns rights to the timber in the area they have signed a tenure agreement for. At that point, they own the timber and can restrict certain activities from taking place on the land. Tenure agreements vary from province to province, but they generally have a lifespan of 5 – 20 years. At which point, if an operator hasn't made use of the land and harvested the timber resource as per the details of the agreement, the tenure agreement will lapse and will return to the government to sell to another operator (Luckert, Haley, & Hoberg, 2011).

4.3.1. Forest Tenure in Alberta

As discussed above, forest tenure agreements transfer the right to operate on publicly owned land to private businesses. Alberta's approach to forest tenure agreements are very similar to the traditional tenure agreements that are a holdover from the early days of negotiating forest tenure agreements with the federal government. In Alberta there are 3 main types of forest tenure agreements, forest management agreements (Appendix D), Coniferous and Deciduous timber quotas (Appendix E), and timber permits (Appendix F) (Government of Alberta, 2019f).

4.3.2. Forest Tenure in B.C.

Forest tenure in B.C. is more diverse than in Alberta due to the larger number of forest operations taking place in B.C. forests. B.C. has over a dozen types of tenure agreements that reflect the needs and interests of forest tenure holders in the province, from large to small operators, indigenous groups, communities and individuals (Government of British Columbia, 2019c). Tenure agreements in B.C. have varying lengths of term depending on the nature of the license, from one-time, non-renewable forms of tenure such as forestry license-to-cut to the more common place large-scale, replaceable timber harvesting tenures that provide large forestry companies with a consistent long-term supply of wood (Government of British Columbia, 2019c). The maximum allowable term for large-scale timber harvesting tenures is 20 years, although the replaceable nature of these tenure agreements essentially ensures that the large-scale timber operators will have consistent access to the areas of timber agreed to. The B.C. government maintains control of the forest tenures system via legislation, policies, regulations, agreements and procedures that refer to the occupation of Crown land and the harvesting of Crown timber (Government of British Columbia, 2019c).

There are two general types of tenure that account for the majority of timber volume that is harvested in British Columbia, "volume-based" tenures, which grant licensees the ability to harvest a specified volume of timber, based on the AAC, and "area-based" tenures which grant licensees harvesting rights for an area of forest land (Clogg, 1999). In direct relation to this, two forms of tenure licenses account for ~80% of the timber volume harvested in B.C.'s Crown forests; area-based tree-farm licenses (TFL's) ~24%, (see Appendix H) and volume-based forests licenses (FL's) ~56%. (see Appendix G) In most cases these licenses are termed 'evergreen' licenses as they are replaceable in perpetuity providing the licensee honors the obligations of the specific license, and requirements contained within the *Forest Act*, and the *Forest and Range Practices act* (Clogg, 1999).

4.4. Annual Allowable Cut

One of the most significant forest management actions regulated for by provincial and territorial governments is the determination of the Annual Allowable Cut (AAC). AAC's must be regulated effectively in order to ensure sustainable harvest levels that will allow for continued economically

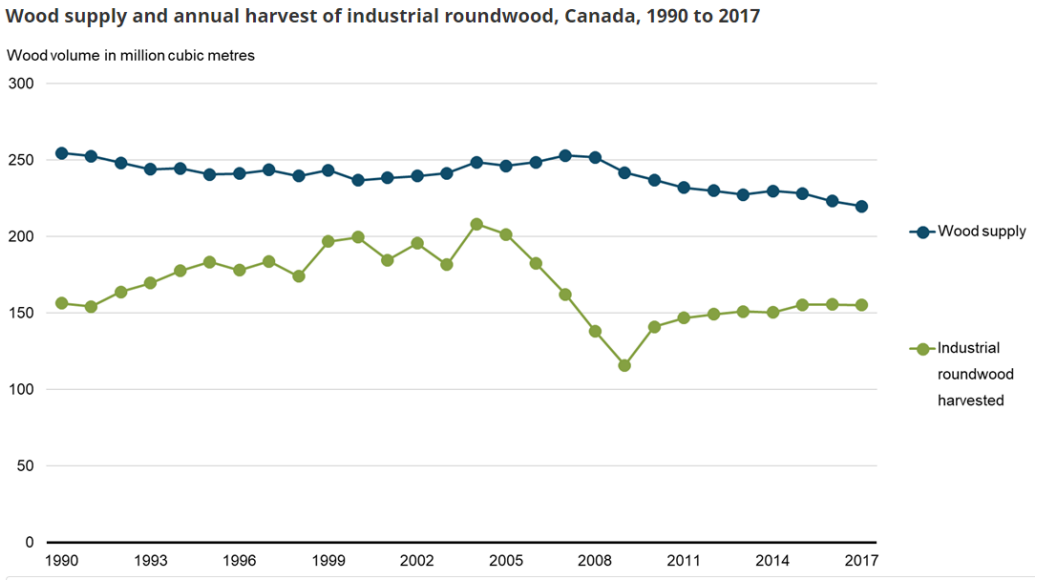
viable forestry activities for generations. This determination is approached differently throughout Canadian jurisdictions but generally it is determined by a ministry official or often times the representative minister themselves. Both Alberta and British Columbia approach determination of the AAC by dividing the total forest area under active management into manageable pieces or units that make up the complete managed forest areas. Alberta divides its forests in Forest Management Areas (FMA's) further subdividing each FMA into Forest Management Units (FMU's) (SFM Canada, 2016). British Columbia's system is very similar to Alberta's with 73 FMU's that make up the totality of the provinces managed forest area (SFM Canada, 2017). The final determination of British Columbia's AAC is mandated by an assistant deputy minister called the Chief Forester who considers information supplied from each individual FMU in determination of the AAC for each FMU that adds up to the final AAC determination (Government of British Columbia, 2019b). Alberta's general AAC is determined by the Ministry of Agriculture and Forestry, which periodically analyzes forest health and growth trends in order to make changes to the AAC dependent upon need (Government of Alberta, 2019b).

On an FMU level, AAC in Alberta is determined by a director who is appointed by the Minister. Generally, the directors are deemed forest area managers who are in control of a certain amount of Alberta's geographically positioned FMU's within their prescribed FMA. AAC's are never to be exceeded in ideal circumstances and indeed regulation of AAC's in Canada has proven to be very effective at regulating forest harvest levels over time. The Canadian government keeps track of sustainable harvest levels that are informed by AAC determinations in all producing forestry provinces and territories in the country. The maximum sustainable harvest level is known as the wood supply level and on a national basis, Canada's harvested timber volumes from 1990 – 2017 have fluctuated between 48% and 84% below the wood supply level, this generally holds true for Alberta and British Columbia as well, where harvest levels rarely reach AAC designations.

"You know, our annual allowable cut calculations, I do think we stretch a bit. We try to max them out, [but] then we go through a process of testing those assumptions, through [the] regen[eration] targets, are we actually meeting them? Do we have a forest there two years later? A lot of cases I think we do, but I'm not sure about that everywhere… For this area I can tell you we haven't exceeded the allowable cut for over 30 years, I think that's the same for most of the province generally…The regulations are good, they protect the forest

industry as well. Because… us in the field, we focus on protecting the environment." – Alberta Forest Area Manager – Kevin Gagne, (Interview Participant A, 2019)

Figure 6 - Canadian Wood Supply (AAC) vs. Harvested Amount 1990-2017



(Government of Canada, 2019c)

4.5. Alberta Forest Regulations That Inform Timber Harvesting and Management practices:

"The main thrust of the forests act in Alberta is to allocate timber and allocate lease areas….and I think from an ecosystem as well as climate change perspective, we actually really need to change that whole approach from one that really prioritizes timber to one that prioritizes ecosystem values, including GHG emissions, climate change and climate adaptation as we go forward in the future" – Conservation Director for Canadian Parks and Wilderness Society (Southern Chapter) – Katie Morrison, (Interview Participant M, 2019).

4.5.1. Alberta Forests Act

The structure of governance and power within Alberta's forests are described in the Forests Act. The act defines the abilities and powers of government representatives, specifically the Lieutenant Governor in Council and the Minister of Agriculture and Forestry within the province. Furthermore, the act provides for the establishment of forest management units that act as mechanisms for the allocation and disposal of Crown timber and harvesting rights within Alberta.

The act details the protocols and methodology of the government as it acts to transfer rights to operate and harvest on public lands to private companies through forest management agreements, (see Appendix D) coniferous and deciduous timber quotas (see Appendix E) and timber permits (see Appendix F). It summarily describes offences and penalties for contravention of the act and its related regulations (Government of Alberta, 2019c).

Alberta's *Forests Act* provides and enforces the power of Lieutenant Governor in Council to make regulations that govern the majority of forestry activities in Alberta including governing the management and use of forest land. As such, the Lieutenant Governor in Council can dictate the way that public forest lands are handled and managed by industrial and individual forest operators on behalf of the public. The details of forest management regulations are not specifically described within the forest act but are instead handled by two other documents that inform management practices. Alberta's *Timber Management Regulations*, and the Alberta's *Forest Management Planning Standard*, which although not an official regulation, is a document that details the standards that are required from industrial forest operators when constructing forest management plans to be approved by governing officials.

4.5.2. Timber Management Regulations

Alberta's Timber Management Regulations (TMR) are an example of how forests in Alberta are being governed mainly to ensure the economic sustainability of the industry. The first 4 divisions of this regulation are primarily concerned with pricing, permitting and offence related regulations regarding the tagging, transportation and general salable aspects of merchantable timber harvested within the province. Under the general provisions of Section 164 of the TMR, the department is mandated to manage forest resources "in the economic interest of the public" (Government of Alberta, 2017e). Although this provision provides that the director may refuse to allow healthy stands of green trees to be harvested when there are "sufficient quantities" of dead or damaged timber for the required use, it is unclear how often these types of salvage logging take place when other stands of living trees are available for merchantable timber harvesting. The director maintains nearly full control of forest management operations within the province but there is clearly a disconnect between economic interests in the forest and the expressed climate change initiatives of the Alberta government.

There are some unique provisions regarding incentives for industrial forest operators and the AAC in specific FMU's. Section 14 of Alberta's TMR specifies that whenever the director determines that the AAC for a certain FMU may be increased, they can offer the increased timber without charge to timber quota holders operating within the FMU (Government of Alberta, 2017e). This may incentivize questionable practices among quota holders seeking to increase profits by increasing their AAC allotment. Even if sustainable forest management practices were the reason for the increase available timber, increasing the AAC simply decreases the amount of forest carbon within the FMU. It is unclear how often this provision is used and what effect it may have on the amount of timber being harvested in Alberta forests.

The TMR directs all timber licensees to construct an annual operating plan that must be submitted to the director that adheres to guidelines specified by the director. In Alberta, these guidelines are known as the *Timber Harvest Planning and Operating Ground Rules.* (OGR) This guideline serves to inform and direct licensee practices in developing forest management plans including annual operating plans, and specific timber harvest plans (Edson Forest Products, 2014). The OGR also informs and directs licensees while conducting forest management operations and the director maintains the right to suspend or withhold timber quotas or timber licenses in the event that the licensee fails to meet the expectations of the OGR during the development of harvest plans or through violations of forest management practices (Edson Forest Products, 2014). The TMR contains some general provisions governing licensees to harvest timber on crown land responsibly such as Section 100 (e) which directs licensees to avoid excessive waste when harvesting and processing timber, and (j) which mandates licensees to avoid excessive damage to regeneration, advanced growth and residual trees (Government of Alberta, 2017e), however there are no references to sustainability, or sustainable forest management and the terms "excessive damage" and "excessive waste" are vague and don't provide distinct definitions to inform management practices. Section 100 of Alberta's TMR can be found in Appendix I.

"There are there are trees over here, you know, the standard spruce trees down here, if it's over a hundred and fifty years old, that stand very well may be releasing more carbon than its sequestering, even though it's still a green forest right? just the decay and rot that's going on in those trees. [We're] seeing the same with the pine stands as they fall down and decay... Whether it's net emitting or sequestering carbon, I don't know. And I think what's going to

be the challenge is figuring this stuff out" – Alberta Forest Area Manager – Kevin Gagne, (Interview Participant A, 2019)

Due to the significant emissions that are released from decaying trees and the loss of HWP value they represent, waste from forest harvest residuals within Alberta's forestry industry has the potential to significantly impact the forest carbon accounted for and stored within Alberta's forests. Directions and provisions regarding the disposal of harvest debris are referred to in the *Forest and Prairie Protection (Ministerial) Regulation* (Government of Alberta, 2017b). The disposal of harvest debris has the potential to significantly add to carbon emissions within the forest as currently the debris is either left in the forest to decompose or is more commonly burnt as a forest fire mitigation practice.

Reforestation requirements and standards are addressed in the TMR sections 141.1 and 141.2 (see Appendix M), but the actual operational direction regarding the implementation of these requirements and standards for licensees are more fully addressed in the OGR. Any holders of a timber disposition are required to carry out reforestation projects within 2 years of the land being harvested for timber. There are significant penalties for licensees who violate this requirement or fail to adequately fulfill their obligation to the crown. The director maintains the right to determine the species of trees that are reforested in an area and can establish requirements regarding the procedures and methods used to determine the extent to which an area requires to become satisfactorily reforested (Government of Alberta, 2019d). The ability to dictate reforestation requirements can significantly impact species diversification and subsequent levels of forest resilience in the reality of a warming climate. This can mitigate for decreasing forest moisture levels and have long-term impacts on rates of carbon storage in forests, and overall forest health (North, et al., 2019).

The TMR are a general outline and framework dictating how licensees conduct forest management activities within Albertan forests. The specifics regarding the planning and on ground management strategies are outlined in Alberta's OGR and forest management plans are required to adhere to the standards described in Alberta's Forest Management Planning Standard.

4.6. Timber Harvest Planning and Operating Ground Rules (OGR)

Alberta has established an overarching set of guidelines that inform "in the field" forest management practices. These baseline practices are used to plan and conduct small and large-scale forest management operations within the province and are the methods used to physically implement decisions made in Forest Management Plans (FMP's). The ground rules are intended to establish practices that minimize the negative impacts associated forest management activities such as harvesting operations and road construction (Government of Alberta, 2019d). Ideally, the OGR are intended to be reviewed every year in order to integrate modifications and "fine-tune" the ground rules based on the most current knowledge and tools available. Alberta's OGR represent the ongoing forest management activities that are planned and described within FMP's.

Industry operators and licensees are required to develop FMP's upon the signing of a forest management agreement and must include public and related stakeholder consultation when developing the FMP by providing ongoing opportunities for public input throughout the duration of the FMP (Government of Alberta, 2019d). Currently, Alberta's FMP's are designed with a 10-year duration however, there are options to extend FMP's for longer pending director approval of licensee application and can be extended to a maximum of 20 years. FMP's must include operational details for the 10-year lifespan of the plan that include the extent and size of the area of forest detailed within the plan, identified stands for harvest within the area, and the intended reforestation methods to be implemented (Government of Alberta, 2019a). FMP's are developed considering a 200-year time span which is regarded as two full lifecycles or rotations of trees covered under the FMP. Plans must describe forest management objectives, strategies and commitments, including the intended methods for cutting, reforesting, and managing of timber resources within the area of responsibility (Government of Alberta, 2019a). FMP's developed by the forest industry in Alberta are intended to:

- Look beyond sustained timber yield
- Embrace the concept of sustainable forest management
- Recognize other resource values and uses
- Explain how the harvesting plan will be delivered

- Explain how performance will be measured (Government of Alberta, 2019a).

These aspirational goals are to be kept in mind when licensed forestry professionals are constructing FMP's and it is important to determine what value climate change mitigation and the enhancement of carbon sinks and reservoirs are given within the context of FMP's and Alberta's OGR. In the Appendix 4 glossary of Alberta's OGR, Sustainable Forest Management is defined as *"Management to maintain and enhance the long-term health of forest ecosystems, while providing ecological, economic, social and cultural opportunities for the benefit of present and future generations."* (Edson Forest Products, 2014). This definition approaches but ultimately falls short of including enhancement of carbon sinks or reservoirs suggested in the Rio Earth summit definition, which would assist with climate change mitigation efforts (UNCED, 1992). Ultimately, these are values that Alberta forest management professionals are not obligated concern themselves with currently.

In addition to requiring the development of a 10-year FMP for FMU's the government of Alberta also requires Annual Operating Plans (AOP's) to be developed and approved by the director on a yearly basis. Alberta holds the power to approve or deny AOP's on an annual basis and may also waive or amend the application of certain ground rules in unusual or special circumstances (Edson Forest Products, 2014).

4.6.1. Forest Planning Procedures - OGR

Alberta's OGR detail standard best practice operational procedures that are expected to be employed by forestry professionals licensed to harvest timber on crown lands. Including details of what non-timber resource values to protect for. Context for the treatment of forests is provided for by the definition of Sustainable Forest Management provided in the OGR Appendix 4 Glossary:

Applying Alberta's definition of sustainable forest development in the context of the OGR provides a further indication of the values protected for and conserved within the forest management planning process. Operational planning under OGR guidelines first hinges on the successful approval of a 10-year FMP from the government, once that hurdle is crossed the rest of the operational planning process begins before any activity can take place on forested crown land (Edson Forest Products, 2014). An overview of the planning process is described in Section 3.0 of the OGR and is located in Appendix J

4.6.2. OGR Section 3.6: Salvage Planning Operations - OGR

Section 3.6 of Alberta's OGR describes the rationale behind planning and managing Salvage logging. Salvage logging takes place in areas heavily affected by natural disturbances such as insect infestations, wildfire damaged areas or other unforeseen circumstances. The OGR considers the purpose of salvage planning to reduce the potential for loss of fibre (Edson Forest Products, 2014). Although salvage logging can be an effective way to preserve carbon sinks and reservoirs by leaving healthy green forests stands to instead harvest merchantable timber from dead or dying stands, Alberta's message surrounding salvage seems instead to concern the loss of merchantable timber. Although salvage logging can provide significant benefits to forest carbon profiles within Alberta it is not mentioned as a reason for pursuing salvage logging within the context of the OGR. In order to be considered as an option, salvage planning must be incorporated into the licensee's FHP and AOP and approved by the director before salvage logging can begin. It is unclear whether the submission of updated FHP's and AOP's is required if salvage logging is mandated by the director under the TMR. Salvage planning is covered in further detail by directive *2007 -01 Fire Salvage and Planning Operations* (Alberta Agriculture and Forestry, 2007).

There are lots of questions surrounding utilization of affected forest debris, how would secondary harvests affect biodiversity? or regeneration capacity? Utilization of fire affected wood might be in their best interests, but uptake has been very low so far, its hard to process, hard to harvest and the economic incentive isn't there yet when there is still enough green wood available. – Forest Analyst for Alberta Government, (Interview Participant G, 2019) (Statement paraphrased by Report Author)

This directive was established in 2007 with the stated purpose to *"utilize as much of the fire-killed timber as possible within two years of the fire event, while maintaining environmental values."* (Alberta Agriculture and Forestry, 2007, p. 1) Under this directive, companies that are operating within the forest management area where the fire damage has occurred are given the first opportunity to salvage the wood. These companies must submit a notice of "intent to salvage" that indicates the volume available for salvage, what stand types are available for salvage and the estimated utilization standards from the salvaged stands. In salvage planning operations AOP's are still required, but in order to meet the two-year goal for harvesting fire salvaged timber the

government will allow certain harvesting activities to take place while aspects of the AOP, such as the reforestation program, are still being developed.

Although Section 164(a) of the TMR permits the government to restrict the harvesting of green timber when sufficient quantities of salvage timber exist in the same forest management area (Government of Alberta, 2017e), the government incentivizes the harvesting of fire damaged timber by categorizing it as dead timber, which carries reduced timber fees owed to government after the timber is harvested. Significantly, if the area damaged by fire is considered too small, the government may include a certain volume of green trees within the area to be harvested and the harvesting of these trees will be charged as endangered trees which also carry a lowed timber and stumpage fee (Alberta Agriculture and Forestry, 2007). Reforestation programs for salvage harvest blocks is still mandatory for harvest operators and normal ground rules for reforestation apply for salvage operations. In order to preserve structure, and offer suitable sites within the cut-block for regeneration to occur retention of 10-25% of merchantable burnt must be left standing in timber patches less than 100 ha in area, for fire damaged areas that are greater than 10,000 ha, the 25% retention number is mandatory (Alberta Agriculture and Forestry, 2007). In certain cases, where fire damage has taken place in remote areas that limit the economic viability of the timber, portable sawmills may be allowed for use which allow for on-site milling of the salvage timber into merchantable wood products.

Alberta also has salvage planning operations in place for insect infested timber areas, salvage planning operations for insect infested timber largely follow directive *2007 -01* (Alberta Agriculture and Forestry, 2007), however there are different determinations based on how much volume of timber is affected and the duration for harvesting action is longer allowing for ten years instead of just two for fire salvage operations (Alberta Agriculture and Forestry, 2007). Similar to the salvage plans for fire affected timber, salvage operations concerned with pine beetle infestations are concerned with the economics of forestry industry within the affected area.

From the Interpretive Bulletin - *Planning Mountain Pine Beetle Response Operations,* distributed by the Alberta government in 2007, *"In the event there is a MPB outbreak in all or part of the area of primary concern that is not manageable with either the control or prevention strategies, salvage activities directed at maximizing the economic recovery within affected areas will be initiated"* (Government of Alberta, 2007, p. 1). Alberta is taking considerable action to combat the

spread of Mountain Pine Beetle (MPB) within the province, which is single largest cause of insect related tree mortality.

In 2007 the government introduced the "Healthy pine strategy" (Government of Alberta, 2019e) which proposes to use a combination of prescribed burns and strategic harvesting to prevent and control the spread of MPB within the province. The strategic harvest strategy aims to target stands of "over-mature" lodgepole pine trees which are the principle species at risk of MPB infestation and harvest them replacing them with younger, healthier regenerating stands. It is estimated that over 60% of Alberta's pine forests consist of even-aged stands aged 80 years of older. Over-mature trees are classified as being 80-120 years old and are particularly susceptible to infestation. Research has shown that the insects do not target younger trees during the lifecycle and this targeted harvesting methodology is an attempt to slow the spread of MPB through large even-aged stands of over-mature pine (Government of Alberta, 2019e). With this strategy in mind, the ministry of Agriculture and Forestry has identified the most susceptible stands and have begun work with Forest Management Agreement holders to reduce the amount of age susceptible pine in their forest management area by 75% by 2026 (Government of Alberta, 2019e). There are currently 16 healthy pine strategy plans in place throughout the province with the hope to replace susceptible pine stands with odd-aged regeneration forests and stem the influx of MPB in Alberta.

The incentivization of salvage logging for timber affected by natural disturbances fits with the chosen international benchmark definition of sustainable forest management and meets climate change mitigation effort standards by enhancing carbon sinks and reservoirs within the province. By leaving merchantable stands of green, growing trees in favour of timber that will inevitably die and decay within a few years is a useful climate change mitigation tactic, although the wording of the regulations and operating procedures surrounding these initiatives in Alberta seem to consider it an economic provision that saves merchantable timber and maximizes profitability from a bad situation. Rather than decreasing the AAC in areas heavily affected by natural disturbances to preserve forest carbon sinks, the action is taken to preserve the economics of the industry when faced with adverse circumstances.

This strategy unintentionally aids climate change mitigation efforts in Alberta forests, although the stated aim of these projects is to preserve the economic integrity of forests in Alberta, management for odd-aged stands of trees and the prioritization of utilizing over-mature stands for merchantable

timber contribute to the creation of carbon sinks and reservoirs within the province. As research has shown that over-mature trees tend to sequester less carbon as they age and may become sources of carbon emissions over time (Jacob, Bade, Dittrich, Leuschner, & Hauck, 2013). Whereas growing trees actively sequester carbon more effectively during the early stages of the growth cycle due to the accelerated actions of photosynthesis (Natural Resources Canada, 2016).

My understanding is that. Charred wood from salvage operations cannot be used for pulp and paper, but it can be used for other products, including biofuels. I think there are many opportunities here that need to be further investigated. I think one important dimension here is that because we have increased losses from climate change, we need to think about strategy used where we use salvage instead of green timber harvest because the green timber harvest, if we avoid it and salvage dead wood anyway, then it gives us an opportunity to maintain carbon sinks in forests that are actively growing. – Canadian Forest Carbon Researcher, (Interview Participant I, 2019). (Statement paraphrased by Report Author)

4.6.3. OGR Section 4: Tree utilization standards

The OGR defines tree utilization standards for timber to be harvested from crown forests in Alberta. Utilization standards are essential for improving the carbon sink potential of Alberta's forests as the harvested tree biomass has value only insofar as it can be used and turned into salable HWP products that determine emissions and removals within Canada's carbon accounting framework.

Alberta has 3 utilization standards are the minimum dimensions of cut timber that that determine the definition of merchantable timber under the OGR. Coniferous trees are subject to a 15/11 utilization standard which describes a cut tree-stem with a minimum length of 3.84 metres, a minimum 15 cm base diametre and a minimum 11 cm top diametre (free of bark), that is free of internal rot which can then be turned into a merchantable piece of timber which adheres to the same 15/11 utilization standard (Edson Forest Products, 2014). Deciduous trees are subject to a 15/10 utilization standard which describes a tree with a minimum length of 4.88 metres, a minimum 15 cm base diametre and a minimum 10 cm top diametre (free of bark), that is free of internal rot which can then be turned into a merchantable piece of timber which is a minimum of 2.49 metres in length to a 10 cm minimum top (free of bark) (Edson Forest Products, 2014).

Salvage operation trees, whether fire damaged or insect infested adhere to a 19/13 utilization standard in order encourage recovery of forest fibre in natural disturbance situations. The salvage operation utilization standard describes a tree with a minimum length of 5.0 metres, a minimum 19 cm base diametre and a minimum 13 cm top diametre, that is free of internal rot which can then be turned into a merchantable piece of timber which is a minimum of 3.84 metres in length to a minimum 13 cm top diametre (free of bark) (Edson Forest Products, 2014).

There are no utilization standards for any other type of forest fibre that may be harvested. As such all forest fibre that does not adhere to these utilization standards is not deemed merchantable timber and is termed as debris or forest harvest residues. The lack of utilization standards for harvest residuals within Alberta's OGR represents a significant loss of forest carbon and can be directly associated with carbon emissions stemming from forest management practices within the province. This is an area the province should improve in order to better protect for forest carbon as a value and would further climate change mitigation efforts from the forestry industry. These residues can make up a significant amount of the harvested timber and are dealt with in accordance with *Alberta's Forest and Prairie Protection act.*

4.6.4. OGR Section 7.2: Debris Management and Wildfire Protection

The OGR guidelines detail the handling requirements for debris leftover from harvest operations also considered forest harvest residues. The stated purpose of this operating guideline is:

To manage the amount and distribution of woody debris left in harvest areas to:

• minimize wildfire risk, particularly near communities

• optimize ecological benefits

• minimize the loss of productive land base

• to minimize the risk of wildfires, and to improve fire suppression capability (Edson Forest Products, 2014).

The clear provincial priority when dealing debris or slash accumulation in forest harvest operations is the mitigation of wildfire risk as this is stated twice in the purpose (Edson Forest Products, 2014). This is due to the increased fuel load that these debris fields represent as the forest harvest

residue (slash) is piled up it tends to dry out and provides increased fuels loads that can intensify fire behaviour and also pose an ignition risk as high piles have a chance of being struck by lighting and causing a wildfire within the area. As such the preferred method is to dispose of this debris to alleviate the associated hazards. However, it is recognized that there are ecological benefits associated with the retention of forest harvest debris in cut blocks as decaying forest fibre returns minerals and nutrients to the soil and provides habitat for certain species of animals (Edson Forest Products, 2014).

The redistribution of the entire forest harvest residue load over the cut block is not always an effective solution as it reduces the area available for reforestation efforts, and significant slash load can inhibit growth in young trees by blocking sunlight (Interview Participant A, 2019). The acceptable methods for reducing hazards associated with forest debris are detailed in OGR Appendix 2 - *Debris Disposal Requirement for Timber Harvest Operations* which indicates that policy regarding harvest residuals under the OGR mandates that operators apply the debris management standards detailed in the *Forest and Prairie Protection Act* (FPPA) (Edson Forest Products, 2014). Specific requirements for dealing with forest harvest residuals under Section 6 of the FPPA can be found in Appendix P. In addition to standards regarding the disposal of harvest debris the policy also applies to harvest debris that is retained for reforestation, wildlife habitat or other landscape management objectives. The standards detailed are enforced by the government and fines will be administered to forest operators if the debris is not dealt with according to FPPA regulations within 24 months of the cessation of harvest activities within the area (Edson Forest Products, 2014).

Considering the enforcement of this regulation and the associated fines that come through violation of it, forest operators are forced to deal with harvest residue debris relatively quickly within the context of a 10-year FMP. The reality for operators is that, there is no easily accessible market for harvest residues, and they are not considered merchantable timber under the OGR. The easiest solution for operators in many cases is to burn the material in accordance with the FPP ministerial regulation. The government does allow for other methods of dispersal or disposal, but these other methods may interfere with reforestation plans and may also interfere with the requirements set out for cut-block areas by reducing the amount of area set aside for regrowth and regeneration. The associated emissions to the atmosphere from burning residual harvest fibre can be significant

and operators also must consider the risk from burning operations that cause a wildfire as a result of burning harvest residuals. Under Section 2.1 of the FPPA, it is stated that the minister can charge a person or entity for the costs associated with the fighting of a wildfire if it can be proven that the fire originated from a source set by the individual or entity (Province of Alberta, 2016). (see Appendix N) The costs of fighting wildfires can run into the hundreds of millions of dollars and this risk is borne by the operator when conducting burnings operations, somewhat ironically, to mitigate the risk of wildfires.

In 2017, Alberta composed directive *AF-FDP-2017-07- Debris Management Standards for Forest Harvest Operations*. The purpose of this directive is to provide standards for the management of residual harvest debris that is in accordance with the FPP and associated regulations in order to reduce wildfire hazards for forests and communities (Government of Alberta, 2017a). This directive defines residual debris as *"any debris resulting from the harvesting process including but not limited to branches, bark, unusable pieces of the bole, tops and mulch/chipping of debris"* (Government of Alberta, 2017a, p. 1). and defines other methodologies, other than burning, that can be used to deal with residual debris in forest management operations. This directive establishes that the intent should not be to remove all debris as there is ecological and habitat benefits from leaving certain amounts of residual debris on the floor of a cut-block or harvesting area. It describes retention of debris for reforestation, wildlife habitat, or other landscape management objectives are acceptable debris management strategies, but these must be accounted for and approved in the AOP. The stated goal of this directive is to maintain amounts of scattered residual debris at pre-harvest levels (Edson Forest Products, 2014). and defines the acceptable standards for residual debris left for these accepted purposes. The standards described in this directive are applicable with ones described in the OGR.

- **Height of piles must not exceed 2 metres.**
- **Base diametre of piles must be no greater than 3 metres.**
- **Distance between piles must be no less than 15 metres.**
- **Distance from standing timber to debris piles must be no less than 25 metres**.

(Government of Alberta, 2017a)

The handling of residual harvest debris in Alberta's forest management activities is not regulated for with climate change mitigation or forest carbon strategies in mind. Although there are frameworks in pace that approach the alternative utilization of residual debris as habitat for wildlife, this decision is left up to the forest operator and the extent of this utilization is not documented or known as there is no supporting data beyond inaccessible expert opinion. Values of forest carbon are not considered and the cumulative impact from burning residual debris can be significant.

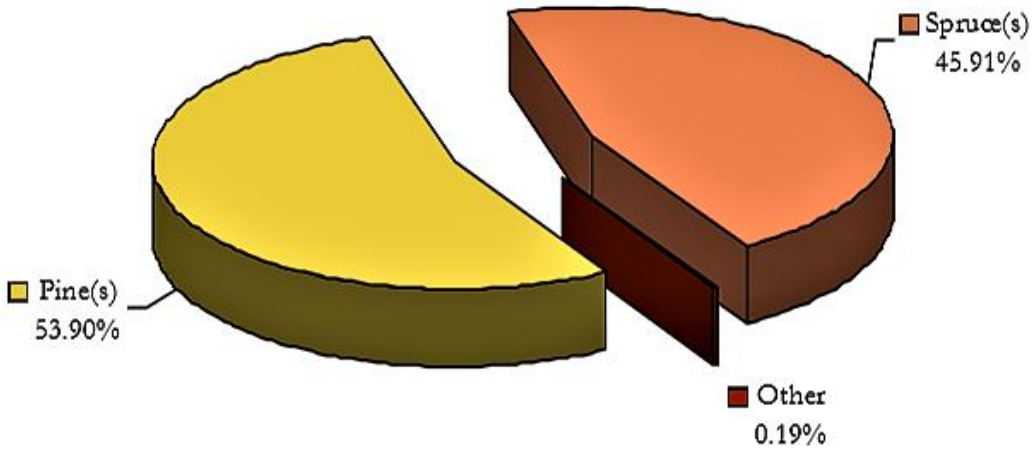
4.6.5. OGR Section 12 – Reporting

Reporting is to be undertaken to ensure sustainable forest management techniques and activities are being applied in FMU's and larger FMA's. Reporting is always to be undertaken by industry operators to ensure data relating to forest harvest volume and forest management activities are recorded in order to monitor adherence to legislated practices. *"The intent of reporting is to communicate that a given activity has occurred, where it occurred and when it occurred*" (Edson Forest Products, 2014, p. 58). Significantly, forest companies that have annual harvest levels greater than 30,000 cubic metres have self-inspection agreements in place with the Alberta government, and are intended to submit reports to the province to support the provincial database (Edson Forest Products, 2014). Relying on industrial operators to reports their management techniques and harvest levels may allow for bias and misleading reporting standards in some instances, especially where forest values at risk are concerned.

Alberta's OGR functions as a guideline that directs tangible forest management activities at the harvest level. Throughout the OGR there are no references to climate change mitigation, forest carbon sinks, or the enhancement of forest resilience in the face of uncertain climate challenges that will be present in Alberta forests in the future. Although forests in Alberta are approached with a 2-cycle, 200-year sustainable harvest scenario (Edson Forest Products, 2014), the definition of sustainable forest management in Alberta does not correspond with international definitions that include enhancement of carbon sinks within the forest. There is significant room for Alberta to adapt its sustainable forest management strategies to meet up with international standards of best practice. Although reforestation programs mandated by the Alberta government are effective and comprehensive, they are undertaken with a preference towards rapid regeneration rates which focus on quick turn-around times to maintain a sustainable timber harvest supply. As such

operators prefer to plant pine and spruce species which tend to have quick turn around times, especially lodgepole pine which regenerates rapidly in cut block areas (Alberta Agriculture and Forestry, 2017b). In 2014-15, Alberta planted over 82 million seedlings province wide, however only 155,062 of those trees were species other than pine or spruce (Alberta Agriculture and Forestry, 2017b).

Figure 7 - Percentage of trees planted in harvested areas by species in Alberta, 2014-15



(Alberta Agriculture and Forestry, 2017b)

The very low percentage of other species reforested seemingly goes against the percentages of trees harvested for in Alberta Forests. In 2014-15, Alberta's AAC was 32.4 million cubic metres, with 60.45% allocated to coniferous trees and the remaining 39.55% allocated to deciduous trees (Alberta Agriculture and Forestry, 2017a). This lack of species diversity could be directing Alberta's forests towards heavier coniferous populations, which reduces species diversity and could affect forest resilience rates to insect infestations and climate change. Forest managers routinely rely on deciduous trees to re-grow naturally after harvesting, as many Alberta deciduous tree species, such as trembling aspen, use shallow root systems to send up new shoots as reproduction instead of requiring germinated seeds (Alberta Agriculture and Forestry, 2017a). However, there is little data regarding regeneration statistics for this type of regeneration program, and the large percentage of coniferous trees planted in the province demonstrates the priority of planting and harvesting timber for the softwood lumber industry. There is not enough data at this time to determine how much of an issue this could be in the future with the implications of climate

change, but the disparity between coniferous and deciduous planting programmes in Alberta should be noted.

Where I think there's scope for improvement is that a company's liability is released when a reforested block is deemed free to grow, and so, their incentive is to reach the free to grow stage at the lowest possible cost in the shortest possible time. The challenge in that is they put too much lodgepole pine in the ground and not enough of other species. Its over-weighted to the fast-growing species that are cheap for companies to purchase the seedlings for from nurseries. – Canadian Climate Change Policy Analyst, (Interview Participant C, 2019). (Statement paraphrased by Report Author).

The OGR guidelines regarding disposal of residual debris represents a forest management activity that could benefit from significant improvement. Although mitigation wildfire risk is an important aspect of sustainable forest management. The practices outlined in Alberta's FPPA and OGR guidelines that call for the burning of residuals is a missed opportunity. Residual forest fibre residuals can be utilized in numerous other ways that could represent increased values for the forest industry. Residual fibres could instead be harvested and utilized to create long-lived HWP which could benefit the economics of forest operators while simultaneously reducing the significant GHG emissions associated with slash pile burnings. Simultaneously, wildfire risk could be reduced, as the practice of burning piles of forests residuals necessarily introduces fire into the forest in a needless way. There have been numerous incidences of wildfires caused by improper residual burning techniques and this represents a simultaneous risk to sustainable forest values as defined by the government and also economic risks to the forest operator who may be held liable for the damages incurred to timber and the costs of fire fighting operations as defined in the FPPA. The scale of residual opportunities within the province of Alberta has been discussed elsewhere and will be examined later in this report. In the face of global climate change challenges and Canada's domestic forest carbon challenges, silviculture practices within Alberta's forest management regimes would be well-served to begin considering the insertion of values like forest resilience into their reforestation program guidelines.

4.7. Alberta's Forest Management Planning Standard

Alberta officially implemented its Forest Management Planning Standard, hereafter referred to as "The Standard" in May of 2006. The standard was adopted from *Sustainable Forest Management: Requirements and Guidance Document*, referred to as CSA-Z809-02, which was developed by the Canadian Standards Association for application in Canadian forests (Alberta Sustainable Resource Development, 2006). Part of the reason for the adoption of this standard is to enable certifications from third-party auditors. Forest certification is recommended but not mandatory in Alberta, and implementation of a nationally recognized standard increases the likelihood of attaining sustainable certification standards. Canada holds the largest area of certified sustainable forests in the world with more than 48% of the country's forests certified as sustainably managed, representing 37% of all globally certified sustainable forests (Natural Resources Canada, 2019). Forest certification is important for the Canadian forest industry as it allows companies to brand their manufactured timber products as sustainable forest products, both domestically and globally enabling them to sell to customers with high standard requirements. All certified forests in Alberta necessarily meet the legal requirements detailed in the standard, however third-party forest certification is not a necessary requirement for FMP approvals from the government.

Even through application of the standard, Alberta relies on the competence and professionalism of Regulated Forestry Professionals (RFP) to apply the principles of sustainable forest management while planning and completing forest management activities (Alberta Sustainable Resource Development, 2006). The standard's focus aims to *"maintain a strong and direct connection between the **desired future forest** condition and a spatially planned forest harvest sequence, and predictions of forest growth and yield and actual stand level performance"* (Alberta Sustainable Resource Development, 2006, p. 7). Alberta's objective for employing the standard as planning guideline is to select a ***sustainable forest management*** scenario that will require minimal changes until the next management plan is approved.

Under the standard's Alberta definitions located in Annex B, desired future forest is "*a spatially explicit projected range of conditions of the forest landscape 100+ years into the future. The range of forest conditions defines the goal towards which forest management will be directed…"* The definition of sustainable forest management under the standard is the same that applies in Alberta's OGR. "*"Management to maintain and enhance the long-term health of forest ecosystems, while*

providing ecological, economic, social and cultural opportunities for the benefit of present and future generations" (Alberta Sustainable Resource Development, 2006, pp. 23,27). These definitions are paramount to understanding Alberta's approach to sustainable forest management strategies and applying these strategies into a long-term outlook for Alberta's forests in the future. Applying sustainable forest management in Alberta through the lens of the standard entails that FMP's shall focus on how forest management activities of timber operators on FMA's will be managed in order to reduce impacts towards other resource users and other resource values, this is accomplished by managing the forest management activities in a way that creates a desirable future forest and upholds the definition of sustainable forest management in an Alberta context (Alberta Sustainable Resource Development, 2006).

4.7.1. Sustainable Forest Management (SFM) Performance Standards

Key to the determination of sustainable forest management activities in Alberta is the development of performance standards that are measurable and are reported for within approved FMP's. The need for sustainable forest management performance requirements is affirmed in section 6.0 of the standard indicating that the mandatory Values, Objectives, Indicators and Targets, (VOIT's) identified by Alberta shall be meaningfully addressed within approved FMP's (Alberta Sustainable Resource Development, 2006). With this consideration, Alberta has developed minimum performance standards to be addressed in FMP's. These VOIT's are quantitative targets that have been developed by Alberta in consultation with stakeholders and are deemed to have been rationalized based on social acceptance, credible analysis techniques and clearly stated value trade-offs (Alberta Sustainable Resource Development, 2006).

The VOIT's located in Annex 4 of the standard provide the framework for linking values to clear forest management objectives and measurable indicators and targets. Under the standard, Indicators and Targets are more fluid than the relatively static Values and Objectives. Alberta is open to considering alternative Indicators and Targets providing they meet the approval of stakeholders and Alberta believes that they are reasonably attainable given the Values and Objectives (Alberta Sustainable Resource Development, 2006). Due to the presence of multiple actors within FMA's and uncertainties regarding the cumulative impact of all these activities, Alberta considers that forest area managers are responsible for reporting on the Indicators and

Targets within Alberta's VOIT's, but are not responsible for the addressing the results of those reports (Alberta Sustainable Resource Development, 2006).

Within the Standard, Alberta has identified 5 Criterions that identify VOIT's to be managed and conserved for within FMP's.

Criterion 1 – Conservation of Biological Diversity

Element 1.1 – Ecosystem Diversity - *Corresponding to "coarse filter" management; i.e. maintaining natural patterns at the landscape level.*

Element 1.2 – Species Diversity – *Corresponding to "fine filter" management; i.e. managing for the needs of individual species.*

Element 1.3 – Genetic Diversity – *Focusing on the genetics of tree species. It is assumed that in meeting the intent of elements 1.1 and 1.2, the genetic diversity of other organisms will have been addressed.*

Element 1.4 – Protected Areas and Sites of Special Significance – *Alberta retains the authority to establish protected areas and sites of special significance, which is addressed through other land use planning methods i.e. the Lands Act.*

Criterion 2 – Maintenance and Enhancement of Forest Ecosystem Condition and Productivity *- This is contingent on the timber supply analysis condition that is described in Annex 1. Has to do with reforestation programs and the maintenance of forest land base.*

Criterion 4 – Forest Ecosystem Contributions to Global Ecological Cycles *– As forest carbon budget models are upgraded and the administrative systems are established, the requirements for addressing carbon issues shall be addressed in updates to the standard or in interpretive bulletins.*
Element 4.1 – Carbon Uptake and Storage

Element 4.2 – Forest Land Conversion

Criterion 5 – Multiple Benefits to Society *- Organizations are not obligated to address 5 as Alberta is responsible for allocating resources.* (Alberta Sustainable Resource Development, 2006)

Although Alberta has identified forest ecosystem contributions to global ecological cycles (i.e. climate change) as a criterion category for identified VOIT's to be managed and conserved for under the standards sustainable forest management performance indicators. Alberta has not yet identified specific Values, Objectives, Indicators, or Targets relating to element 4.1, forest carbon uptake and storage, or element 4.2, Forest Land Conversion. In Annex 4 of the standard, the phrases "to be determined" and "results of forest carbon budgeting model" are the only entries into the performance standards table for this criterion (Alberta Sustainable Resource Development, 2006). The standard has been in place since 2006 and since that time Canada's carbon budget model CBM-CFS3 has been updated and applied to the last few national inventory reports (Kurz, et al., 2018). Since 2006 there have been no updates to the standard, and additional interpretive bulletins attached to the standard have also failed to mention any updates or changes related to Criterion 4 – Forest Ecosystem Contributions to Global Ecological Cycles. This includes the most recent update, *AF-FDP-2017-03 - Forest Management Planning Standard Interpretive Bulletin: Stewardship Reporting Requirements* released in 2017 (Government of Alberta, 2017c). This is a significant issue for Alberta's sustainable forest management practices and puts into question the certified sustainable aspects of the provinces forest management programs. This issue should be addressed in the future, as more information is currently available and forestry information for provinces are accumulated and are integrated into Canada's carbon accounting reporting system to the UNFCCC.

Considering the definition of sustainable forest management, from the UNCED 1992 Rio Earth Summit, chosen as a benchmark for this report. Alberta's forestry regulations and policies do not go far enough to protect for forest carbon reservoirs or sinks. None of the regulations and policies examined in this report mention or protect for forest carbon sequestration or propose managing Alberta's forests for resilience under the reality of climate change. Alberta should consider expanding the definition of sustainable forest management within their forestry regimes to reflect changing global opinions regarding the importance of sustainable forest management in climate change mitigation efforts as demonstrated by the Rio Earth Summit and the recent Paris Agreements (UNFCCC, 2015); (UNCED, 1992). This definition would assist the integration of climate change and forest carbon values into Alberta's forestry management regime. The enhancement of forest carbon sinks, and the reduction of forest carbon emissions associated with forest management practices especially the practice of slash pile burning should be regulated for

within Alberta's forest management framework. Alberta's definition of desired future forests should integrate climate change resilience and species retention so Alberta's forests can be managed for these values into future generations.

4.8. Regulations and Policies Governing Forest Harvest Practices in British Columbia

There are two main pieces of legislation that govern forest harvest practices in B.C. and several other acts that inform harvest practices to a lesser degree.

- *The Forest Act (FA):*
    - Deals primarily with determination of how much timber can be harvested (AAC), who can carry out the harvesting, and assessing value to the harvested timber through forest rents and stumpage fees.
- *The Forest and Range Practices Act (FRPA):*
    - Sets regulatory requirements for actual harvesting activities, including planning for roads and cut-blocks, reforestation requirements, and environmental standards that must be met. The FRPA lays out the guidelines for development of Forest Stewardship Plans that are the key element of all forest management plans in the province. The FRPA also sets out administrative penalties for organizations that fail to perform to the standards set under the act.
- *Secondary Non-timber specific acts that effect harvest regulations*
    - Wildfire Act
    - Wildlife Act
    - Water Act
    - Others

(Government of British Columbia, 2005)

4.8.1. Forest Act

B.C.'s Forest Act (FA) lays the foundation for forestry operations in the province and gives the power to regulate tenure lengths and AAC calculations for Crown timber. Under the FA, the Minster of Forests and Ranges, in conjunction with other government officials, can issue tenure agreements of various lengths to companies, individuals, communities, or indigenous groups. Determination of the AAC is the responsibility of British Columbia's independent chief forester, their responsibility is to intake information from the timber supply review in order to determine AAC volumes for each of the provinces Forest Management Units (FMU's). As of 2019 British Columbia has 73 FMU's made up of 38 Timber Supply Areas (TSA'S) and 34 Tree Farm Licenses (TFL's) (Government of British Columbia, 2019a). The Chief forester uses detailed analysis involving 200-year fibre supply projections, consideration of non-timber values such as biodiversity, watersheds (hydrology), etc. and public comments to inform decisions regarding AAC for each forest management unit. The Chief Forester also integrates economic, environmental and social concerns into their determination of the AAC ensuring that recent upgrades or changes to policies or forest management practices are considered in the final decision (Government of British Columbia, 2012). The average area that is allocated for timber harvesting in the province of B.C. is ~22 million hectares (SFM Canada, 2017). Under Section 8 of the Forest Act, The Chief forester must make determinations for the AAC at least once every 10 years for Crown land Timber supply areas and TFL's separately and must notify forest operators in the area of the changes in AAC if there are any.

Under the Section 14.1 of the *Forest Act*, the Lieutenant Governor in Council maintains the ability to increase the AAC and decrease stumpage prices to take advantage of natural disturbances by designating a Mountain Pine beetle salvage area. These programs are aimed at increasing the harvestable area of British Columbia's forests that have been devastated by insect infestations and do affect forest carbon levels, but the explicit goal of salvage logging operations is not aimed at climate change mitigation or enhancement of forest carbon sequestration at this time. Similarly, the flexibility in determining the AAC in British Columbia can also diminish the amount of available timber to be harvested in response to large scale natural disturbances. In 2003 the government passed the *Forest Revitalization Act* which placed a 20% reduction on each area of crown land areas described in a timber license. This was done in response to the emerging pine

beetle infestation in the province and affected the AAC available for British Columbia harvesters significantly (Government of British Columbia, 2003). With the power to make decisions regarding the AAC and incentivize salvage logging through decreased stumpage rates, the opportunity exists for the Lieutenant Governor in Council, the chief forester, and other regulators within British Columbia's forest ministry to incorporate climate change and forest carbon values into legislation and protect for these values in the administration of British Columbia's forest management practices.

It is clear we do not have effective legislation in place to deal with carbon. It's not even mentioned in the Forest Resource Practices Act, or in any of the professional reliance models for professional forester accountability and the list goes on. So, I think there needs to be an institutional overhaul that brings greenhouse gas emissions and removals into the accountability framework for land managers so that they can't continue to do this stuff without. Without consideration of the implications of their actions. – Canadian Forest Carbon Researcher, (Interview Participant I, 2019). (Statement paraphrased by Research Author).

4.8.2. Forest and Range Practices Act

British Columbia's Forest and Range Practices Act (FRPA) is the principle piece of legislation that defines operational forest harvest activities in the province. All timber harvesting operations on public (Crown) lands that are subject to tenure agreements under the Forest Act, must comply with the regulatory requirements under the Forest and Range Practices Act. Importantly, the Act lays out the content of Forest Stewardship Plans (FSP's) that represent the backbone of forest management plans for forest harvest operations. The Act requires that FSP's document how forest management activities will be consistent with resource-specific objectives set by government and protect for 11 key values detailed under the FRPA. Before FSP's are approved by the government, companies must allow for public comment and scrutiny regarding the plans short and long-term objectives and provide information to various indigenous groups who may be affected by forest management activities (Government of British Columbia, 2012). Importantly, the Act also mentions external requirements to forest management activities such as road construction, determination of forest health, and reforestation (silviculture) (Government of British Columbia, 2012).

4.8.3. Forest Stewardship Plans under FRPA

On an operational level, FSP's are intended to direct the activity of forest harvesters in public forests and hold them to a standard of ground level operation in spatial forest units that is in line with overarching government objectives for British Columbian forests. The Ministry of Forests, Lands, Natural Resources and Rural Development (FLNRO) in British Columbia has established a hierarchy for provincial timber management goals, objectives and targets that establishes certain values in provincial crown forests that are to be considered when informing FSP's at the operational level for forest units.

The provincial hierarchy of goals, objectives and targets at various levels includes:

• **Vision for B.C. provincial forests** – provides a provincial context for timber management goals, objectives and targets.

• **Provincial timber management goals, objectives and targets** – provides context and direction to help guide the development of supporting local management unit targets.

• **Local (management unit) timber targets** – Local targets guide timber management activities such as harvest practices and silviculture. (Minstry of Forests, Lands, Natural Resource Operations and Rural Development, 2017)

The goal of FLNRO's vision for sustainable forest management in British Columbia is to keep the various levels of the forestry industry accountable to the main vision for provincial forests. The guiding framework for provincial forests necessarily includes:

• Managing forests to meet present needs without compromising the ability of future generations to meet their needs;

• Providing stewardship of forests based on an ethic of respect for the land;

• **Maintaining and restoring proper ecosystem function and promoting ecological resilience for influences such as climate change**;

• Balancing economic, social, spiritual, ecological and recreational values of forests to meet the needs of people and communities, including First Nations; and

• Conserving biological diversity, soil, water, fish, wildlife, scenic diversity, and other forest resources (Minstry of Forests, Lands, Natural Resource Operations and Rural Development, 2017).

British Columbia's overarching objectives for timber and non-timber values are detailed in the *Forest Planning and Practices Regulations* (FPPR) within the FRPA. These objectives are legally applicable to FSP's developed by forest licensee's BC timber sales operators (Minstry of Forests, Lands, Natural Resource Operations and Rural Development, 2017). Through the establishment of a hierarchy dictating provincial goals and objectives, FLNRO intends to inform timber management strategies for industry stakeholders at all levels. Timber management strategies that reflect the overarching provincial vision seek to optimize benefits for multiple values in provincial forests. Under Section 5 – 10 of the FPPR, FSP's are legally required to consider the following values to conserved and protected for as objectives set by the government to be achieved:

- Soils
- Timber
- Wildlife
- Water, Fish, Wildlife and Biodiversity with Riparian Areas
- Fish habitats in Fisheries sensitive watersheds
- Water in Community Watersheds
- Wildlife and Biodiversity – Landscape Level
- Wildlife and Biodiversity – Stand Level
- Visual Quality
- Cultural Heritage Resources (Minstry of Forests, Lands, Natural Resource Operations and Rural Development, 2017).

Conflictingly, the values of the government protected for at the operational harvest level under FSP's do not reflect the overarching vision for sustainable forest management of British Columbia's as detailed in guiding framework of the provincial vision statement. Although the sustainable vision for British Columbia's forests includes fostering ecological resilience respecting

climate change, there is no specific mention of climate change initiatives or the enhancement of forest carbon as values to be protected for. This could be due to the vague wording of the climate provision in the provincial vision statement. However, the lack of a clear designation for climate change and related objectives to be protected for in British Columbia's forests is an issue that needs to be addressed at the operational level where the actual harvesting and forest management activities take place.

Forestry regulations in BC are still grounded in the early 2000's changes in the legislation, and those changes basically put management of forests into the hands of the forest industry and the result of that has been that public interest in the crown forest has been discounted greatly as compared to the benefits for the private shareholders of these large industrial forestry companies. – Canadian Climate Change Policy Analyst, (Interview Participant C, 2019). (Statement paraphrased by Report Author).

4.8.4. "Results Based" Forestry: Regulatory changes under the FRPA

The FRPA underwent significant amendments in 2002 with the government scaling back it's influence and control over forest management practices, instead placing increased amounts of trust and responsibility into the hands of large forestry companies and forest industry operators to manage forest resources in the best way they saw fit. This roll back of government influence introduced a new regime of "results-based" forestry that reportedly diminished 55% of government "red-tape" and paperwork; essentially reducing the requirements that industry operators had to fulfill to operate in British Columbia's Crown land forests (West Coast Environmental Law, 2004). These changes were enacted in the face of decreasing profits from the forest sector in general and was a response to corporate complaints that forest harvesting practices were too heavily regulated by the government and interfered with effective business practices on the side of forest harvest operators (West Coast Environmental Law, 2004).

The changes to FRPA came into force January 31, 2004 and as a result of the governments attempt to increase industry investment and revitalize the economics of the forest industry in British Columbia, many concessions were made to environmental protections, and sustainable forest management policies. For example, the industry was able to write and control the environmental results that they were legally required to achieve; installing restrictions as to when the government

could reject a FSP for failing to adequately protect forest values. Provisions were inserted for industry operators to "opt-out" of certain standards that were previously governed for in the *Forest Practices Code* and increased regulatory restrictions and bureaucratic hurdles restricted the government from taking meaningful action to protect environmental values (West Coast Environmental Law, 2004).

The effect of this large-scale deregulation of the British Columbian forestry industry served to transfer control of significant portions of publicly held resources (crown land) into industry control. These effects were amplified by significant cutbacks to the BC Ministry of Forests staff and budgets. Effectively, the changes to FRPA and its applicable new regulations under Bill 22 in November of 2002 left "inadequate checks and balances in the regulations" and reduced public input on the practices of forest industry on public lands (West Coast Environmental Law, 2004). Specific changes to regulatory requirements are evidenced by the almost complete repealing of the *Forest Practices Code* (FPC), which had governed numerous aspects forest management activities in BC since the mid 1990's. The FPC's main aims were to regulate the preparation and application of forest site development plans and silviculture (reforestation) prescriptions. The FPC operated to approve operational plans in the forest industry, under the FPC site development plans were developed in conjunction with silviculture prescriptions before cut-blocks for timber harvesting would be authorized and approved (West Coast Environmental Law, 2004). This involved setting aside certain areas of timber cut-blocks to be left standing, and certain prescriptions for tree species were required to increase reforestation diversity levels and enhance forest ecology and biodiversity. The FPC was criticized in certain industry circles as being "too bureaucratic and uncertain" (West Coast Environmental Law, 2004).

"I think they had it right once in BC, when they had the forest practices code, but the majors got fed up with it because it was such a learning curve for even the technicians that were employed by the government in enforcing it. So, it was a bit of strong arming going on and it was not enjoyable to try to meet all the rules, regulations and guidelines. So, they relaxed to the point where they threw it all in the RPF's lap and made them accountable. They were employed by the company. Well, for me, I've seen it firsthand where that's way too heavy on the company's side. So, I'm thinking that they need to revisit and go back to where they were." – Retired British Columbia RFP and Owner of Sunshine Logging – Jeff Mattes, (Interview Participant K, 2019).

Due to significant industry pressure, and related economic uncertainty, the majority of the FPC was repealed and planning and practices codes were replaced under the FRPA by the Forest Planning and Practices Regulation (FPPR) (Government of British Columbia, 2004), which significantly reduced the content formerly required for forest development plans and weakened the planning and practices approach. The FPPR approach limited the amount of industry information that flows to the forest service and eliminated the necessary approval of the forest for site level plans and has replaced forest development plans with the very opaquely constructed Forest Stewardship Plans that have since become the backbone regulating the approval of industry operations in Crown lands (West Coast Environmental Law, 2004).

"[FRPA] basically has provided for corporate bottom lines and people continue to be continue to be pawns in that game and to fight one against the other, or use the workers to try to hold onto that would supply because at the same time that the companies just again buying and selling…When the Forest Range and Practices Act took the place of the Forest Practices Code… We took a giant step backwards in British Columbia." – Conservation Director at Wildsight eNGO – John Bergenske, (Interview Participant H, 2019).

The elimination of site level plan approvals decreased the ability of the government to protect certain values within the forest ecosystem, such as wildlife habitats and ecology zones. For example, silviculture prescriptions were site level plans that offered the government the opportunity to identify practical changes to logging plans that would protect for certain values in the forest, and could then require that operational plans be altered to preserve for example a section of forest that serves as winter habitat for animals (West Coast Environmental Law, 2004). As mentioned above, the FPPR significantly reduced the amount of information required for forest development plans under the FRPA. This can be seen in the content requirements for FSP's in Section 5 of FRPA in Appendix K

FSP's do not require the same level of specificity which limits the amount of detail coming to government and the public for review and comments. For instance, under their previous formulation, forest development plans were required to specifically detail where cut-blocks and road locations would be placed spatially within a forest management area due for harvesting activities (West Coast Environmental Law, 2004). Under the new regulations, industry was only

required to detail that road construction would be taking place somewhere within the forest management unit. Which is far less spatially specific.

British Columbia's forest management practices have for the most part performed poorly at protecting for the forest values beyond timber, and changes to the FRPA exacerbated this problem by giving industry operators more control of forest management from planning to actual activity-based harvesting (West Coast Environmental Law, 2004). Changes the FRPA gave industrial operators lots of leeway to obtain licenses and cutting permits even before their FSP's had been approved as legislated in section 195 of the FRPA (Government of British Columbia, 2002).

Significantly, the changes to the FRPA in favour of large-scale industry operators reduced the ability of the government to enforce the protection and conservation of values within FSP's as stated by the provinces forest management objectives. For all stated objectives in Section 5 – 10 of the FPPR, except timber, the caveat "without unduly reducing the supply of timber from British Columbia's Forests" proceeded (Government of British Columbia, 2004). This vaguely worded provision can be loosely interpreted by forest industry personnel who construct FSP's for forest development units. With no specific definition in the FPPR describing what unduly reducing the timber supply would look like, the ability for industrial forest operators to take advantage of weak government provisions opens even further.

The deregulation of the FRPA in 2002 placed a significant amount of control in the hand of forest industry operators in British Columbia. The government became less able to limit the plans and environmental damage caused by industry operators on public lands and numerous small business that had previously existed in communities were swallowed up by large corporations financially equipped to take advantage of the industry deregulation. Forest values of concern to the public and to a lesser degree the previous forest values of concern to the BC government were ignored in favour of increased industry investment and the stabilizing presence of large-scale operators. This led to many large-scale forestry operations increasing production and taking advantage of the softer regulatory climate in British Columbia. Values such as forest carbon and climate change mitigation were not considered in the FSP's that inform operations and forest management activities in British Columbia's forests and this, along with significant instances of natural disturbances such as wildfire and insect infestations, greatly reduced the forest sink potential in BC during this time. Recently, in an attempt to regain control of the forestry industry in British

Columbia, Bill 22 was passed which includes proposed amendments to the FRPA (Government of British Columbia, 2017).

4.8.5. Changes to the FRPA via Forest Amendment Act

Bill 22, or the *Forest Amendment Act*, intends to support the health and sustainability of British Columbia's forests and strengthen public confidence regarding how forests are managed (Government of British Columbia, 2017). The Minster of Forests, Doug Donaldson, gave a brief statement regarding how the proposed changes will affect the FRPA and how these changes will inform the public and direct forest management practices in British Columbia's forests. Notably, the changes are intended to:

- **Clarify government's objectives for forest and range resources**
- **Improve information sharing in forest planning**
- **Ensure those who manage forest and range resources on the ground are accountable for achieving desired outcomes**
- **Increase opportunities for communities to engage in the planning processes** (Government of British Columbia, 2017).

Although Bill 22 has been passed, the implementation of the amendments is likely to take a few years until they begin to impact harvesting activities in a meaningful way. Significantly, the government has opened a public discussion period revolving the integration of climate change considerations and ecosystems resilience into forest planning and practices through the amended FRPA.

This is a major regulatory step for British Columbia to take; as the integration of climate change and forest carbon protection initiatives in the province's most impactful forest regulatory framework would begin to protect for these values in a meaningful way. Proper assimilation of forest carbon values into British Columbia's forest framework would align the provinces application of sustainable forest management with international benchmark definitions and demonstrate an increased commitment to Canada's global climate commitments. Simultaneously enhancing the health of forests and increasing their resilience and adaptability to withstand the

impact of natural disturbances in the forest. Some proposed climate change mitigation directions to be discussed in this public consultation involve providing more regulatory assurance that tree species selected for reforestation projects would be chosen for their resilience to climate change and help ensure that associated plant and animal species would be more prepared to adapt to a changing climate. Some of the benefits expected to be realized from integrating climate change mitigation and forest carbon as values to be protected for under the *Forest Amendment Act* are suggested to be:

• Mitigating forest losses associated with climate change and natural disturbance events on timber and forage supply, wildlife, water and other values

• Creating more resilient forest landscapes that continue to provide sustainable benefits to communities and Indigenous Nations over the long term

• Enhancing the economic benefits associated with carbon management and fibre utilization

• Improving public awareness of the effects of climate change on forest and range ecosystems and the importance of adapting forest and range management to a changing climate (Government of British Columbia, 2017).

While the proposed amendments to British Columbia's FRPA are a start, there still exists a significant need for greater integration of climate change and forest carbon concerns throughout British Columbia's forest management and regulatory structure. The proposed changes may take years to implement and there is no guarantee that the shift to climate change resilience and forest carbon protection will be meaningfully implemented at this time. As it stands the current regime structure is ineffective at preserving these important values for British Columbian forests.

4.8.6. Slash Pile Burning Regulations, BC Wildfire Act and BC Industrial Burning Guidelines

The guidelines regarding the burning of harvest residuals in British Columbia is governed by Section 12.1 of British Columbia's *Wildfire Act* (Government of British Columbia, 2019d). Similar to Alberta's slash burning guidelines, the government's interest in burning or removing the leftover harvest debris is one of risk mitigation for wildfires. The regulations require that industrial operators on crown lands must abate the risk of wildfire on the lands they operate on within 24 months after operations on the land have begun and a potential fire hazard that the operator is

"aware of or ought to be aware of" has been identified (Government of British Columbia, 2019d). These hazards are identified during assessment periods that take place every 6 months while harvest operations are taking place and are ideally written into the harvest operator's FSP for the FMU (Government of British Columbia, 2019d).

Under the BC *Wildfire Act*, there is no direct regulatory requirement to burn the harvest residuals, only the instead the tenure holder or operator must "reduce the fuel hazard on the…site as necessary to…ensure that risk of fire does not increase… [and] if a fire were to start, it would not increase the fire behaviour [on the site]" (Government of British Columbia, 2019d). This provides significant leeway for alternative methods of hazard abatement across the province. Significantly, this regulation provides opportunities for secondary harvesting practices through fibre recovery tenure agreements and fibre recovery zones to alleviate carbon emissions from this practice in British Columbian forests. These opportunities will be discussed later in this report.

The designated hazard abatement areas are subject to very specific fire guidelines and the government is very strict about when and how operators can conduct their burning operations. Slash piles burnt under this regulation are considered industrial burning and are deemed Category 2 open fires (Government of British Columbia, 2019d). This category of industrial fires is subject to stringent burn periods and restrictions which significantly reduce the burn-window (FLNRO, 2019). British Columbia's Guidelines for Category 2 Open Fires can be found in Appendix O.

As Canada's foremost forestry province (Government of Canada, 2019b), British Columbia progressively reports its own GHG emissions by sector in their PIR. As of 2019, they are the only province to do this for the LULUCF sector. The PIR impacts carbon accounting practices in the province and informs governmental and forestry stakeholders decision making processes. British Columbia's PIR follows national reporting standards developed by ECCC and thus currently excludes all emissions contributed by forest management operations and only includes emissions resulting from deforestation and afforestation (Government of British Columbia, 2016). In 2016, estimated emissions from provincial forest management operations in accounted for 30,968 kilotonnes of $CO_{2\ eq}$ (kt $CO_{2\ eq}$) but were excluded from the 62,264 kt $CO_{2\ eq}$ provincial total. emitted across all sectors. (Government of British Columbia, 2018b) Forest management is not considered largely because of mandated reforestation projects that replace 80% of harvested forest biomass annually with the remaining balance being replaced via natural generation (Government

of British Columbia, 2017), but this method fails to account for poor forest management practices which have substantial GHG emission implications. For instance, the practice of slash burning which is undertaken to remove residual biomass after harvesting operations as a forest fire mitigation technique, contributes large amounts of CO_2 to the atmosphere is quantified and reported, but not included in the final emission profiles in the provinces PIR, nor the Canada's NIR.

Although forestry practices are similar in British Columbia and Alberta, Alberta does not currently have a publicly available PIR or similar report accounting for emissions from the forest sector indicating a significant need for transparency regarding practices and accounting. Emission profiles from Canada's National Energy Board (NEB) and the NIR are the only public accounting sources for Alberta's forest sector currently. Whereas British Columbia is much more transparent with their emission profiles and most assessment reports can be found on government websites.

As part of national efforts to adhere to the Paris Agreement, Canada's Pan-Canadian Framework on Clean Growth and Climate Change in 2016 has specified a goal to reduce country-wide carbon emissions by 30% from 2005 levels by 2030 (Environment and Climate Change Canada, 2018). Under the guidance of the framework, the federal government has committed to support the flexibility of provinces to design and implement their own policies and programs to meet the specified emission-reduction targets.

In response, Alberta instituted the Climate Leadership Plan in 2015 which was aimed to incentivize renewable energy investment and decrease overall GHG emissions by 30% by 2030 (Government of Alberta, 2016). Although this plan is ambitious, it does not properly address the issues stemming from forestry emissions, with the most significant forestry-related clause of the plan being the *Carbon Competitiveness Incentive Regulation directive*, offering carbon offset incentives for secondary harvesters who facilitate the removal of forestry debris destined to be burned, and re-purpose it for bio-energy usage (Alberta Government, 2018). In contrast, British Columbia has been more aggressive in its approach to carbon challenges within their forestry sector and has recently instituted a number of policies and regulations aimed to reduce anthropogenic GHG impacts in the forest management sector and enhance forest carbon reservoirs. Policies such as the Forest Fibre Initiative which is aimed at increasing the utilization of residual forest fibres (Kozuki

& Stewart, 2019), and the Forest Carbon Initiative (FESBC, 2017), which has received substantial federal and provincial government funding to reforest areas affected by mountain pine beetle and wild fires and increase the carbon sink potential of British Columbia's forests. While Alberta has ambitious climate change policies regarding the energy sector and fossil-fuel based emissions, it has few mitigation policies explicitly targeting managed forests or the use of HWP for carbon sequestration opportunities.

Chapter 5: Opportunities: Economics of Slash Pile Utilization and Progressive Forest Carbon Initiatives

5.1. Perspectives on Economic Opportunities for Slash Pile Utilization and Current Forest Carbon Initiatives.

A lot of people are pushing for bioenergy, but with bioenergy we're producing energy with a lower density per unit of carbon emission than even coal and so we're not actually making a positive contribution to the atmosphere. If instead, we use wood for long lived products. We keep a large fraction of the carbon out of the atmosphere and we have a higher displacement factor. So, we're reducing the emissions in other sectors. Obviously, not every piece of wood that we take out of a forest can be used for a long-lived product. So, there will always be some residues that we could use for bioenergy. But bioenergy should always be the secondary or tertiary use of wood, not the primary use. – Canadian Forest Carbon Researcher, (Interview Participant I, 2019). (Statement Paraphrased by report Author)

In terms of where the climate has gone and some of the events we've seen, both in Alberta and BC, I would say that the current forest management regime has been an abject failure. It may have been a success in terms of the large forest companies in terms of providing them certainty, to providing employment. That certainly has not provided a diversity of employers in an area. We basically have an oligarchy in forestry in B.C., a few major companies and in the small regional areas it's a monopoly whereby people who are selling services within the forest industry only have one buyer. In terms of economics it's an absolutely horrible situation. – Canadian Climate Change Policy Analyst, (Interview Participant C, 2019). (Statement paraphrased by Report Author)

"I think personally, I think you're going to have to move all the way to regulation, policy is nice, [but] do whatever you have to do. I think you do have to move to regulation. And again, I would emphasize that the regulation has to be tied to economic incentives." – Conservation Director at Wildsight eNGO – John Bergenske, (Interview Participant H, 2019).

5.2. Opportunities for Utilization of Forest Harvest residuals in western Canada.

5.2.1. Potential of Forest Residuals to Provide Bioenergy (Heat and Electricity)

Due to the reality of climate change and the threat it poses to global populations, interest in bioenergy has been steadily increasing around the world and western Canada is no exception. Bioenergy, in the form of heat or electricity has the potential to assist climate change mitigation efforts by reducing emissions associated with the combustion of traditional fossil fuels such as coal or natural gas to produce energy (Goerndt, Aguilar, & Skog, 2013). The integration of bioenergy into the Canadian energy mix faces significant challenges, traditional energy needs have long been met by low-priced fossil fuel and coal-fired electrical plants, British Columbia supplies much of its energy needs with a large hydro-power resource and Alberta has dedicated a significant amount of its upcoming energy projects to natural gas, a resource which the province has in abundance.

There are 3 leading impediments to widespread bioenergy adoption in North American energy grids; policy uncertainty, the low price of natural gas and feedstock source uncertainties (NRCan, 2014). A 2010 study conducted by Jones, Loeffler, Calkin and Chung, compared the total emissions associated with harvesting and combusting harvest residual fibre in a boiler for thermal energy generation against the alternative of burning the same amount of residual fibre on the harvest block in a slash pile, and generating the same amount of usable energy using natural gas (Jones, Loeffler, Calkin, & Chung, 2010). Compared to the on-site harvest residual combustion/natural gas alternative, cumulative emissions for the harvest residual to energy alternative produced 40% less carbon emissions, and 97% less methane emissions (Jones, Loeffler, Calkin, & Chung, 2010). Although the combustion of any fuel source produces GHG's of concern, it is important to consider the cumulative emission mitigation potential of utilizing harvest residuals for bioenergy. The climate change mitigation potential of combusting harvest residuals for energy depends upon the energy density of the fuel they are replacing and end-usage practice they are avoiding. (Jones, Loeffler, Calkin, & Chung, 2010). Utilizing harvest residuals that would have simply been burnt, or left to decay on-site, for bioenergy instead provides significantly more climate mitigation potential than burning the same amount of harvested green forest biomass (FLNRO, 2013).

Recognizing the potential of bioenergy support climate change initiatives, British Columbia has taken steps to introduce policies to increase the integration of bioenergy into their energy grid through government programs such as the Climate Action Plan, (British Columbia, 2008) and a recent emphasis under the Clean BC bioenergy strategy (CleanBC, 2019). Alberta similarly began pursuing bioenergy as a renewable energy source to assist the phase-out of coal-fired power plants under the guidance of the 2015 Climate Leadership plan (Government of Alberta, 2016), though it is uncertain whether these plans will be abandoned with the newly elected provincial government in Alberta. Although bioenergy technology has been utilized for decades in industrial forestry mills, such as lumber and pulp and paper mills, which have used their self-produced mill residues to partially satisfy their internal energy requirements. Significant potential exists for both British Columbia and Alberta to integrate forest harvest residuals into their energy grid (Layzell & Ralevic, 2006); (Niquidet & Friesen, 2014).

Estimations regarding the amount of available forest harvest residues in British Columbia could be as much as 11.9 million tonnes per year (Layzell & Ralevic, 2006). If all this residue was collected and fed into bioenergy plants it would amount to approximately 53 terawatt hours of energy produced annually, enough to supplant ~21% of the province's total fossil fuel energy demand (Layzell & Ralevic, 2006). Furthermore, if this model were expanded to include unmerchantable dead biomass resulting from the mountain pine beetle epidemic, it could add a further 11 million tonnes of annually available forest biomass to this theoretical bioenergy supply chain, further increasing the energy generation potential within the province and supplanting a further ~19% of BC's fossil fuel energy demand (Layzell & Ralevic, 2006). However, the increased utilization of residual forest biomass for energy production requires an adaptable and integrated supply chain. There needs to be viable end-chain demand for the products and a constant, long-term supply source (Goerndt, Aguilar, & Skog, 2013). Although the potential for large scale bioenergy production exists in British Columbia's forests, due to the sheer volume of available biomass, there exists significant barriers to utilization throughout the supply chain.

The economic incentives for harvesting slash are really variable, it all depends on the proximity. The value of the debris is directly correlated to how close the slash pile is to a facility. Most logging takes place long-distances from most facilities, so the economic incentives are fairly minimal right now. As it currently stands, it's just not economical to

harvest that debris. – Forestry Consultant in British Columbia – Patrick, (Interview Participant F, 2019). (Statement paraphrased by Report Author)

5.2.2. British Columbia's Bioenergy Outlook Modeled

In 2011, FPInnovations was contracted to develop a method to estimate the supply of residual forest biomass within selected Timber Supply Areas (TSA's) in British Columbia. This project assessed the availability of residual biomass per hectare of clear-cut forest and assessed delivery distances, as well as grinding and chipping costs, in order to estimate the economic viability of harvest residual collection and delivery within the selected TSA's (Friesen, 2018). Studies were conducted for 11 TSA's within BC's forest management areas. These areas were selected due to the proximity of communities with road accessible timber processing facilities that could handle and process the collected residual forest fibres and 7 of these locations served as theoretical stand-in locations for potential future bioenergy plants to determine the economic viability and volume of harvest residuals that could be conceivably delivered (Friesen, 2018). The availability of forest residuals was based on harvest rates for a typical 20-year tenure agreement, assuming 30% harvest residual generation with 50% recovery rates and taking into account recent annual allowable cut determinations. The model determined that between years 1 – 10, 8.8 million oven-dry-tonnes (ODT) were delivered to the 7 potential bioenergy plant sites, indicating significant available supply levels in region the model was applied to (Friesen, 2018). Pricing for the model was based on standard British Columbia payment rates for hog fuel, expenses associated with on-site collection activities like chipping/grinding (communition) costs, and expected transportation costs. The threshold for economic viability at standard industry price assessments was set at $60/ODT of delivered hog-fuel to the theoretical biorefineries (Friesen, 2018).

Hog fuel is commonly used as a fuel in biomass fueled energy plants and is most commonly produced from waste residual fibre derived from lumber mills and pulp and paper mills. It is an unrefined mixture of coarse woody debris that can consist of any type wood waste or by-product, but is distinguished from wood chips, mulch, and sawdust by its lack of uniformity in contents, size and shape (Cloverdale Fuels, 2019). Finding consistent sources of hog fuel is currently the largest on-going cost item for bioenergy plants and hog fuel can easily be produced from forest harvest residuals provided they are properly communited (Renewable Energy World, 2019).

Communiting wood fibre essentially means grinding or chipping it down to a coarse woody debris that can be utilized for bioenergy production (Renewable Energy World, 2019). Hog fuel is currently the most common product derived from forest harvest residuals as it relatively simple and cost-effective to produce and, by grinding the tops, branches, needles and bark that commonly make up harvest residuals, secondary fibre harvesters are able to maximize the amount of volume they are able to transport from the harvest block by reducing air space in truck loads (Spencer & Roser, 2017). Hog fuel can be used in direct fire bioenergy plants, co-gen plants and can be compressed into highly marketable wood pellets, which are a rapidly emerging industry in British Columbia (Spencer & Roser, 2017); (Renewable Energy World, 2019).

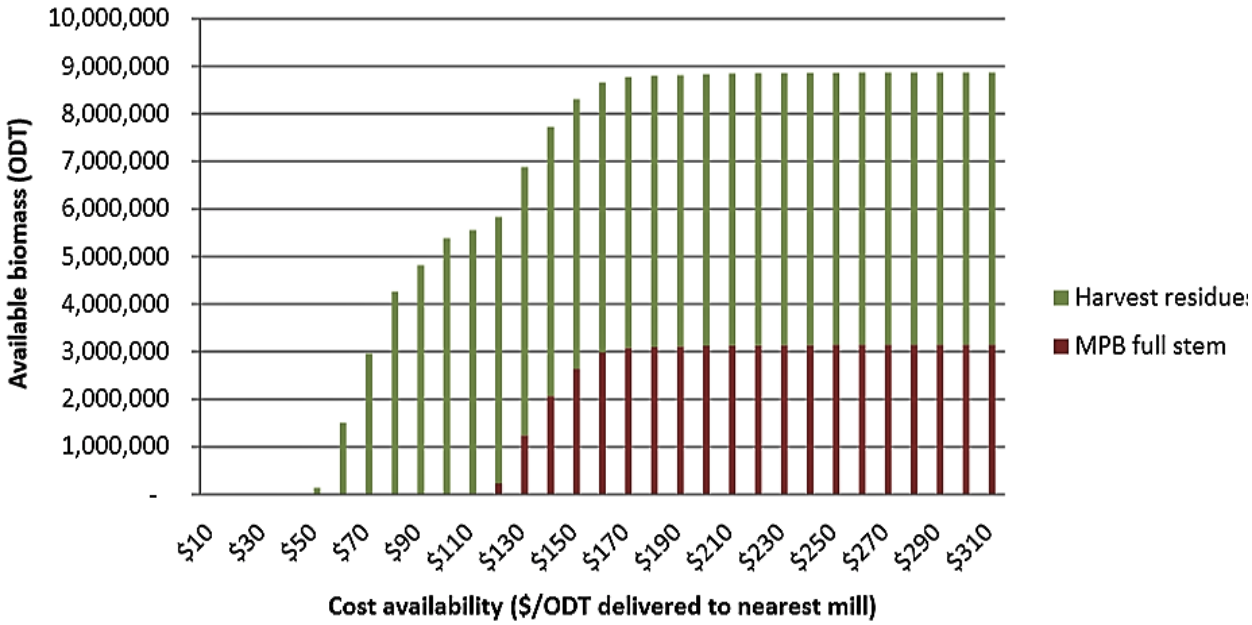
Figure 8 - Hog Fuel

(Cloverdale Fuels, 2019)

The FPInnovations model assessed approximate costs for delivered biomass to these facilities and estimated that of the total delivered 8.8 million ODT, only 1.5 million ODT were delivered at the calculated economically viable benchmark rate of $60/ODT, representing approximately 150,000 ODT/year (Friesen, 2018). In years 11-20 of the FPInnovations study, the amount of available

harvest residuals delivered at $60/ODT grew to 1.6 million ODT, however, approximately three times more residual fibre was available at the delivered price of $90/ODT, and substantially more residual fibre was available from the range of $100/ODT to $310/ODT (Friesen, 2018).

Figure 9 - Available Residual Biomass in British Columbia $/ODT Delivered to Mill



(Friesen, 2018)

The theoretical case-study model developed by FPInnovations clearly demonstrates the financial obstacles that wide-spread utilization of harvest residuals face in the forestry industry in British Columbia. Without the addition of significant government provided financial offsets or incentives, a fraction of the available supply of residual forest fibre is economically viable for secondary harvesters. In Canada, anything above $90/ODT delivered for hog fuel is considered prohibitively expensive (Friesen, 2018). Although countries like Sweden and Finland can support hog fuel costs over $120/ODT, they are supported by long-standing emission offset incentives and a substantial tax on fossil fuel combustion that has been in place since 1991 (IEA Bioenergy, 2017); (Extension, 2013).

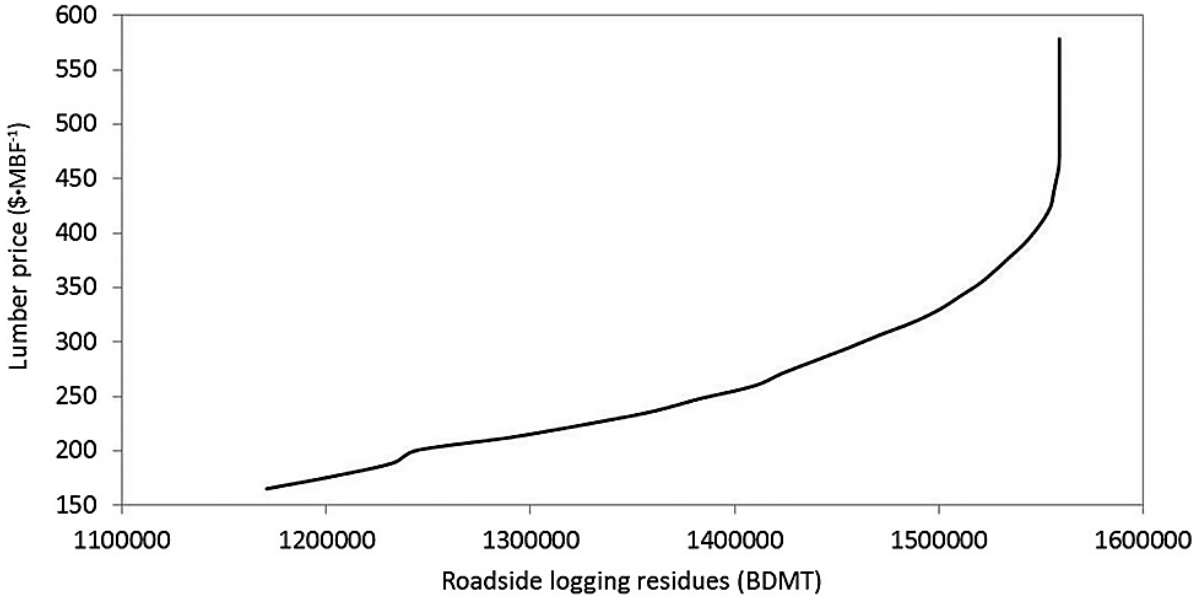
5.2.3. Alberta Bioenergy Outlook Modeled

Niquidet & Friesen completed a similar modeling exercise for Alberta's harvest residual supply in 2014, and determined that Alberta's forestry industry produces about 1.5 million bone dry metric tonnes (BDMT) of forest harvest residuals annually which, if fully utilized, could provide approximately 2.3 million MWh of electricity and supply ~23% of Alberta households with their annual electricity needs (Niquidet & Friesen, 2014).

However, Alberta suffers from the same utilization barriers as British Columbia; collection and transportation costs are extremely high, due to the long distances between harvest areas and communities capable of supporting a bioenergy plant, severely limiting the utilization potential of forest harvest residuals for bioenergy production in the province currently. Significantly, harvest residuals are often only considered for use after residue supplies from lumber and pulp and paper mills are exhausted due to the often prohibitive costs associated with harvesting and transportation from distant harvest blocks (Niquidet & Friesen, 2014).

Niquidet & Friesen constructed a utilization model using a set baseline price for electricity in Alberta, and a baseline harvest residual collection cost assumption of $\$400 \cdot MBF^{-1}$ (1000·Board feet). The application of this model determined that, under static price and supply scenarios, only 72, 823 BDMT of harvest residuals, out of 1.5 million available BDMT, could be considered economically viable for energy generation scenarios (Niquidet & Friesen, 2014). However, the amount of economically viable forest harvest residuals dramatically increases in scenarios where the price of electricity in Alberta increases. Under the model, if the price of electricity in Alberta increased 10% from the baseline level, 512, 371 BDMT of harvest residuals could be economically utilized in energy generation scenarios province wide (Niquidet & Friesen, 2014). The increased electricity price scenario still only predicts that ~3.4% of available harvest residuals would be viable for bioenergy production in Alberta (Niquidet & Friesen, 2014), suggesting that regulatory or policy action aimed at reduce the price of extracting harvest residuals from the forest could have significant benefits to the bioenergy industry in Alberta.

Figure 10 - Estimated available forest harvest residues (BDMT) at lumber price ($·MBF–1)



(Niquidet & Friesen, 2014)

Beyond forecasting a significant rise in provincial electricity prices or Canadian hog fuel prices, the vast majority of forest harvest residuals are simply priced out of the western Canadian market due to high collection and transportation costs relative to value. The forecast for residual utilization becomes increasingly negative when the economic models of transporting harvest residuals factor in the potential of rising fuel costs and possible carbon tax levies aimed at fossil fuel consumption (Niquidet & Friesen, 2014). Although British Columbia already has a provincially applied carbon tax on fossil fuels that it can realistically forecast into the future, Alberta currently does not. The potential impact of a carbon tax or levy on the viability of large-scale harvest residual collection is clear; as increasing fuel costs significantly reduced the amount of economically viable residuals available within the FPInnovations model (Friesen, 2018). A standard fuel price of $1.25/Litre was assumed for the duration of the model and increasing the applied fuel parameters price to $2/Litre reduced that amount of economically viable $60/ODT fibre by 57% (Friesen, 2018), suggesting that additional costs would have to be absorbed by the government to consider the practice financially feasible for primary and secondary harvesters.

In order to increase slash pile utilization, you have to increase the economics of it, explore what prices work and maybe look at baby step changes to slowly change management practices. It won't happen quickly. Increased utilization has been discussed in the past, but the economics of it have yet to make sense for most areas. – Forest Analyst for Government of Alberta, (Interview Participant G, 2019) (Statement paraphrased by Report Author)

The issues surrounding the economic viability harvest residual utilization could be approached through policy; either through a carbon tax or a carbon credit, or it could be incentivized purely through market mechanisms in time given a range of high-performing products. In order to become truly viable there needs to be an increase in demand for forest harvest residuals and currently demand remains very low while the supply is incredibly high. As such, it is not economically viable for forest harvest operators to collect the residuals and transport them to facilities to processed further. Barring a substantial change in production methods, a change demanding more HWP from harvest residuals, or a significant increase in bioenergy demand, regulation and policy currently appear to be the best, if not the only, options for increasing the utilization of forest harvest residuals and eliminating the practice of slash pile burning in western Canada.

5.2.4. Conversion of Forest Harvest Residuals into Harvested Wood Products

We should do everything we can to incentivize using the forest sector as a carbon sink, and by that I really mean thinking in the sense of grow, harvest, and then put the trees into a harvested wood product. Long-lived harvested wood products. We should be constructing massive timber buildings and avoiding steel, concrete, plastics, aluminum, etc. That's the winning strategy to mitigation outcomes through forest harvesting. – Forest Carbon Research Scientist, (Interview Participant I, 2019). (Statement paraphrased by Report Author)

Harvested wood products (HWP) can be an important tool in climate change mitigation efforts, the natural carbon that is absorbed via the photosynthesis process in growing trees is retained within the wood until it either is combusted, or naturally decays and is released into the atmosphere again. The Food and Agriculture Organization of the United Nations (FAO) has suggested that two ways the forestry sector can contribute to climate change mitigation efforts is the use of woody

biomass to create biofuels and the increased usage of HWP for construction materials instead of carbon intensive non-wood materials (FAO, 2015). When timber is harvested and turned into HWP, such as dimensional lumber, oriented strand board, plywood, particle board and even cardboard and paper products; carbon is retained within the product at various decay rates, dependent upon the product usage and composition, for the duration of the product life. The value that this carbon storage represents in the larger context of climate change can most effectively be realized when HWP are used to replace more carbon intensive forms of material (Geng, Yang, Chen, & Hong, 2017).

Depending on the usage and life-cycle of the HWP, the substitution of HWP for carbon intensive building materials such as cement can actually be more effective at reducing the GHG footprint than substituting wood for fossil fuels in bioenergy plants and biofuels for transportation, and it is estimated that for each milligram of carbon stored in a wood product reduces 0.25 – 5.6 milligrams of carbon emissions. (Geng, Yang, Chen, & Hong, 2017).

HWP can provide climate change mitigation benefits in three ways: sequestering carbon throughout the duration of their lifecycle, becoming a substitute for materials that require greater energy intensity to create (Cement, plastics etc.) and providing a renewable material for future energy generation (FLNRO, 2013). This last benefit concept has to do with the collection of landfill-bound construction debris and converting it into either bioenergy or biofuel to replace fossil fuel usage. If the converted HWP is replacing an energy intensive fuel source, the associated carbon benefits will increase.

In a recent search for optimal national climate change mitigation strategies, Canada's National Forests Sinks Committee assessed 6 different forest related mitigation strategies and found that the best strategy, in the long term (up to 2050), was a combination approach implementing progressive forest management strategies and increasing the use of wood and timber in commercial products (FLNRO, 2013). Increasing the usage of HWP contributes to both the economy and climate change mitigation efforts and these benefits increase in tandem with the utilization of forest harvest residuals for the creation of long-lived HWP as wood fibre that was previously destroyed or neglected can be used for significant emission reductions (FLNRO, 2013).

Johnston and Radeloff, found that in 2015 the global HWP pool was responsible for an annual net sink of -335 Mt $CO_{2\ eq,}$ and could grow to as much as -441 Mt $CO_{2\ eq}$ by 2030 if assuming certain socioeconomic developments (Johnston & Radeloff, 2019). This projection is expected to grow further still in coming years as global producers are producing increasing amounts of wood products. From 1961-2015, global production of saw logs increased from 231 million cubic metres to 454 million cubic metres. Similarly, the production of wood panels has seen exceptional growth, with production increasing from 25 million cubic metres in 1961 to 402 million cubic metres in 2015 (Johnston & Radeloff, 2019).

Canada is exploring opportunities to increase the utilization of HWP in the economy and have begun to examine innovative ways to use forest biomass for the production of useful consumer products (NRCan, 2019). It is understood within the large Canadian forestry industry that the traditional way of doing things cannot be relied on as a strong plan heading into the future. Between 2003-2009, due to changes in the global commodities markets and the 2008 recession, the Canadian forestry industry lost approximately 130,000 jobs and saw the closure of 455 mills temporarily or for good (NRCan, 2019). Recognizing that traditional products from Canadian forests were on the decline globally, Natural Resources Canada (NRCan) partnered with FPInnovations in 2007 to begin the Transformative Technologies Program (TTP), this program partners NRCan with provincial governments, industry and other stakeholders to uncover innovative solutions to the Canadian forestry sector and help foster a strong Canadian bioeconomy (NRCan, 2019). The TTP has established 4 goals aimed to drive the overall strategy and improve the economic and environmental outlook in Canadian forests:

- Improve the productivity and returns on existing products and services
- Expand markets for existing products and services using competitive intelligence
- Leverage the role of the sector as a provider of environmental stewardship
- Provide new niche products and services with greater profit margins (NRCan, 2019).

This strategy is poised to have significant impacts on the increased utilization of harvest residuals throughout the forest product value chain, as the TTP strategy intends to identify existing values within the chain that are underutilized and then extract and capitalize on these market deficiencies (NRCan, 2019). This focus on extracting value is intended to explore every

aspect of the forestry supply chain and focus on maximizing utilization while extracting value. Including, "*identifying new uses for wood fibre and new markets for the new products and processes identified"* (NRCan, 2019, p. 1). In order to achieve the goals of the TTP there needs to be substantial stakeholder and industry buy-in as well as consistent governmental support.

What we need is commercialization of some of the innovative products that have been developed and that can use harvest residuals, so projects that need dimensional lumber that can begin to use material that is currently being left on the block and burnt. We need to properly commercialize those products because without demand, things will stay stagnant on the residuals front. – Climate Related Scientist - (Interview Participant C, 2019). (Statement paraphrased by Report Author)

In order to support the TTP, the Bio-Pathways Project was founded in 2009. Backed with support from NRCan, the Forest Products Association of Canada, FPInnovations and others, scientists and researchers were recruited from across the country to begin researching the most effective ways to make use of Canada's large forest resources and substantial forestry industry (NRCan, 2019a). Studies from the Bio-Pathways project estimate that the global market opportunities for bioproducts including biofuel, bioenergy, and wood products to be $200 billion with substantial increases still to be seen in the coming years as forecasts have indicated that consumer choice will increasingly favor demonstrably sustainable products (NRCan, 2019). This forecast bodes well for Canada, and the Canadian forestry industry, as Canada's vast forest resources coupled with emerging infrastructure that will support current and future bio-technology research, development and production indicates that Canada is poised to take advantage of these predicted trends and has the opportunity to revitalize the forest industry by creating new innovative products to meet increasing demands. In order for this to occur, the forestry industry will have to be supported by governmental regulation and policy, strategic partnerships and private investment (NRCan, 2019).

There is no better time to increase invest in the future of Canadian forestry than the present. Mill closures are once again occurring at significant rates in British Columbia, as softwood lumber agreements with the United States are on shaky ground and British Columbia's midterm timber supply will likely be significantly reduced over the next few years due to decades of

overharvesting coupled with the mountain pine beetle epidemic and catastrophic wildfire seasons (Hoekstra, 2019). Part of the reason for the wide-spread mill closures in British Columbia is due to reductions in timber supply; in order to be profitable, the mills need access to forest fibre and the impact of natural disturbances has severely reduced the amount of available timber. Some estimates suggest the available timber supply will drop as much as 40% from its peak at the height of the pine beetle epidemic when AAC's were increased to attempt to salvage the timber before it was lost (Hoekstra, 2019).

"We have one local operator and they have basically half the allowable annual cut they need to supply their fibre needs, [so] they've gone out and… [committed to] a value-added facility and they're building it right now. I think it's a $30 million-dollar lamination plant to better utilize the wood they do have rather than [just] cutting boards." – Retired British Columbia RFP and Owner of Sunshine Logging – Jeff Mattes, (Interview Participant K, 2019).

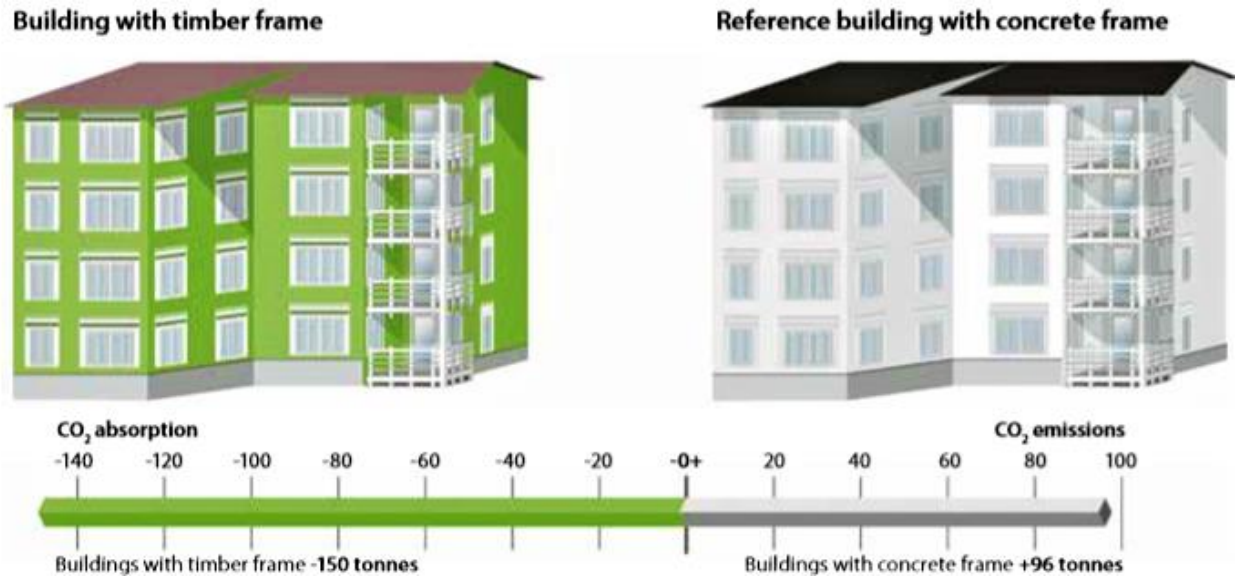
In order to stay competitive in a fast-growing market for new forest products and to help mitigate the significant uncertainty that surrounds the international global commodities market for Canadian forest products, Canada's forest sector needs to consider new and innovative approaches in the forestry sector. The ongoing softwood lumber trade dispute with Canada's with the United States illustrates the need to diversify the industry. Nearly two thirds of Canada's total timber exports went to the United States in 2017, representing over $24 billion dollars in exports (NRCan, 2018). The vast majority of the timber exports to the United States consist of traditional forest industry products like dimensional lumber and full saw logs. The United States has been steadily raising the tariff and duty rates on Canadian timber imports citing that low-stumpage rates in Canada are akin to provincial subsidies that allow provinces like British Columbia and Alberta to under-cut American producers and supply lumber at below market value (Jang, 2018). United States duties on Canadian lumber currently cost the average Canadian forestry company 20.23% on import duties, substantially increasing the financial pressure on the already fragile lumber and pulp and paper mills in British Columbia (Jang, 2018).

In order to decrease the reliance of the Canadian forestry industry on traditional marketplaces and traditional market offerings, new strategies and new products must be developed to diversify the industry and revitalize the economics of forestry in Canada. There have been significant

private and public investments put into developing innovative new products that the forestry sector can begin to produce in order to transition away from traditional HWP offerings. The Bio-Pathway project has determined that, in order for the Canadian forestry industry to support itself and thrive into the future, Canada needs to develop a fully diversified range of bio-products (NRCan, 2019a). Early estimates have suggested that bioenergy derived from Canada's forest biotechnologies could power up to 2.5 million Canadian homes annually, however, bioenergy is a currently a low-value product in the forestry value chain, in order to fully diversify the industry and expand into future markets and opportunities, a blend of low, medium and high value forest products needs to be developed (NRCan, 2019a).

Products such as Cross-Laminated Timber (CLT), produced by gluing thin sheets of saw log cuttings together to make durable and strong timber products that can be used in construction projects to replace steel, concrete and cement is one method to increase the viability of Canadian forestry products (Wood Solutions, 2019). CLT has already gained a strong market share in Europe where it is being used in a wide range of construction projects. By alternating the direction of the wood grain at 90° with each sheet of thin wood veneer that is glued together, CLT increases the tensile strength of product significantly over traditional lumber. (Wood Solutions, 2019). As such, it can be used in numerous applications where concrete or steel would be used such as in supporting structural beams and retaining walls. Considering that estimates suggest producing one tonne of concrete can emit approximately one tonne of carbon emissions into the atmosphere (Pasay, 2018), beyond creating a high-value product that has significant market value, CLT technology can greatly impact climate mitigation efforts as it can be used as a replacement for more energy intensive building materials and can store carbon for the duration of its in-use life (Wood Solutions, 2019).

Figure 11 - Sequestration Potential of Timber Frame Building vs. Concrete Frame Building



(Bostrom, 2015)

Estimates suggest that, after the production process, each cubic metre of CLT will sequester approximately -676 kilograms of carbon and represent a 75% lower carbon footprint than traditional construction methods (Building Construction Design, 2015). The strength and longevity of CLT allows it to be used in construction projects where traditional dimensional lumber could not be used, suggesting it can begin to take the place of steel and concrete in the building of new homes, but also new multi-story structures (Building Construction Design, 2015). As an demonstration of how this new HWP technology can support the western Canadian forest industry, the University of British Columbia finished construction of the world's tallest wooden building in 2017 (Lichtert, 2017). The building is 18 stories tall and is composed primarily of CLT panels and beams, utilizing concrete only for the buildings pad and two concrete supported stair wells. Due to the ability to pre-fabricate the CLT pieces, the entire building was constructed in 9 and a half weeks, representing a significant time advantage over traditional building methods, further adding to the climate change benefits associated with the building (Lichtert, 2017). CLT represents a high-value product in the forestry industry, the panels and beams are currently quite expensive, both to produce and to purchase, however, CLT is an emerging technology and should be a product of interest for the western Canadian forestry moving forward.

The progress made sequestering carbon with innovative products like CLT is one part of the climate change mitigation potential provided by HWP. However, the integration of harvest residuals into the HWP dimension of the forestry industry is a more difficult challenge. One of the key findings from research done by the Bio-Pathway Project is that making more efficient and economic use of forestry waste streams is a critical element in fostering Canada's burgeoning bioeconomy (NRCan, 2019a). Countries such as Finland and Sweden are world leaders in the utilization of forest harvest residuals, but at this time the vast majority of their collected residual fibre is being utilized for bioenergy purposes (Bostrom, 2015); (Ministry of Agriculture and Forestry of Finland, 2018). Although bioenergy can be a valuable climate change mitigation tool when sourced from waste products such as harvest residuals, it still constitutes a low-value product due to the high associated costs. This can be seen with the low volumes of collection and utilization currently seen in British Columbia and Alberta.

"To increase the utilization of residual slash, other uses than energy should be considered; it might make sense to pursue higher value products. Maybe jet-fuels or specialized wood products; the ability [to charge] higher end prices may increase utilization and make transportation and collection more viable" – Bioenergy Businesswoman - Maryam Mkhani, (Interview Participant L, 2019).

There are a few current widely produced HWP that can integrate the use of forest harvest residuals in their production, but do you not yet incorporate them on a significant scale. Oriented Strand Board (OSB) is a composite wood product that is a large consumer of merchantable logs. In 2016, veneer and OSB mills processed the second largest amount of logs in British Columbia after lumber mills, consuming over 5 million cubic metres of merchantable saw logs (FLNRO, 2016). Veneer plants have a need for full saw logs as the product they produce is composed of long sheets of wood fibre, but OSB mills can intake and utilize residual fibre in their production process (Forestry Innovation Investment, 2007). OSB, and a similar product called particle board, are made by gluing together pulverized pieces of wood chips into a pressed panel, creating an inexpensive yet durable product that is widely used in a variety of HWP such as counter-tops, cabinets and flooring material. Considering that in 2015-16, British Columbia was a net importer of wood chips used to supplement as feedstock into the pulp and paper and OSB/particle board supply streams (FLNRO, 2016), there is a clear market opening for forest

harvest residuals in these particular product streams provided they can provide a competitive price point.

The question of how to increase slash pile utilization and how that could best be structured is a million-dollar question right now; and the government has to play an active role in that structure. They will need to provide an optimal mixture of incentives and disincentives to achieve the outcome of eliminating all unnecessary slash pile burning. – Canadian Forest Carbon Researcher, (Interview Participant I, 2019). (Statement paraphrased by Report Author)

The fact that it appears to be more economic for pulp and paper and OSB/particle board producers in British Columbia to import wood chips into the province in order to meet their fibre needs suggests there is clear supply demand gap that could be filled by increased uptake and utilization of forest harvest residuals from the harvest block. Harvest residuals do make up a portion of the supply stream for products in British Columbia, but it is currently a very small amount. In 2015-2016, an estimated 1.15 million cubic metres of harvest residuals were used to support pulp and paper, chip and wood pellet manufacturing mills in British Columbia (FLNRO, 2016). This is out of the estimated 11.9 tonnes of residual fibre that is estimated to be available annually in the province of British Columbia (Layzell & Ralevic, 2006). There is significant potential to increase the utilization of residual fibres into western Canadian HWP, however demand needs to catch up to the overwhelming supply. Innovative projects like the Bio-Pathway project are a good start, but the government needs to begin to meaningfully prioritize residual fibre initiatives, both to assist in provincial and national efforts to mitigate climate change and to attempt to diversify an strengthen the economy of the forestry industry in western Canada. British Columbia and Alberta are currently wasting millions of tonnes of forest fibre annually that could be utilized to enhance and bolster an industry that is currently floundeirng, and what's worse is that they are burning this potentially economically useful material while greatly contributing to provincial and national atmospheric carbon emissions as well as overall global climate change. Although the issues surrounding forest harvest residuals are complex, it is clear that something needs to be done. Both to incentivize the complete cessation of slash pile burning practices, and to incentivize the increased collection and utilization of harvest residuals. Currently, the market is not providing enough demand for the residues left from forest harvest operations, if the government seriously wants to increase harvest residue uptake into the forest

product chain, they should begin to explore methodologies and initiatives to increase utilization and begin regulatory and policy discussions to address this market inefficiency. The current global conversation around climate change and international agreements like the Paris agreements have put pressure on Canada to live up to its emission reduction commitments. The forestry industry in western Canada has a significant role to play in Canada's broader climate change goals and there remains a need for more effective regulations and policies aimed at the industry's forest carbon challenges.

5.3. British Columbia's Forest Carbon Enhancement Projects and Practices

British Columbia began significant climate change mitigation plans when the province introduced the Climate Action Plan (CAP) in 2008. The CAP was an attempt to implement targeted actions towards all sectors of the provinces economy in order to reduce GHG emissions by 33% sector-wide by 2020 (British Columbia, 2008). Forests were specifically targeted and emphasized within CAP and the project implemented a sector-specific goal to *"maximiz[e] the enormous potential and capacity of [British Columbia] forests beyond timber-use, for energy production and carbon storage capacity"* (British Columbia, 2008, p. 1). With this goal in mind, the British Columbian government began implementing a series of initiatives aimed at climate change mitigation within forests. A net-zero deforestation policy was introduced realize the full value of forest carbon storage potential and ensure the viability of forests for future generations. Although this seems like a significant commitment it is important to realize that clear-cutting and forestry operations are not considered deforestation under definitions from the UNFCCC, as they are regenerated through mandatory reforestation initiatives (FAO, 2019).

5.3.1. Forests for Tomorrow and British Columbia's Bioenergy Strategy

The Forests for Tomorrow (FFT) program was initiated in 2005 in response to large-scale damage from wildfires significantly reduced timber supply in many areas of British Columbia. The program receives from private companies and introduces reforestation programs into areas that have significantly impacted by natural disturbances. Currently, investment in the FFT program are aimed at improving the future timber supply and addressing risks to other forest values as of 2014, FFT estimates they have replanted around 15 million seedlings and reforested nearly 11,000 ha of

forest land (LeRoy, 2014). The FFT initiative is an effective reforestation tool for disturbed forest areas as funding for the program is mostly private. However, its main stated goal is to increase the timber supply area rather than focusing on enhancement of forest carbon values or climate change mitigation. It is acknowledged that these values are correlated, but the main goal of the program is not explicitly aimed at enhancing carbon sinks or reservoirs in British Columbia.

Within the 2008 CAP, British Columbia also launched a program to support bioenergy initiatives within the province, the bioenergy strategy was aimed to encourage research and development into areas of biofuel, wood pellets, and co-generation power/heat plants. It was estimated that British Columbia has enough biomass resources to power 640,000 household with bioenergy alone. (British Columbia, 2008). The British Columbian government initially committed $25 Million to the project and estimated that sustainable forestry practices involving the harvesting and collection of forest residuals could supply 53% of the feedstock for the province's bioenergy strategy, and that timber sourced from the MPB affected timber could supply 34% of the feedstock needs (Government of British Columbia, 2008). British Columbia's bioenergy strategy has the potential to significantly affect British Columbia's on the ground sustainable forestry practices, the collection of forestry residuals for use in bioenergy projects is a more effective strategy for climate change mitigation than disposing of the forest residuals through burning practices. The degree to which this bioenergy strategy has impacted forest management practices on the ground in BC was limited, necessitating a re-imagination of the province's bioenergy strategy structure. However, bioenergy in British Columbia is gaining new grounds in recent years thanks to CleanBC's renewed bioenergy strategy which is aimed at reducing GHG emissions within the province with a 2030 target in mind. This strategy involves the utilization of waste streams for increased energy production and has specifically targeted coastal forestry areas for it's first significant applications of the program (CleanBC, 2019).

In January of 2019, changes were announced that will attempt to reverse the decline seen in the west coast forestry sector for the past two decades. In what is being called the *Coast Forest Sector Revitalization Initiative*, the government is taking policy action to increase the solid wood and secondary industries to ensure more logs and fibre from forest operations are being processed and utilized within British Columbia, this will be accomplished by improving harvest performance to ensure more fibre is available for domestic mills (FLNRO, 2019). These goals and others are

intended to be achieved through changes to regulatory and policy system over the next two years. Doug Donaldson, The Minister of Forests, Lands, Natural Resource Operations and Rural Development. Had this to say regarding the initiative. *"We need to shift our approach away from the status quo and create markets for waste fibre that, until now, has been left in harvest areas. We will continue to work with all forest-sector participants so together we can enjoy the benefits from a stronger coastal forest sector"* (FLNRO, 2019, p. 3). In part, these changes will be enforced by the development of a "coastal fibre recovery zone" where penalties will be introduced from leaving forest waste amounts above a to-be-determined threshold. This strategy is expected to increase the amount of available forest fibre to bioenergy and pulp-and-paper plants by ~2 million cubic metres (FLNRO, 2019).

Regulatory strategies like the coastal fibre recovery zone should significantly decrease the amount of forest carbon emissions that are released by the forest industry in coastal British Columbia, either by preventing direct emissions from burning practices. Incentivization of secondary harvest recovery is a key strategy aimed towards over-all reductions of GHG emissions within BC's forest industry.

5.3.2. Forest Enhancement Society of British Columbia.

On the strength of an $85 million government contribution, the Forest Enhancement Society of British Columbia (FESBC) was created in 2016 (FESBC, 2019). As a government funded organization, FESBC has distinct objectives and purposes related to environmental and resource stewardship with British Columbia's forests. Specifically, their mandate includes:

i. Preventing and mitigating the impact of wildfires;
ii. Improving damaged or low value forests;
iii. Improving habitat for wildlife;
iv. Supporting the use of fibre from damaged and low value forests; and
v. Treating forests to improve the management of greenhouse gases. (FESBC, 2019)

FESBC supports increased residual fibre utilization and fibre recovery in strategic areas where the costs of recovery and transportation are uneconomic for primary harvesters by providing financial support for increased fibre recovery efforts and facilitating the transportation of collected to fibre to localized bioenergy, pulp and paper, and pellet plants to support the economics of secondary forest harvest operations in British Columbia (FESBC, 2019). Relatedly, FESBC supports provincial and federal climate change mitigation targets through financially supporting reforestation efforts in areas affected by natural disturbances.

FESBC also undertakes fertilization operations to improve the growth rates of replanted forests allowing the grow more effectively and actively sequester increased amounts of organic carbon. Similarly, supporting the increased collection and utilization of residual fibres that would otherwise have been burnt decreases the amount of associated GHG emissions in BC forests and impacts the overall carbon balance (FESBC, 2019). The FESBC targets reforestation operations for locations that would have remained unproductive as a result of natural disturbances. Current targets for FESBC's enhanced reforestation initiatives include reforesting 38,500 ha with over 57 million seedlings in areas affected by the 2017 Caribou and Elephant Hills wildfires. It is anticipated that these plantations will sequester up to 3 million tonnes of carbon by 2050 (FESBC, 2019).

5.3.3. Forest Carbon Initiative

In order to combat the widespread loss of forest carbon due to increasing instances of natural disturbances over the past 12-15 years, BC has announced the creation of the Forest Carbon Initiative (FCI). This program is being joint funded between the BC provincial government and the federal government. The FCI has three main goals: to increase carbon storage in forests, increase rate of replanting and fibre recovery and to reduce or completely avoid emissions from forest operations (SISCO, 2017).

With these goals in mind, there are few restrictions as to how the money can be invested as long as forest carbon indicators are benefitting (SISCO, 2017). One of the first strategies approached with the forest carbon initiative is widespread reforestation plans starting in 2017, beginning with the planting of 20,000 ha in 2017 with the overall goal to reforest nearly 300,000 hectares of British

Columbia's forest area that has been affected by natural disturbances and increase its regeneration potential (Environment and Climate Change Canada, 2019a). So far, the federal government has committed $140 million to the project funneled through the low carbon economy leadership fund. Provincial investment in the initiative was nearly $50 million between 2017-2019 and is expected to be nearly $70 million for 2019-2020 (Environment and Climate Change Canada, 2019a).

5.4. Initiatives for Secondary usage of Residual forest debris in British Columbia

The government of British Columbia is demonstrating a strong commitment to the increased utilization of residual forest debris in their forest management framework by recognizing the improvement utilization standards for residual forest fibre as an official British Columbia government initiative (Government of British Columbia, 2019f). The intent of this initiative is to support the creation of new forest industries that can use lower quality timber such as harvest residuals (slash) to increase industry productivity and economics while mitigating anticipated timber short falls due to natural disturbances (Government of British Columbia, 2019f). These actions simultaneously support forest carbon initiatives by reducing the need to burn residuals post-harvest and rates of decay on harvest blocks.

Central to this initiative is the recognition of areas where secondary fibre recovery efforts are most in demand i.e. Timber Supply Area's (TSA's) with processing facilities such as bioenergy plants, pulp and paper mills, or wood pellet industries in economically viable proximity. In these areas where residual demand is determined to be strong enough, primary and secondary harvesters are being encouraged to establish "business to business relationships" where they integrate the fibre recovery process in FSP's and other harvest plans to streamline operations for efficacy and efficiency (Government of British Columbia, 2019f). Where business to business relationships have not been established, the government may establish a fibre recovery zone in which the primary operator can indicate whether they will be utilizing the residual material or if they are abandoning their rights to the residual fibre allowing secondary roadside operations to collect and utilize the fibre in their place. These actions are supported by legislation within the *Forest Act* regarding *Fibre Supply Licenses to cut* and *Forestry fibre licenses to cut* under Part 3 Division 8.2 Licenses to Cut (Government of British Columbia, 2019f).

Similarly, the government can also impose do not destroy orders regarding residual timber in areas where business to business relationships can not be facilitated and have demonstrated increased support for innovative utilization of forest residuals. In 2014, the British Columbian government approved of an additional forest license to be given to companies in need to timber or residual supply called a supplemental forest license (Canadian Biomass, 2014). This supplemental forest license is supported by the *Forest Act* Section 14.2 *Supplemental Forest Licenses* (Government of British Columbia, 2019f). and permits companies to harvest timber or residual biomass only when residual fibre from business to business agreements are limited or supplies are low. This additional license helps ensure that holders, bioenergy companies, pellet producers etc. maintain an ongoing access to fibre even without the support of primary harvester agreements which strengthens the position of companies looking to enter these secondary markets for British Columbia timber supply (Canadian Biomass, 2014).

In an effort to increase the demand for harvested residuals to drive economic investment in timber processing and manufacturing facilities, the government of BC has partnered with Forest Product Innovations (FPInnovations) a non-profit Canadian company dedicated to designing and creating new products from timber and wood materials. FPInnovations also assists with educational initiatives aimed to increase awareness throughout the industry about best practices for residual harvesting initiatives such as the "*Roadside Residual Handling Guideline Version 3*" (FLNRO, 2018). and providing volume estimates of available residual forestry debris within BC's TSA's to inform harvesting efforts. The government of BC has also taken steps to ensure that forest residuals have the ability to be sold on the timber sales market to would-be processors. British Columbia Timber Sales has created a new a timber-sales license aimed at secondary harvest residual materials called the Innovative Timber Sales license (ITSL) which allows the utilization of low-quality timber stands and collected residuals to be put up for development and auction sales within the province (Government of British Columbia, 2019e). This is an important step to ensure that demand for forest residuals and low-quality timber stands are economically viable for those operators looking to enter this secondary market.

5.4.1. Forest Fibre Initiative

In 2015 the BC ministry of Forests, Land, Natural Resource Operations and Rural Development (FLNRO) began the planning and implementation of the *Forest Fibre Initiative*, a program designed to increase education surrounding secondary harvest operations and to increase the uptake of residual fibres from the forest operations in BC forests that was officially installed in 2016 (Kozuki & Stewart, 2019). The main objective of this initiative was to approach challenges within BC's forest sector such as increased global competition, the MPB infestation and the changing economics of the industry by improving the utilization factors of residual fibre and subsequently increasing the value of that recovered fibre within the production chain.

The task of examining these issues and making improvement recommendations to the government went to the Forestry and Fibre Working Group, which was comprised of industry representatives, primary harvesters, secondary users, FPinnovations representatives and input from BC government representatives and came up with 13 recommendations that were adapted into technical policy adjustments called the Forest Fibre Action Plan (Kozuki & Stewart, 2019).

Table 4 - Forest Fibre Action Plan Grid

#	Forest Fibre Action Plan	Status/Timing
1	Implement the Fibre Recovery Process for situations where residual supply and demand exist.	Implemented / Dec 2015
2	Develop and Implement "Biomass Handling Guidelines" - FPInnovations under contract	Initiated / Mar 2016
3	Update and Maintain Timber Tenure Summary Information #3a Report	Implemented / Sept 2015
4	Monitor and Amend the Fibre Recovery Tenures (Road and Landing Tenures)	Ongoing / Sept. 2015
5	FLNRO to advertise and enter Into Supplemental Forest Licence where appropriate. - First Licence awarded in Prince George Timber Supply Area	Ongoing / Sept. 2015
6	Review the proposal to expand the use of Cruise-based billing.	Initiated /Spring 2016
7	Grade 4 Cut accountability and Sustainable Cut Control Credit	Implemented / Sept. 2015
8	Fibre Utilization Baseline - Linked to actions #11 and #12	Initiated / Spring 2016
9	Operational Initiatives	Ongoing / Sept. 2015
10	Review the Pricing of Lower Quality Fibre - Linked with actions #11, #13	Initiated / Mid- 2016
11	Review of Waste Benchmarks - Short term action of extending waste benchmarks completed Sept 2015 - Linked with actions #10 , #13	Ongoing / Mid 2016
12	Conduct a review of the policies and procedures of Measuring Waste including the use of the dry grades in waste measurement	Initiated / Mid – end 2016
13	Review the proposal to move Waste Measurements Offsite to Secondary Uses Scale site.	Final stages / Early 2016

(Kozuki & Stewart, 2019)

The Forest Fibre Action Plan is grounded in 4 themes for fibre utilization:

1) **Support integrated harvesting.**
    (a) Improve Fibre Recovery process, facilitate business to business relationships between primary and secondary harvesters.
    (b) FP Innovations to provide biomass handling guidelines to educate primary and secondary harvesters of ways to increase efficiency of collection practices and inform processors of possible end-uses for fibre.
    (c) Review Cruise-Based billing (Cruise Based billing does not require waste assessments)
    (d) Facilitate for "one-pass" delivery of fibre to primary and secondary user through the integration of a Pre-harvest waste assessment program.
    (e) Introduction of "Special Forest Products Rates" – Defined rates for wood chips, hog-fuel etc.
    (f) Extension of waste benchmark to increase amount of usable residual fibre on block without penalty to primary harvester.
2) **Providing tenure opportunities for secondary users to access fibre.**
    (a) Forest act provides opportunities for secondary harvesters to access fibre through fibre recovery tenures i.e. Fibre supply license to cut (Section 47.72), Residual forestry license to cut (Section 47.6), and relevant permits (Section 79.1)
    (b) Supplemental Forest Licenses and Restricted Forest Licenses (Section 54.4)
3) **Improving waste fibre measurement techniques to properly reconcile opportunities within timber supply.**
    (a) Review of Policy and Procedures regarding measurement of residual and waste fibres.
4) **Provide continuous integrated support with other related initiatives province wide.**
    (a) Pilot projects to inform future practices.
    (b) Analysis of fibre supply, short and long-term.

    (Kozuki & Stewart, 2019)

British Columbia is making a significant push to integrate climate change mitigation and forest carbon values into their forest management policies. The proposed amendments to the *Forests and Range Practices Act* have specifically targeted the enhancement of forest carbon sinks and reservoirs as a priority within the larger forest management scheme (Government of British Columbia, 2017). The focus of the government's regulation of the forestry industry seems to be slowly shifting from the previous "results based" style of forest management that prioritized the value of timber and maintenance of the timber supply as its principle goal. Recent projects like the *Forest Carbon Initiative* and the *Forest Fibre Initiative* are focused on two interconnected aspects of forestry the health and well-being of the forests and the ability to extract value from this resource in a truly sustainable way. It remains to be seen how effective these new policies and initiatives will ultimately be in enhancing the economic benefits associated with sustainable forest management, but the change has to start somewhere. British Columbia is attempting to drastically reform the values protected for within their forests, but the forestry industry is slow moving and resistant to change. It may well be the case that more significant regulatory action is needed to truly drive change in British Columbia's forests.

5.5. Alberta's Forest Climate Change Mitigation Projects and Practices

5.5.1. Forest Resource Improvement Association of Alberta (FRIAA)

FRIAA, was established in 1997 by the Alberta Ministry of Agriculture and Forestry and was tasked with utilizing industry funds to enhance forest resources in Alberta. Delegated as a non-profit organization, portions of the stumpage fees collected by the government from forest harvest operators are directed into FRIAA in order to support and enhance the forest resources for the benefit of all Albertans. FRIAA's mandate is "*to establish and administer programs and initiatives as directed under the Forest's Act and the Environmental Protection and Enhancement Act*" (FRIAA, 2019, p. 1). It's defined purpose and objective is to established programs and initiatives designed to:

Enhance the forest resources of Alberta

- Promote the enhanced management of the forest resources of Alberta
- Improve the sustained yield of the forest resources of Alberta

- Promote integrated resource management
- Reforest public land using reforestation levies

(FRIAA, 2019, p. 1)

FRIAA's objectives are not specifically tailored to managing Alberta's forests with climate change in mind. Although many of their initiatives help to support the enhancement of Alberta's carbon sink by reforesting areas that would otherwise not receive reforestation. Specifically, FRIAA's Wildfire Reclamation Program (WRP), and Mountain Pine Beetle Forest Rehabilitation Program (MPBFRP) are two initiatives that utilize funds to reforest areas affected by large-scale natural disturbances within the province and may otherwise have a difficult time recovering from the damage incurred (FRIAA, 2019).

The MPBFRP was introduced in 2013 as the scale of the MPB epidemic was beginning to significantly impact Alberta's forests on the eastern slopes of the Rocky Mountains as the infestation slowly spread from BC's forests across the mountains. Reforestation of stands significantly affected by insect infestations can provide many benefits to the forestry community and the health of forests in Alberta in general. Significantly, FRIAA considers the restoration of insect infested forests under the MPBFRP to mitigate for ecological, economic, and social damages inflicted upon the forest and considers that carbon sequestration is one of the forest values that is enhanced by the application of this program. This is a positive outlook for the future of Alberta's forests, but currently this program has a relatively small area of application (FRIAA, 2019a).

FRIAA's WRP is less comprehensive than the MPBFRP. This reforestation initiative allows for forestry companies to apply for funding and grants to complete reforestation projects for areas that were under active or completed reforestation management and were subsequently damaged by wildfire (FRIAA, 2019b). Typically, reforested areas that are destroyed by wildfire relieves the liability of the forestry company from reforesting the harvested area and FRIAA's WRP only covers reforestation efforts for replanted forest areas under active management within their first 14 years of regeneration and funding is not fully guaranteed. Significantly, the WRP does not cover reforestation of other areas of forests that have been significantly impacted by wildfires if they were not under active management at the time and rely on the natural regeneration of forested

areas to occur for the majority of fire-affected forest areas. This is a shortcoming of the program, though it is likely due to a lack of funding availability.

FRIAA is a program that has options for restoration of affected pine stands, but there hasn't been much uptake for that program as of yet. Again, low economic benefits so far. – Forest Analyst with Government of Alberta, (Interview Participant G, 2019). (Statement paraphrased by Report Author)

FRIAA is a good start to exterior forest management programs in Alberta. The initiatives the organization undertakes are aimed to enhance Alberta's forest resources, however the importance of mitigating the effects of climate change and enhancing carbon sinks within the province are not prioritized within the organization. Although FRIAA's programs do provide increases to Alberta's forest carbon sequestering capacity, these enhancements are a result of the established programs, rather than a stated goal of the programs. Alberta should consider expanding funding for FRIAA's initiatives and empowering the organization to take on more diverse projects that allow for the protection and enhancement of the climate change mitigating potential of Alberta's forests and focus on increasing the resiliency of forests against the threat of an increasing climate.

Compared to the significant amount of initiatives being launched and pursued in British Columbia, Alberta's forest related climate change mitigation strategies have fallen behind industry standards. This is an issue that should be addressed if Alberta wants to keep the forestry industry, which is the third largest resource-based industry in the province (Government of Alberta, 2018b), viable and ensure consistent access to fibre supply and markets for Alberta forest products. Alberta's Ministry of Agriculture and Forestry has set out some tentative plans to address concerns within the industry with it's 2018-2021 business plan that establishes objectives and goals within the forestry industry for the 3-year period described (Government of Alberta, 2018b).

5.5.2. Alberta Ministry of Agriculture and Forestry 2018-2021 Business Outlook

Within this forecasted business outlook, the ministry of Agriculture and Forestry suggests that Alberta's forestry industry is facing challenges to address societal expectations for conservation while still maintaining industry competitiveness within global markets (Government of Alberta, 2018b). However, the ministry has determined that Canada's global commitments to climate

change mitigation and GHG reduction strategies have created opportunities for the forestry industry in Alberta to capitalize on competitive advantages within global markets supported in part by the role that Alberta's vast forest resource plays in carbon management (Government of Alberta, 2018b). The ministry has identified opportunities to preserve Alberta's forest resources and grow the industry while responding to public sentiment to enhance and protect forests within the province. Key strategies proposed include:

- Enhance and refine wildfire management programs to reduce the risk to communities and maintain healthy forest ecosystems.
- Develop a forest products strategy to grow and diversify the industry.
- Review current forestry practices to ensure the ongoing sustainability, economic viability, health and resilience of Alberta's forests.
- **Through cooperation with Environment and Climate Canada, to enhance carbon sequestration in Alberta's forests** (Government of Alberta, 2018b).

These identified opportunities in Alberta's forestry industry support the overall aims of Alberta's Climate Leadership Plan (CLP) which was introduced in 2015. However, recent changes in provincial government may dismantle many of the provisions and commitments made under the CLP framework (Giovanneti, 2019). It is unclear what effect these political changes will have on the ministry of agriculture and forestry's plan to enhance forest management techniques and support forest carbon sequestration within the province. Although it is positive to see the relevant regulatory authorities recognizing the need to improve Alberta's approach to climate change mitigation strategies within the forestry sector, there is no guarantee that the opportunities identified to enhance Alberta's forestry sector are anything more than aspirational at this time. In order to directly affect forest management decisions at all levels within the forest management system, policies and regulations directly aimed forest carbon initiatives and climate change mitigation need to be codified and applied before significant changes take place within Alberta's forests.

Chapter 6: Conclusions and Recommendations

Carbon challenges in the western Canadian forestry industry are complex and multifaceted. The size and scope of the natural forest resources in Alberta and British Columbia provide significant benefits to the provinces economically but are simultaneously a source of great expenditure and uncertainty. Combatting wildfires and insect infestations costs these provinces hundreds of millions of dollars annually and, due to the positive feedback loop associated with these natural disturbances and climate change, the long-term health of these provincial forests is uncertain (Harvey, 2017); (Natural Resources Canada, 2017). In the past two decades, largely due to influences from climate change and ecological fluctuations, the forests of Alberta and British Columbia have been steadily shifting from substantial carbon sinks into concerning sources of carbon emissions.

Considering Canada's national climate change commitments based on the Paris Agreement and their own jurisdictionally specific climate change mitigation plans, the Climate Leadership plan and the Climate Action Plan, both Alberta and British Columbia have made a commitment to contribute to global efforts to mitigate climate change. Given the size of their respective forest industries, both spatially and economically, there are significant underutilized opportunities to approach western Canadian climate change mitigation efforts through the enhancement and protection of forest carbon in sustainable forest management practices. With the risks posed to forest health by the reality of climate change, and the influence that forest carbon fluxes can have in driving or mitigating climate change, it is essential to understand the carbon related challenges facing the forest sector before effective mitigation efforts can be implemented.

GHG emission accounting efforts measuring forest carbon fluxes are an essential informational tool that can either enhance or suppress understanding of carbon emissions and removals in western Canadian forests. Canada is party to international emission reduction commitments through the UNFCCC that call for the annual reporting of estimated anthropogenic emissions in the Land Use, Land Use Change and Forestry Sector (LULUCF). The public quantification of anthropogenic emissions is meant to draw attention to emission intensive practices and incentivize countries on an international stage to take concrete actions to reduce their emissions profile. Under the UNFCCC's reporting framework, good practice guidelines call for the clear and transparent

documentation of all anthropogenic sources of emissions within the LULUCF sector. This is an area of concern for Canada as in recent years, carbon emissions in the LULUCF sector have been increasingly influenced by natural disturbances to the point that the inclusion of Canada's managed forest lands emissions would significantly misrepresent the actual anthropogenic influences on sector emissions. Partly as a result of this, although Canada reports emissions and removals of carbon for the LULUCF sector, this total is excluded from the final inventory accounting total. This is an identified inefficiency within the UNFCCC emissions accounting system and has become an issue for Canadian GHG inventory transparency.

Relatedly, emissions reporting in Canada's LULUCF sector suffers from a lack of activity-specific data. Nearly all aspects of forest management activities including harvesting operations, prescribed burning operations and significantly, the carbon intensive practice of slash-pile burning, are included under a single LULUCF sub-category, Forest Land remaining Forest Land. Although the final emissions total for the forest land sub-category is reported, there is no break-down of emissions by activity for this sector. This reporting methodology does not transparently document the anthropogenic emissions impact that specific forest management activities have on the sector as a whole. If Canada is serious about reducing its GHG emissions, it should not bury the significant emissions associated with an unnecessary practice like slash-burning in a category where the scope and impact of its carbon emissions will not be clearly shown, this opaque emissions reporting may contribute to a lack of public knowledge and policy failings.

Another significant transparency issue regarding carbon in Canadian forests is the lack of jurisdictionally specific provincial and territorial estimates for LULUCF sector emissions and removals. These are not reported or documented in Canada's National Inventory Report nor are they made available to the public in any form. Currently, British Columbia is the only province that compiles and publishes a GHG inventory for the LULUCF sector.

Although Canada is following the reporting guidelines and rules set out by the UNFCCC and IPCC, the exclusion of LULUCF emissions from the final inventory total, understates the significance of forests and the forestry industry to climate change and climate change mitigation. Clear and concise reporting on forest carbon trends and fluxes is essential to inform the development of progressive regulations, policies and sustainable forest management practices as

accurate documentation of emissions allows for implemented regulations to be evaluated against previous emission levels. For effective mitigation strategies to be developed, there needs to be a clear line of communication between the researchers and scientists who track emission trends and the relevant policy actors who have the power to influence and regulate those trends. This is something that should be addressed the future versions of Canada's NIR, especially as Canada has developed effective methodologies that separate anthropogenic from non-anthropogenic emissions within Canada's managed forests with the partitioning approach taken under the CBM-CFS3. Given the significance of anthropogenic emissions arising from preventable or poor forest management practices such as slash burning have on provincial emissions, even if they are not recorded in the final inventory total, they should be reported for in an activity specific sub-category in order to draw attention to the practice and also quantify its effect on GHG emission totals.

The practice of burning forest harvest residuals (slash-piles) is widespread in both Alberta and British Columbia. It constitutes a significant source of carbon emissions within the forestry industry and despite both provinces having installed provincial plans aimed at reducing GHG emissions, both provinces have imposed strict removal guidelines that force the hand of forest harvest operators to get rid of the slash in any way that they see fit, provided it is removed in the regulated time-frame. As a result of these regulated removal timelines, and a permissive government attitude towards slash-pile burning, a significant portion of usable forest fibre is burnt every single year, ironically as a fire mitigation measure. Emissions from the burning of harvest residuals are estimated to be the source of nearly 8% of British Columbia's total provincial emissions annually, for a practice that is avoidable this calls for a review of irresponsible waste practices of potentially valuable forest fibre.

Although attempts have been made in both provinces to incentivize the utilization of the harvest residuals, these efforts have run into substantial implementation problems. The largest barrier to greater utilization of harvest residuals is simply poor economic incentives and logistical challenges due to distance and volume. There is an unmanageably large amount of harvest residuals available annually, and while the supply is incredibly high, the demand for it is extremely low. Compounding the problem is that a majority of harvest residuals are located hundreds of kilometres from mill locations that could process the harvest residuals into usable bioenergy, biofuel, or HWP. The cost of secondary harvesting, transportation and eventual processing of the

material is economically unviable for the majority of forest cut-block locations and operators are not interested in taking a financial risk on an unknown low-value product. Harvest residuals also have to compete with comparatively easily accessible mill residues, the sawdust, wood chips and shavings from timber processing mills which have the immediate benefit of proximity and have already been partially comminuted vie the primary mill processing treatment. As a result, Alberta and British Columbia have a serious problem on their hands. The harvest residuals that make up slash piles currently have limited economic utility; they also increase the risk of wildfire in newly replanted cut-blocks and impede replanting efforts aimed to rapidly regenerate the harvested timber. Considering that burning the residual material is often the most cost-effective option for many operators and the fact the practice is government permitted and regulated for, it will be very difficult to eliminate the practice of slash pile burning any time soon.

The question of how to solve Alberta and British Columbia's harvest residuals problem is not an easy one. It is clear that the practice undermines sustainable forest management efforts in both provinces but as of yet there is no ideal solution. Carbon taxes aimed to disincentivize slash burning have been discussed but faced strong opposition from industry and have numerous difficult design problems to overcome such as how to accurately measure and quantify the emission without controversy. Other proposed options include carbon offsets and incentivizes aimed to increase the amount of economically viable fibre for harvesters and processors. British Columbia is taking the latter approach and has been investing in fibre utilization initiatives since 2015. However, it is too early to tell how significant a difference these efforts have made thus far, British Columbia's forestry industry is currently experiencing significant changes and upheavals at the moment as large industrial operators are pulling out of the province to access more profitable fibre supplies elsewhere, catastrophic natural disturbances are significantly reducing the available timber supply and previously viable mills are shutting down and closing their doors impacting communities across the interior. It is clear that the most influential motivator for increased uptake of harvest residuals into the forest product value chain is to increase their economic value.

One valuable alternative to consider are the regulations and national forestry strategies installed by Finland and Sweden. These countries made the decision decades ago to begin pursuing a bioeconomy to decrease their reliance on fossil fuels to meet their needs. Both of these countries have revitalized their forestry sector both environmentally and economically. Annual forest

harvests have increased substantially since the 1990's however, both countries have managed to increase the carbon sink within their forests. Both of these countries have prioritized full-scale integrated harvesting systems where primary stem log harvesting and secondary harvest residual harvesting are harvested simultaneously, significantly increasing harvest efficiencies and decreasing associated costs. The efficiency of their harvesting system, and a blended regulatory approach that combines both incentives and disincentives, have led to a robust bioenergy industry which makes use of a majority of the collected forest harvest residuals. These approaches have contributed strongly to the economies of both of these countries and have had the dual effect of benefitting their GHG mitigation efforts. It is important to note that forestry in both Finland and Sweden has benefitted from very punitive carbon taxes directed towards fossil fuel combustion, and substantial national and international emission reduction incentives through their membership in the European Union. Without the background support of targeted government regulations and policies, Alberta and British Columbia's slash pile problem will likely be more difficult to conquer.

Although debates can be had regarding the most effective regulatory framework or policy applications, a strong first step towards enhancing climate change mitigation within the western Canadian forest sector could nonetheless start with progressive regulations surrounding the practice of slash pile burning. Increased collection and utilization of this previously wasted fibre would decrease sector emissions and could potentially revitalize the industry economically. In order to maximize the efficacy of any installed regulations or policies, a blended approach of incentives and disincentives is recommended.

Both Alberta and British Columbia pride themselves on their sustainable forest management practices, demonstrated by the substantial amounts of independently certified sustainable forests within each province. These are internationally recognized designations that allow them to market HWP as "certified sustainable" forest products to higher end consumer markets. However, despite the wide swath of certified "sustainable" forests present in western Canada, it is fair to question how sustainable managed forests in Alberta and British Columbia are. Utilizing a benchmark definition of sustainable forest management first established at the Rio Earth Summit in 1992, the overarching regulations and policies that govern and direct forest management practices in both provinces fell short of adhering to this nearly 30-year-old benchmark definition. Despite Canada's ratification of international climate change mitigation agreements that have suggested that forests

should be managed for the enhancement of carbon sinks and reservoirs, the preservation of forest carbon and to assist in climate change mitigation efforts. Neither Alberta's nor British Columbia's relevant forestry regulations or policies that influence "on the ground" forest management practices even mention forest carbon, or climate change mitigation as a value to be conserved or protected for within their provincial forests.

Without clear definitions to base management practices on, or clear indications as to what values to be protecting for it is no wonder that certain aspects of western Canadian forest management practices are inefficient at protecting for carbon or fostering forest resilience. In the past, both provinces have deregulated their forest industries in order to increase industrial investment and create job security and economic well-being within the industry. However, this system of "results based" forestry as it was defined in British Columbia, has proven over time that the most important value considered, conserved and protected for in forest management plans in western Canada is timber, the preservation of timber, and the short, mid-term and long-term supply of timber. This timber focused approach to forest regulation and management has essentially served to benefit the largest industrial producers at the cost of the smaller operators and has failed for the most part in preserving the inherent values of the forest.

The "results based" approach to regulation within British Columbia has even failed to adequately conserve the timber supply and the industry is facing substantial proposed decreases to the annual allowable cut in numerous areas. Natural disturbances definitely share some of the blame for the decrease in short and mid-term timber supply, but industry experts have known about these incoming challenges for many years and failed to adequately address them which has left the forestry industry in British Columbia in a very uncertain position heading into the future. It is clear that new values should be included into British Columbia's relevant forestry regulations, in order to begin to prepare for the impacts of climate change upon one of the provinces largest industries.

Within the last 5 years, British Columbia has begun to institute progressive policies, directives and initiatives aimed at approaching climate change mitigation through forest management, including: enhancing forest carbon, increasing the utilization of forest residuals and fostering forest resilience. Although it is unknown how effective these efforts will be at revitalizing the forestry industry in British Columbia, they represent significant steps forward and the recognition of the

value that forests possess in regards to climate change and the economic well-being of the communities that rely on them to earn a living.

In contrast to British Columbia, Alberta has very few current initiatives or policies that target climate change mitigation or preservation of forest carbon. Some programs, such as the reforestation programs initiated by the Forest Resource Improvement Association of Alberta (FRIAA) are providing valuable opportunities for companies to enhance and regenerate the carbon sink potential in Alberta's forests, but the stated goal of these projects is to protect timber supply within the province and preserve the economic well-being of Alberta's industrial forest operators. Although there are forest carbon benefits associated with FRIAA's programs, they are subsidiary benefits rather than primary. There remains ample opportunity for Alberta to begin prioritizing forest carbon values within their regulatory scheme. Progressive regulatory action should be taken to phase out the practice of slash pile burning as this represents a waste of economic potential, and a significant source of GHG emissions. In order to begin increasing the uptake and utilization of forest harvest residuals within Alberta, the province should consider similar initiatives to those being installed in British Columbia. The *Forest Fibre Initiative* and its attached *Forest Fibre Action Plan* being prime examples. These initiatives are centered around education and providing the means to fostering economic incentive between primary and secondary harvesters in order to increase markets for forest harvest residuals. Alberta should also consider installing a system to disincentivize the practice of slash burning, although it is acknowledged that under the current political climate, this may be a longer process.

Though there are many challenges facing the western Canadian forestry industry regarding forest carbon, how to account for it, how regulate for it, how to enhance it in existent and future forests and how manage it with the uncertainty of climate change and how that will change forest management practices in the future; it is clear that the action is required sooner rather than later. Forests can be one our greatest allies in the fight against climate change, however, if managed unsustainably, without considering how they will change in a world significantly affected by climate change, they also represent one of humanity's most significant risks.

Although there is tremendous uncertainty regarding the future of forestry in western Canada, progressive sustainable forest management practices, informed by regulations and policies that

seek to mitigate climate change and enhance carbon sequestration throughout the forestry value chain may be the way that successful forest policy is measured in the future (Cerezke, 2009).

6.1. Limitations and Areas for Future Research

Given the complexities associated with examining forest carbon there are numerous areas where this report failed to cover important aspects of western Canada's carbon challenges in the necessary depth required. Future research should be directed towards assessing specific regulatory and policy approaches that could be applied to the forestry industry. For example, an in-depth modeling report on how a carbon tax levied at slash pile burning could be implemented and the significant design issues that would follow. Similarly, the literature would benefit from a detailed examination of the feasibility of carbon offsets or other forms of carbon incentivization that could be applied to slash pile utilization initiatives or forest carbon sinks. Although this report has touched briefly on these issues, a more detailed and thorough examination would provide better insight regarding the most feasible approach to incentivizing or disincentivizing carbon emissions in western Canadian forestry.

The economic viability of harvest residual utilization was touched upon in chapter 5, this report did not go so far as to investigate the economic viability, potential pricing schemes or life-cycle analysis of harvest residuals that could be used in HWP such as OSB or particle boards. This is an interesting area to direct future research as uncovering an economically viable use for forest harvest residuals would be of tremendous value to the western Canadian forestry industry. FPInnovations is currently involved in research in this direction, but the author of this report was unable to find any specific data or report information regarding the implementation of the innovative wood products.

Although this report briefly summarized two reports concerning the economic feasibility of harvesting and transporting forest harvest residuals for use in bioenergy plants in Alberta and British Columbia. It would be valuable to direct future research at modeling different scenarios for slash pile collection and communition. The general costs associated with communition by chipping have been well established in western Canada, but less research has been done on the economic feasibility of other slash collecting technologies such as the 'Dutch Dragon" which is a slash bundling that wraps and compresses slash bundles into dense "logs" that nearly have the same

density as saw logs. (Wellink Caesar Timber Technology, 2019) Due to increased density and lack of air spaces with this harvesting method it would be interesting to compare it and other advanced slash harvesting techniques to determine if there are improvements that could be made within the collection system that could increase the economic viability of slash collection.

An aspect that was regrettably left out of this report in any significant detail is the potential to create high-grade transportation fuels such jet-fuel, marine diesel, and other functional transportation fuels from harvest residuals. These high-grade fuels represent high-value bioenergy products. They are expensive to produce, but also lucrative to sell and could provide another potential destination source for waste forest harvest biomass. A detailed examination into the economics of utilizing forest harvest residuals for the long-term production of high-grade biofuels should be conducted, as the potential is there to increase utilization, provide carbon benefits and possibly increase the economic potential of the forestry industry.

It is a limitation of this report that not many areas were examined with appropriate depth, the scope of the project necessitated a high-level overview of the identified carbon challenges within the western Canadian forestry industry, but did not go so far as to identify solutions or concrete findings to ground the conclusions of the research. Future research is required to propose solutions for the complex issues surrounding forest carbon in western Canadian forestry.

References

Alberta Agriculture and Forestry. (2007). *Directive 2007 - 01.* Edmonton: Alberta Sustainable Resource Development.

Alberta Agriculture and Forestry. (2017a, Spring). *Sustainable Forest Management: 2015 Facts and Statistics.* Retrieved from Annual Allowable Cut: https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/formain15744/$FILE/2015-AAC-Fact-Sheet.pdf

Alberta Agriculture and Forestry. (2017b, Spring). *Sustainable Forest Management: 2015 Statistics.* Retrieved from Agriculture and Forestry: https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/formain15744/$FILE/2015-Reforesting-Harvested-Area.pdf

Alberta Government. (2018). *Energy Generation from the Combustion of Biomass Waste: Carbon Competiveness Incentive Regulation.* Edmonton: Alberta Government Directive.

Alberta Sustainable Resource Development. (2006). *Forest Management Planning Standard: Vers. 4.1.* Edmonton: Forest Management Branch.

Andersson, K., Evans, T. P., & Richards, K. R. (2009). National forest carbon inventories: policy needs and assessment capacity. *Climatic Change*.

Barnes, A. (2018). *2017 Economic State of the B.C. Forest Sector.* Victoria: Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Bostrom, B. (2015). *Forests and climate change mitigation in the Swedish context.* Stockholm: Swedish Environment Protection Agency.

British Columbia. (2008, June 13). *Climate Action Plan.* Retrieved from Government of British Columbia: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cap/climateaction_plan_web.pdf

British Columbia Timber Pricing Branch. (2011, January 13). *Provincial Logging Residue & Waste Measurement Procedures Manual.* Retrieved from Government of British Columbia: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-pricing/residue-and-waste/rwp_ch1.pdf

Britten, L. (2018, November 1). *Where there's smoke, there's ire: Green MLA criticizes slash burning after hazy Halloween*. Retrieved from CBC: https://www.cbc.ca/news/canada/british-columbia/slash-burning-bc-1.4888724

Buendia, E., Guendehou, S., Limmechokchai, B., Pipatti, R., Rojas, Y., Sturgiss, R., . . . Wirth, T. (2019). *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Ottawa: IPCC Task Force on National Greenhouse Gas Inventories.

Building Construction Design. (2015, August 10). *Carbon sequestration – locking up carbon and unlocking the full potential of timber*. Retrieved from Building Construction Design: https://www.buildingconstructiondesign.co.uk/news/carbon-sequestration-locking-up-carbon-and-unlocking-the-full-potential-of-timber/

Buizer, M., & Lawrence, A. (2014). The politics of numbers in forest and climate change policies in Australia and the UK. *Environmental Science & Policy, 35*, 57-66.

Canadian Biomass. (2014, October 28). *B.C. introduces innovative, flexible forest licence* . Retrieved from Canadian Biomass: https://www.canadianbiomassmagazine.ca/bc-introduces-innovative-flexible-forest-licence-4746/

Carver, T., & Kerr, S. (2017). *Facilitating Carbon Offsets from Native Forests.* Wellington: Motu Economic and Public Policy Research.

Cerezke, H. (2009). *Climate Change and Alberta's Forests.* Edmonton: Alberta Sustainable Resource Development.

Chipeniuk, R., Duerichen, H., Hart, D., & Imhof, W. (2017). *Position Paper of Smoke and Carbon Emissions from Forestry Slash Burning.* Vancouver: Voices for Good Air.

CleanBC. (2019, July 3). *CleanBC.* Retrieved from Government of British Columbia: https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/symposium/2018/cas_cleanbc-public-sector-leadership_claudia-trudeau.pdf

Climate Action Reserve. (2019, July 24). *California's Compliance Offset Program*. Retrieved from Climate Action Reserve: http://www.climateactionreserve.org/how/california-compliance-projects/

Clogg, J. (1999). *Tenure Background Paper.* Nelson: West Coast Environmental Law. Retrieved from https://www.for.gov.bc.ca/hfd/library/documents/bib96990.pdf

Cloverdale Fuels. (2019, August 25). *Hog Fuel*. Retrieved from Cloverdale Fuels: https://cloverdalefuel.com/products/hog-fuel/

Cruickshank, A. (2016, May 11). Carbon release in wake of Fort McMurray wildfire spikes greenhouse gasses. *Edmonton Journal*.

Davidson, G., & Shah, R. (2015). *Canada's failure to reduce emissions: Unlawful or above the law?* Ottawa: Canadian Centre for Policy and Alternatives.

Dymond, C. (2012). Forest carbon in North America: Annual Storage and Emissions from British Columbia's Harvest. *Carbon balance and management, 1*(10), 1-10.

Edson Forest Products. (2014). *Timber Harvest Planning and Operating Ground Rules.* Edson: Edson Forest Products.

Eggleston, H., Srivastava, N., Tanabe, K., & J., B. (2010). *Revisiting the Use of Managed Land as a Proxy for Estimating National Anthropogenic Emissions and Removals.* Sao Jose dos Campos: Institute for Global Environmental Strategies.

Enters, T. (2001). *Trash or treasure?: logging and mill residues in Asia and the Pacific.* . Bangkok: Food and Agricultural Organization of the United Nations, Regional Office for Asia and the Pacific.

Environment and Climate Change Canada. (2018). *Pan-Canadian Framework on Clean Growth and Climate Change.* Gatineau: Environment and Climate Change Canada.

Environment and Climate Change Canada. (2019a, April 18). *Canada and British Columbia announce funding to help tackle climate change and reduce emissions*. Retrieved from Government of Canada: https://www.canada.ca/en/environment-climate-change/news/2019/04/canada-and-british-columbia-announce-funding-to-help-tackle-climate-change-and-reduce-emissions.html

Environment and Climate Change Canada. (2019b). *Canada NIR 2019: Part 3.* Ottawa: Governement of Canada.

Environment and Climate Change Canada. (2019c). *National Inventory Report 1990-2017: Greenhouse Gas Sources and Sinks in Canada.* Ottawa: Government of Canada.

European Commission. (2012, July 6). *Innovating for Sustainable Growth - A Bioeconomy for Europe*. Retrieved from European Commission: http://ec.europa.eu/research/bioeconomy/pdf/bioeconomycommunicationstrategy_b5_brochure_web.pdf

Extension. (2013, September 10). *The Economics of Forest Biomass Production and Use.* Retrieved from Extension: https://articles.extension.org/pages/69966/the-economics-of-forest-biomass-production-and-use

Food and Agricultural Organization of the United Nations (FAO). (2015). *Wood Construction and Climate Change Mitgation.* Food and Agriculture Organization of the United Nations.

Food and Agricultural Organization of the United Nations (FAO). (2019, July 13). *Deforestation*. Retrieved from Food and Agriculture Organization of the United Nations: http://www.fao.org/3/j9345e/j9345e07.htm

Favreau, J., & Ristea, C. (2016). The Roles of FPInnovations, Governments, and Industry in transforming Canada's Forest Industry. In J. Audy, & Y. Feng, *Forest Value Chain Optimization and Sustainability* (pp. 76-88). Ottawa: CBC Press.

Forest Enhancement Society of British Columbia (FESBC). (2017). *Forest Enhancement Society of British Columbia*. Retrieved from $150-MILLION Reforestation Investment: https://fesbc.ca/reforestation-investment.html

Forest Enhancement Society of British Columbia (FESBC). (2019). *Accomplishments Report.* Vancouver: Forest Enhancement Society of British Columbia.

Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO). (2013). *Climate mitigation potential of British Columbian Forests: Growing Carbon Sinks.* Vancouver: Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO). (2016). *Major Primary Timber Processing Facilities in British Columbia 2016.* Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO). (2018, May 9). *Roadside Residual Handling Guidline Version 3.0.* Retrieved from Ministry of Forests, Lands, Natural Resource Operations and Rural Development: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-tenures/fibre-recovery/roadside_residue_handling_guidelines_version_3.pdf

Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO). (2019, August 5). *Backyard and Industrial Burning.* Retrieved from Ministry of Forests, Lands, Natural Resource Operations and Rural Development.: https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/wildfire-status/fire-bans-and-restrictions/bcws_backyardburning.pdf

Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO). (2019). *Office of the Premier: News Release.* Vancouver: FLNRO.

Forestry Innovation Investment. (2007). *Beetle-killed sawmill residuals could supply OSB strands.* Forestry Innovation Investment.

Forest Resources Improvement Association of Alberta (FRIAA). (2019, August 2). *Who is FRIAA?* Retrieved from Forest Resource Improvement Association of Alberta: https://friaa.ab.ca/who-is-friaa/

Forest Resources Improvement Association of Alberta (FRIAA). (2019a, August 12). *Mountain Pine Beetle Forest Rehabilitation Program*. Retrieved from FRIAA: https://friaa.ab.ca/programs/mountain-pine-beetle-forest-rehabilitation-program/

Forest Resources Improvement Association of Alberta (FRIAA). (2019b, August 12). *Wildfire Reclamation Program*. Retrieved from FRIAA: https://friaa.ab.ca/programs/wildfire-reclamation-program/

Friesen, C. (2018). *Using FPInterface to Estimate Availability of Forest-Origin Biomass in British Columbia: Prince George TSA.* Vancouver: FPInnovations.

Geng, A., Yang, H., Chen, J., & Hong, Y. (2017). Review of carbon storage function of harvested wood products and the potential of wood substitution in greenhouse gas mitigation. *Forest Policy and Economics*, 192-200.

Giovanneti, J. (2019, May 21). UCP and NDP at odds over climate policies as Alberta legislature returns. Calgary, Alberta, Canada. Retrieved from https://www.theglobeandmail.com/canada/alberta/article-ucp-and-ndp-at-odds-over-climate-policies-as-alberta-legislature/

Global Carbon Project. (2018). *Global Carbon Budget 2018.* Montreal: Futurearth.

Global Forest Resources Assessment. (2015). *Global Forest Resources Assessment 2015 Country Report Canada.* Rome: FAO.

Goerndt, M. E., Aguilar, F. X., & Skog, K. (2013). Resource potential for renewable energy generation from co-firing of woody biomass with coal in the Northern U.S. *Biomass and Bioenergy*, 348-361.

Government of Alberta. (2007). *Planning Mountain Pine Beetle Response Operations.* Edmonton: Goverment of Alberta.

Government of Alberta. (2016, July). *Climate Leadership Plan 2015*. Retrieved from Alberta Government: https://www.alberta.ca/climate-leadership-plan.aspx

Government of Alberta. (2017a). *Debris Management Standards for Forest Harvest Operations.* Edmonton: Alberta Government.

Government of Alberta. (2017b, August 14). *Forest and Praire Practices Ministerial Regulation.* Retrieved from Government of Alberta: http://www.qp.alberta.ca/documents/Regs/2017_065.pdf

Government of Alberta. (2017c). *Forest Management Planning Standard Interpretive Bulletin: Stewardship Reporting Requirements.* Edmonton: Alberta Government.

Government of Alberta. (2017d). *Sustainable Forest Management: 2015 Facts and Statistics.* Edmonton: Agriculture and Forestry.

Government of Alberta. (2017e). *TImber Management Regulations.* Retrieved from Province of Alberta: http://www.qp.alberta.ca/documents/Regs/1973_060.pdf

Government of Alberta. (2018a, June 18). *Alberta Government.* Retrieved from Energy Generation from the Combustion of Biomass Waste: https://open.alberta.ca/dataset/882aa4e1-9358-4a98-a633-9435b2a49830/resource/501c00bd-4385-4c45-94bd-bc4a0efa0ee0/download/energygenerationbiomass-jun18-2018.pdf

Government of Alberta. (2018b). *Business Plan 2018 –21.* Edmonton: Agriculture and Forestry.

Government of Alberta. (2019a, July 16). *Alberta*. Retrieved from Overview of Forest Mangement Plans: https://www.alberta.ca/forest-management-plans-overview.aspx

Government of Alberta. (2019b, July 18). *Forest Harvest Operations*. Retrieved from Government of Alberta: https://www.alberta.ca/forest-harvest-operations.aspx

Government of Alberta. (2019c, July 18). *Forests Act*. Retrieved from Alberta Government: https://open.alberta.ca/publications/f22

Government of Alberta. (2019d, July 16). *Timber Harvest Planning and Operating Ground Rules*. Retrieved from Alberta Government: https://open.alberta.ca/publications/2196327

Government of Alberta. (2019e, July 17). *Alberta Government*. Retrieved from Mountain Pine Beetle Strategy: https://www.alberta.ca/mountain-pine-beetle-in-alberta-strategy.aspx

Government of Alberta. (2019f, July 26). *Forest Tenure*. Retrieved from Alberta.ca: https://www.alberta.ca/forest-tenure.aspx

Government of British Columbia. (2002). *Bill 74: Forest and Range Practices Act.* Victoria: Queen's Printer.

Government of British Columbia. (2003, March 31). *Forestry Revitatilzation Act*. Retrieved from BClaws: http://www.bclaws.ca/civix/document/id/complete/statreg/03017_01

Government of British Columbia. (2004). *Forest Planning and Practices Regulation.* Victoria: Queens Printer.

Government of British Columbia. (2005). *Non-replaceable Forest Licence Management; Understanding the basics.* Ministry of Forests and Range.

Government of British Columbia. (2008, July 21). *BC BioEnergy Strategy.* Retrieved from British Columbia: http://www.energybc.ca/cache/usage/usage3/www.energyplan.gov.bc.ca/bioenergy/PDF/BioEnergy_Plan_005_0130_web0000.pdf

Government of British Columbia. (2012). *Forest Governance in British Columbia.* Governmant of British Columbia .

Government of British Columbia. (2016). *Provincial Inventory Report 2016: FAQ*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory/faq

Government of British Columbia. (2017, April 7). *Forests, Lands, Natural Resource Operations and Rural Development*. Retrieved from Factsheet: Reforestation in B.C.: https://news.gov.bc.ca/factsheets/factsheet-reforestation-in-bc

Government of British Columbia. (2018a, July 22). *British Columbia's Carbon Tax*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax

Government of British Columbia. (2018b). *Environmental Protection & Sustainability*. Retrieved from Provincial Greenhouse Gas Emissions Inventory: https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory

Government of British Columbia. (2019a, July 22). *Sustainable Forest and Timber Management*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/timber-management-goals

Government of British Columbia. (2019b, July 22). *Sustainable Forest Mangement Practices*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/sustainable-forest-management-practices

Government of British Columbia. (2019c, July 27). *Timber Harvest Rights*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/industry/forestry/forest-tenures/timber-harvesting-rights

Government of British Columbia. (2019d, August 3). *Wildfire Act.* Retrieved from Government of British Columbia: http://www.bclaws.ca/Recon/document/ID/freeside/11_38_2005

Government of British Columbia. (2019e, August 8). *Over Storey Removal for Innovative Timber Sale License (ITSL)*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/stand-establishment-and-treatment-standards/over-storey-removal-for-innovative-timber-sale-license-itsl

Government of British Columbia. (2019f, August 12). *Residual Fibre Recovery*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/industry/forestry/forest-tenures/forest-tenure-administration/residual-fibre-recovery

Government of Canada. (2015, November 3). *Canada's international action on climate change*. Retrieved from Canada's role in the United Nations Framework Convention on Climate Change : https://www.canada.ca/en/environment-climate-change/services/climate-change/united-nations-framework-convention.html

Government of Canada. (2018, September 26). *Natural Resources Canada*. Retrieved from Indicator: Carbon emissions and removals: https://www.nrcan.gc.ca/our-natural-resources/forests-and-forestry/state-canadas-forests-report/how-does-disturbance-shape-canadas-forests/indicator-carbon-emissions-removals/16552

Government of Canada. (2019a, July 9). *Canada's Official Greenhouse Gas Inventory*. Retrieved from Government of Canada: https://open.canada.ca/data/en/dataset/779c7bcf-4982-47eb-af1b-a33618a05e5b

Government of Canada. (2019b, July 24). *Job Bank*. Retrieved from Forestry: Region of Western Canada and the Territories: 2014-2016: https://www.jobbank.gc.ca/content_pieces-eng.do?cid=10708

Government of Canada. (2019c, July 17). *Sustainability of Timber Harvest*. Retrieved from Government of Canada Sustainability Indicators: https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/sustainability-timber-harvest.html

Government of Canada. (2019d, April 15). *Canada's Official Greenhouse Gas Inventory.* Retrieved from Government of Canada: https://open.canada.ca/data/en/dataset/779c7bcf-4982-47eb-af1b-a33618a05e5b

Graff, P., & Henderson, S. (2018). *Initiatives to Utilize Post-Harvest Residual Fibre.* Victoria: Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Gren, I.-M., & Aklilu, A. Z. (2016). Policy design for forest carbon sequestration: A review of the literature. *Forest Policy and Economics*, 128-136.

Harvey, C. (2017, October 13). *Scientific Amercan*. Retrieved from What are climate change feedback loops?: https://www.scientificamerican.com/article/heres-what-we-know-about-wildfires-and-climate-change/

Herold, A., Monni, S., Lin, E., & Meyer, C. (2006). *Chapter 4: Methodological Choice and Identification of Key Categories.* Hayama: IPCC Task Force on National Greenhouse Gas Inventories.

Hoberg, G., St-Laurent, G., Schittecatte, G., & Dymond, C. (2016). Forest carbon mitigation policy: A policy gap analysis for British Columbia. *Forest Policy and Economics, 69*, 73-82.

Hoekstra, G. (2019, June 12). No Quick Fix for B.C. Sawmill Closures Linked to Drop in Timber Supply. *Vancouver Sun*, p. 1.

Hoyne, S., & Thomas, A. (2001). *Forest residues: Harvesting, storage and fuel value.* Ireland: COFORD.

International Energy Agency (IEA) Bioenergy. (2017). *Bioenergy in Sweden.* Gothenburg: IEA Bioenergy.

Intergovernmental Panel on Climate Change (IPCC). (2008). *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Hayama: Institute for Global Environmental Strategies.

Intergovernmental Panel on Climate Change (IPCC). (2019, August 1). *Special report: Global Warming of 1.5*. Retrieved from IPCC: https://www.ipcc.ch/sr15/

IRENA. (2018). *Bioenergy from Finnish forests: Sustainable, efficient, modern use of wood.* Masdar City: International Renewable Energy Agency.

Iverson, P., Lee, D., & Rocha, M. (2014). *Understanding Land Use in the UNFCCC.* GHG Institute.

Jacob, M., Bade, C. C., Dittrich, S., Leuschner, C., & Hauck, M. (2013). Significance of Over-Mature and Decaying Trees for Carbon Stocks in a Central European Natural Spruce Forest. *Ecosystems*, 336-346.

Jang, B. (2018, January 5). Canada calls for stop to U.S. Softwood-lumber duties. *The Globe and Mail*, p. 1.

Johnston, C. M., & Radeloff, V. C. (2019). *Global mitigation potential of carbon stored in harvested wood products.* Madison: Department of Forest and Wildlife Ecology, University of Wisconsin–Madison.

Jones, G., Loeffler, D., Calkin, D., & Chung, W. (2010). Forest treatment residues for thermal energy compared with disposal by on-site burning: emissions and energy return. *Biomass and Bioenergy*, 737-746.

Kallio, M., & Leinonen, A. (2005). *Production Technology of Forest Chips in Finland.* Finland: VTT Processes.

Kamp, A. (2013). *Policies for the Reduction of Slash Pile Burning in BC Forests.* Burnaby: Simon Fraser University.

Kozuki, S., & Stewart, D. (2019). *Forest Fibre Action Plan.* Victoria: Ministry of Forests, Lands, and Natural Resource Operations.

Krug, J. H. (2018). Accounting of GHG emissions and removals from forest management: a long road from Kyoto to Paris. *Carbon Balance and Management*.

Kurz, W., Hayne, S., Fellows, M., MacDonald, J., Metsaranta, J., Hafer, M., & Blain, D. (2018). Quantifying the impacts of human activities on reported greenhouse gas emissions and removals in Canada's managed forest: conceptual framework and implementation. *Canadian Journal of Forest Research, 48*(10), 1227-1240.

Layzell, D., & Ralevic, P. (2006). *An Inventory of the Bioenergy Potential of British Columbia.* Calgary: Cesar.

Le Quere, C. (2018). Global Carbon Budget 2018. *Earth System Science Data, 10*(4), 2141-2194.

LeRoy, M. (2014, September 17). *Strategic Plan: 2013-2017.* Retrieved from British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development.:

https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/fft_strategic_plan_presentation_ml_2014.pdf

Lichtert, N. (2017, September 20). *The world's tallest wood building opens to residents at University of British Columbia*. Retrieved from Archinect: https://archinect.com/news/article/150029630/the-world-s-tallest-wood-building-opens-to-residents-at-university-of-british-columbia

Lindroos, O., Nilsson, B., & Sowlati, T. (2011). Costs, CO2 Emissions, and Energy Balances of Applying Nordic Slash Recovery Methods in British Columbia. *Western Journal of Applied Forestry*, 30-36.

Luckert, M., Haley, D., & Hoberg, G. (2011). *Policies for Sustainably Managing Canada's Forests.* Vancvouer: UBC Press.

Lundmark, T., Bergh, J., Hofer, P., Lundstrom, A., Nordin, A., Poudel, B., . . . Werner, F. (2014). Potential Roles of Swedish Forestry in the Context of Climate Change Mitigation. *Forests, 5*(4), 557-578.

MacDonald, A. (2006). *Estimated Costs for Harvesting, Comminuting, and Transporting Beetle-killed Pine in the Quesnel/Nazko Area of Central British Columbia.* Vancouver: Forest Engineering Research Institute of Canada.

Makkonen, M., Huttunen, S., Primmer, E., Repo, A., & Hilden, M. (2015). Policy coherence in climate change mitigation: An ecosystem service approach to forests as carbon sinks and bioenergy sources. *Forest Policy and Economics*, 153-162.

Ministry of Agriculture and Forestry of Finland. (2018). *Ministry of Agriculture and Forestry of Finland*. Retrieved from Forest legislation in Finland: https://mmm.fi/en/forests/legislation

Ministry of Agriculture and Forestry of Finland. (2019). *National Forest Strategy 2025.* Helsinki: Ministry of Agriculture and Forestry of Finland. Retrieved from National Forest Strategy: http://www.e-julkaisu.fi/mmm/national-forest-strategy_of_finland-2025/mobile.html#pid=22

Minstry of Forests, Lands, Natural Resource Operations and Rural Development. (2017). *Provincial Timber Management Goals, Objectives and Targets.* Government of British Columbia.

Morgan, T. (2009). *An assessment of forest-based woody biomass supply and use in Montana.* Missoula: Montana Department of Natural Resources and Conservation.

Muraro, S. (1966). Lodgepole Pine Logging Slash. *Department of Forestry*, 6-12.

Natural Resources Canada. (2016, June 12). *Forest Carbon*. Retrieved from Natural Resources Canada: https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/forest-carbon/13085

Natural Resources Canada. (2017, October 2). *NRCan*. Retrieved from Roles and Responsibilities of Governments in Natural Resources: https://www.nrcan.gc.ca/our-natural-resources/minerals-and-mining/mining/taxation/mining-taxation-canada/roles-responsibilities-governments-natural-resources/8882

Natural Resources Canada. (2019, July 30). *Forest Certification in Canada*. Retrieved from Natural Resources Canada: https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/sustainable-forest-management/forest-certification-canada/17474

Niquidet, K., & Friesen, D. (2014). Bioenergy potential from wood residuals in Alberta: a positive. *Canadian Journal of Forest Research* , 1586-1594.

North, M., Stevens, J., Greene, D., Coppoletta, M., Knapp, E., & Latimer, A. (2019). Tamm Review: Reforestation for resilience in dry western U.S. forests. *Forest Ecology and Management*, 209-224.

Natural Resources Canada (NRCan). (2014, January 16). *Selective Cuttings: Bioenergy in Alberta: Opportunities for additional bioenergy capacity*. Retrieved from Natural Resources Canada: https://cfs.nrcan.gc.ca/selective-cuttings/64

Natural Resources Canada (NRCan). (2018, September 26). *Natural Resources Canada*. Retrieved from Statistical Data: 2015-2017: https://cfs.nrcan.gc.ca/statsprofile/trade/ca

Natural Resources Canada (NRCan). (2019, July 2). *Squeezing more value from trees.* Retrieved from Natural Resources Canada: https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/forest-industry-trade/forest-industry-tools-research/squeezing-more-value-trees/13331

Natural Resources Canada (NRCan). (2019a, July 2). *Bio-Pathways Project*. Retrieved from Natural Resources Canada: https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/forest-industry-trade/forest-bioeconomy-bioenergy-biop/bio-pathways-project/13321

New Zealand (NZ) Forestry. (2019). *NZ Forestry: Forestry Management & Consulting*. Retrieved from Carbon Forestry: https://nzforestry.co.nz/services/carbon-forestry/

Office of the Auditor General. (2018). *Perspectives on Climate Change Action in Canada—A Collaborative Report from Auditors General—March 2018.* Ottawa: Officer of the Auditor General.

Pacific BioEnergy. (2019, January 18). *News*. Retrieved from Pacific BioEnergy: https://www.pacificbioenergy.ca/pacific-bioenergy-corporation-enters-into-new-long-term-supply-contracts-to-japanese-power-producers/

Pan, Y. B., Piao, S., Rautiainen, A., Sitch, S., & Hayes, D. (2011). A large and persistent carbon sink in the world's forests. *Science, 333*(6045), 983-993.

Pasay, J. (2018, April 9). *Cross Laminated Timber Can Reduce the Carbon Footprint of New Buildings*. Retrieved from Climate Trust: https://climatetrust.org/cross-laminated-timber-can-reduce-the-carbon-footprint-of-new-buildings/

Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Krguer, D., Pipatti, R., . . . Wagner, F. (2003). *Good Practice Guidance for Land Use, Land-Use Change and Forestry.* Hayama: Institute for Global Environmental Strategies.

Province of Alberta. (2016). *Forest and Prairie Protection Act.* Edmonton: Queens Court Bench.

Renewable Energy World. (2019, August 25). *BioPower*. Retrieved from Renewable Energy World: https://www.renewableenergyworld.com/bioenergy/tech/biopower.html

Riley, S. (2018, August 13). How climate change is making B.C.'s wildfire season hotter, longer, drier. *The Narwhal*.

Romppanen, S. (2017, September 14). *University of Eastern Finland*. Retrieved from Controversy over EU's LULUCF Accounting Rules: https://blogs.uef.fi/oikeuttakohtuudella/2017/09/14/the-eu-was-the-first-to-update-lulucf-accounting-rules-post-paris/

Sustainable Forest Management (SFM) Canada. (2016). *Forest governance in the Province of Alberta.* Ottawa: Canadian Council of Forest Ministers.

Sustainable Forest Management (SFM) Canada. (2017). *Forest governance in the Province of British Columbia.* Ottawa: Canadian Council of Forest Ministers.

SISCO. (2017). *New Initiatives Forest Enhancement, Forest Carbon, Forests for Tomorrow, Strategic Wildfire Prevention Initiative.* Victoria: Ministry of Forests, Lands and Natural Resource Operations.

Spencer, S., & Roser, D. (2017). *Integrated Harvest Operations in British Columbia.* Vancouver: FPInnovations.

Ter-Mikaelian, M., Colombo, S., & Chen, J. (2015). The Burning Question: Does Forest Bioenergy Reduce Carbon Emissions? A Review of Common Misconceptions about Forest Carbon Accounting. *Journal of Forestry, 113*(1), 57-68.

United Nations Conference on Environment and Development (UNCED). (1992). *Principles of sustainable tropical forest management where wood production is the primary objective*. Retrieved from Food and Agriculture Organization.: http://www.fao.org/3/W8212E/w8212e04.htm

United Nations Framework Convention on Climate Change (UNFCCC). (2015). Adoption of the Paris Agreement. *FCCC/CP/2015/L.9* (pp. 1-24). Paris: United Nations.

United Nations Framework Convention on Climate Change (UNFCCC). (2019a, July 12). *Reporting and Review under the convention: Greenhouse Gas Inventories*. Retrieved from UNFCCC.int: https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/reporting-requirements

United Nations Framework Convention on Climate Change (UNFCCC). (2019b). *United Nation Climate Change*. Retrieved from Cooperation with the IPCC: https://unfccc.int/topics/science/workstreams/cooperation-with-the-ipcc

United Nations Framework Convention on Climate Change (UNFCCC). (2019c). *United Nations Climate Change*. Retrieved from Reporting requirements: https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/reporting-requirements

United Nations Framework Convention on Climate Change (UNFCCC). (2019d). *United Nations Climate Change*. Retrieved from Parties & Observers: https://unfccc.int/parties-observers

United Nations Framework Convention on Climate Change (UNFCCC). (2019e). *United Nations Climate Change*. Retrieved from What is the United Nations Framework Convention on Climate Change?: https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change

United Nations. (2015). *Adoption of the Paris Agreement.* Paris: Framework Convention on Climate Change.

Vice. (2015, November 30). *Inside Canada's Anti-Pipeline Resistance Camp*. Retrieved from Vice Travel : https://www.vice.com/en_us/article/dp5epq/my-time-at-canadas-anti-pipeline-resistance-camp

Virkkula, A., Levula, J., Pohja, T., Aalto, P., Keronen, P., Schobesberger, S., . . . Kumala, L. (2014). Prescribed burning of logging slash in the boreal forest of Finland: emissions and effects on meteorological quantities and soil properties. *Atmospheric Chemistry and Physics*, 4473-4502.

Voices for Good Air. (2017). *Scientific Methods Measuring Slash Volume and Weight.* British Columbia: Clean Air Now.

Wahlen, C. B. (2018, November 13). *IISD*. Retrieved from Scientists Highlight Forests' Critical Role in Climate Mitigation: http://sdg.iisd.org/news/scientists-highlight-forests-critical-role-in-climate-mitigation/

Wellink Caesar Timber Technology. (2019, August 28). *Wellink Caesar Timber Technology*. Retrieved from Dutch Dragon - Model SD60 - Bundler: https://www.agriculture-xprt.com/products/dutch-dragon-model-sb-60-bundler-561226

West Coast Environmental Law. (2004). *"Timber Rules" Forest Regulations Lower Standards, Tie Government Hands and Reduce Accountability.* Vancouver: West Coast Environmental Law.

Wieting, J. (2015, June). *SIerra Club B.C.* Retrieved from B.C. Forest Wake-up Call: Heavy Carbon Losses hit 10-year mark: https://sierraclub.bc.ca/wp-content/uploads/2015/08/Forest-Emissions-Detailed-Backgrounder_June22.pdf

Wood Solutions. (2019, August 22). *Cross-Laminated Timber*. Retrieved from Wood Solutions: https://www.woodsolutions.com.au/wood-product-categories/Cross-Laminated-Timber-CLT

Appendix A

List of Interview Participants:

Interview Participant A: Alberta Forest Area Manager - Kevin Gagne, Interviewed by Josh Mitchell on July 2, 2019

Interview Participant B: Former Residuals Manager for Weyerhaeuser – Stuart McCormick, Interviewed by Josh Mitchell on July 5, 2019

Interview Participant C: Climate Related Scientist – Requested Confidentiality, Interviewed by Josh Mitchell on July 17, 2019

Interview Participant D: Director of Canadian eNGO – Requested Confidentiality, Interviewed by Josh Mitchell on July 9, 2019

Interview Participant E: Canadian Climate Change Policy Analyst – Requested Confidentiality, Interviewed by Josh Mitchell on July 5, 2019

Interview Participant F: Forestry Consultant in British Columbia – Patrick, Interviewed by Josh Mitchell on August 20, 2019

Interview Participant G: Forest Analyst with Alberta Government – Requested Confidentiality, Interviewed by Josh Mitchell on July 4, 2019

Interview Participant H: Conservation Director at Wildsight eNGO – John Bergenske, Interviewed by Josh Mitchell on July 9, 2019

Interview Participant I: Canadian Forest Carbon Researcher – Requested Confidentiality, Interviewed by Josh Mitchell on July 3, 2019

Interview Participant J: Director of Operations and Engineering at Steeper Energy - Bob Moll, Interviewed by Josh Mitchell on July 2, 2019

Interview Participant K: Retired British Columbia RPF, Owner of Sunshine Logging – Jeff Mattes, Interviewed by Josh Mitchell on July 9, 2019

Interview Participant L: Bioenergy Businesswoman – Maryam Mkhani, Interviewed by Josh Mitchell on July 16, 2019

Interview Participant M: Conservation Director for Canadian Parks and Wilderness Society (Southern Chapter) – Katie Morrison, Interviewed by Josh Mitchell on July 2, 2019

Appendix B

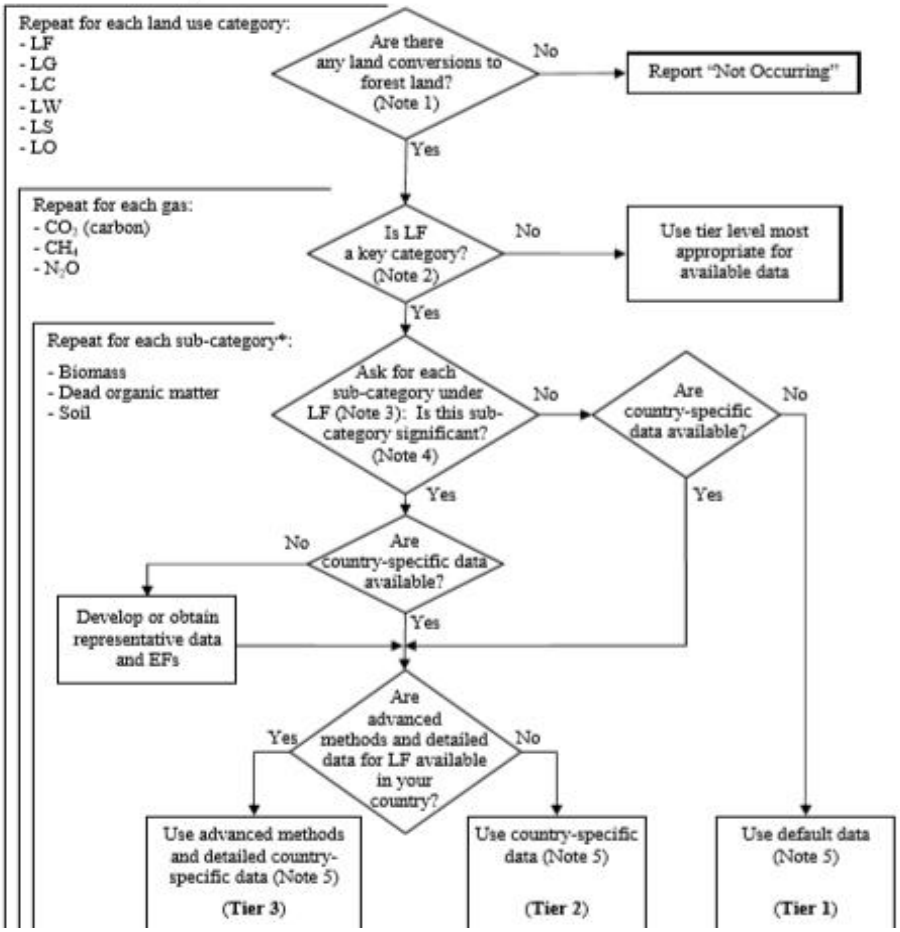
Tiered Reporting Methodology Hierarchy for UNFCCC National Inventory Reporting

Among the good practices suggested by the 2006 refinement to IPCC guidelines is the establishment of "key categories" defined as "*[a category] that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sink categories*" (Herold, Monni, Lin, & Meyer, 2006, pp. 25,28). The IPCC considers using the most rigorous available reporting methodologies to report on each category or sub-category within a specific sector, however it recognizes that it may not be feasible to apply the most rigorous standards to every category. Thus, the establishment of key categories within national inventory report sectors is important as they serve to prioritize reporting efforts and diminish uncertainty within overall reporting estimates (Herold, Monni, Lin, & Meyer, 2006). Although earlier IPCC guideline iterations (1996, 2000) did not consider the LULUCF sector in their key category analysis, the updated 2003 IPCC guideline recommended inclusion of the entire inventory, including all LULUCF categories (Penman, et al., 2003). The IPCC developed a decision tree model for LULUCF key categories to aid and direct inventory compilers towards acceptable reporting standards in the sector.

To hierarchize reporting methodologies and define best practice standards, the IPCC guidelines for national greenhouse gas submissions describes three tiers of methodological complexity. Tier 1 is the most basic reporting methodology to be accepted by the IPCC, while tier 2 and tier 3 are considered higher level reporting methodologies representing increasing accuracy of reporting methodologies in terms of complexity and data requirements (Buendia, et al., 2019). Although tier 3 reporting methodologies would represent good practice reporting standards, the IPCC recognizes that tier 3 standards are not practical for every sub-category and each reporting country is able to choose which tier their reporting standards will adhere to as long the basic requirements of tier 1 are met. Canada, as an Annex I country strives to apply tier 3 methodologies wherever possible across GHG reporting sectors to ensure transparent and accurate accounting of the countries anthropogenic emissions, however tier 3 reporting standards are not universally applied throughout the entire inventory.

Tiered Decision Tree for LULUCF Sector

Figure 1.1 **Decision tree for identification of appropriate tier-level for land converted to another land-use category (example given for land converted to forest land, LF)**



(Penman, et al., 2003)

Appendix C

Canada, UNFCCC and the Kyoto Protocol

In 1997, Canada was active in the discussions that led to the Kyoto Protocol. Canada signed the Kyoto Protocol accord in 1997 and officially ratified it in parliament in 2002 with the stated goal to reduce overall emissions to less 6% above the 1990 baseline emission levels by 2012 (Davidson & Shah, 2015). The Kyoto protocol calls for each Annex I party, in the process of achieving its reduction and emission commitments to implement policies and control mechanisms to include the enhancement of sinks and reservoirs…and the promotion of sustainable forest management practices, reforestation and afforestation. In line with this stated goal, the Kyoto Protocol mandated specific provisions for the treatment of the LULUCF sector within national inventory reporting (Iverson, Lee, & Rocha, 2014).

GHG accounting under the Kyoto protocol for the LULUCF sector is based on a direct effort to increase the representation of anthropogenic influences on the LULUCF sector. Reflecting this, the Kyoto protocol had two designed commitment periods for Annex I parties, the first commitment period made it mandatory for reporting countries under Article 3.3 of the protocol which states that: *" the net change from GHG emissions by sources and removals by sinks resulting from afforestation, reforestation, and deforestation since 1990 shall be used to meet commitments".* This provision in the accord made reporting of the mentioned categories mandatory for Annex I countries who had signed onto the Kyoto Protocol. Article 3.4 of the Kyoto Protocol stated that: "additional activities to be defined may be used to meet commitments for the first commitment period. For the first commitment period these additional voluntary activities were subsequently agreed to be forest management, cropland management, grazing land management and revegetation" (Iverson, Lee, & Rocha, 2014). Upon ratification, the Kyoto protocol permitted countries to make the choice as to elect which categories they included in year one of the commitment, beyond afforestation, reforestation and deforestation, with the requirement that, once selected, these categories must be reported for in any subsequent years. Significantly, under the second commitment period, reporting for the forest land category became mandatory as well as any additional category selected by the country in the first reporting period.

The Kyoto Protocol is significant in Canada's LULUCF GHG inventory because the Canadian government initially ratified the protocol but opted out of the protocol in 2011 when the second

commitment period was about to take effect. Part of the possible reasoning for this decision was suggested in an interview with Bob Moll, Operations Director for the advanced Biofuel company Steeper Energy.

"My understanding… with the Kyoto Protocol, is Canada signed on, and the thinking for the people who were developing the protocols at that time was that we would meet our requirements simply through the application of the forestry sink. Then they went away and did the modeling and came to the conclusion that with the impact of climate change that there would be a lot more forest fires, and with the forest fires, the forests would no longer be a carbon sink they'd be a carbon source and so they backed out of the protocol." (Interview Participant J, 2019).

Under the Kyoto protocol, reporting for the LUUCF sector takes an activity-based approach rather than the land-based approach implemented by the IPCC under the managed land proxy. An activity-based approach focuses on anthropogenic activities that take place in specified land use zones, and allows for the differentiation of activities on lands, essentially allowing for partitioning of activities from anthropogenic and non-anthropogenic sources, whereas the managed land proxy suggested by the IPCC considers all emissions on managed lands to be anthropogenic (Iverson, Lee, & Rocha, 2014). The elective inclusion of certain LULUCF categories under the Kyoto Protocol seems less likely to be comprehensive than the land-based approach implemented by the IPCC guidelines. This was reinforced by the limited amount of countries that chose to report emissions for all optional sectors under the Kyoto Protocol (Iverson, Lee, & Rocha, 2014). Canada's opting out of the second commitment requirement of the Kyoto Protocol meant that the ability to partition emissions in the LULUCF sector was reduced to the requirements set out by the land-based managed land proxy suggested under the IPCC guidelines.

Significantly, emissions reduction requirements under the Kyoto Protocol were considered legally binding economy-wide targets that held certain liabilities for countries that did not fulfill their commitments. This is juxtaposed against the UNFCCC reporting standards that require reporting of LULUCF emissions in national inventory reports only and does not mandate their inclusion in final inventory totals and are not legally binding requirements (Iverson, Lee, & Rocha, 2014). Part of the Kyoto Protocols intended solutions for the LULUCF sector was to include certain categories under the LULUCF sector, after designating assigned amounts of removals. This allowed for accounting practices that were subject to the specific rules of the Kyoto protocol. Essentially, if

inclusion of the LULUCF sector resulted in positive emissions (emission reduction, or increased sequestration) then there would be more room for emissions from other sectors in order to reach the commitment totals, with the opposite occurring if inclusion of certain LULUCF categories decreased removals and increased emissions (Iverson, Lee, & Rocha, 2014). Partially as a result of the Kyoto protocol, and Canada's initial ratification, Canada still reports emissions and removals from reforestation, deforestation and afforestation in its national inventory totals. All other emissions from the LULUCF sector are reported for transparency, but not included in the accounting total.

Appendix D

Tenure in Alberta - Forest Management Agreements

Forest management agreements are generally the largest and are reserved exclusively for large commercial operators. The agreement is for an area of land usually deemed an FMU that is within a certain FMA. Forest management agreements are held for 20 years and can be negotiated every 10 years as necessary. Reforestation is mandatory for the tenure holder however it is interesting to note that this is the only agreement that gives the responsibility of developing the Forest Management Plan (FMP) to the tenure holder (Government of Alberta, 2019f). This means that the government is relying on the company or operator who has purchased the tenure agreement to decide how they want to approach the forest area, and leaves questions as to if they are managing the forest in the public interest. The development of sustainable and practical FMP's is important as the FMP helps inform the determination of the Annual Allowable Cut (AAC), reforestation protocols, operation ground rules and other key management decisions (Government of Alberta, 2019f). In this case, a government representative in the form of the forest area manager must approve the companies forest management plan before any forest operations or activities can take place on the land. Individuals or companies that sign forest management agreements with the Alberta government are bound to manage the area of crown forest they a signatory to in a way that corresponds with forest management practices and methodologies determined by the government. In this way, holders of forest management agreements are liable to governmental standards of sustainability when it comes to forest management. From Alberta *Forests Act* Section 16(1)

16(1) The Minister, with the approval of the Lieutenant Governor in Council, may enter into a forest management agreement with any person to enable that person to enter on forest land for the purpose of establishing, growing and harvesting timber in a manner designed to provide a yield consistent with sustainable forest management principles and practices.

Appendix E

Tenure in Alberta - Coniferous and Deciduous Timber Quotas:

There are two distinctions for timber quotas, Coniferous and Deciduous, and both carry 20-year terms that are renewable. These timber quotas can be purchased on either a volume or area basis, but FMP's for timber quotas are embedded in Forest Management Area planning and must adhere to the protocols of the specified area's FMP. From Forests Act Section 18(2)

18 (2) When a timber quota certificate has been issued, the quota holder shall prepare, at the request of the director, a general development plan for the director's approval with respect to the forest land for which the quota was issued. © Alberta Queens Printer

Reforestation is mandatory if the timber quota is 10,000 m^3 or greater, however if the quota is under 10,000 m^3 the tenure holder can choose to reforest themselves or pay a reforestation levy to the Forest Resource Improvement Association of Alberta (FRIAA) who will then reforest the harvested area for the tenure holder (Government of Alberta, 2019f).

Appendix F

Tenure in Alberta - Timber Permits

Timber permits are smaller scale tenure agreements, they apply to commercial harvesting operations 5,000 m3 or smaller and community timber permits of the same size (Government of Alberta, 2019f). Due to the smaller harvest volumes, timber permits have a limited term of 1-5 years, are not renewable and development of the forest management plan falls on the provincial government. If the timber permit is not part of larger timber quota agreement or forest management agreement, then a reforestation levy must be paid to FRIAA, who will undertake reforestation of the harvested area. Although timber permits are generally for much smaller land areas and timber harvests, in most cases holders of timber permits are required to submit operational plans to be approved by the government. Forests Act Section 22(3)

22 (3) A holder of a timber permit shall, if requested by the director, prepare an operating plan for the holder's first and each subsequent year of operation and have the plan approved by the director.

(Government of Alberta, 2019f) © Alberta Queens Printer

Appendix G

B.C. Forest Licenses

The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO), is a multifaceted government organization that oversees numerous natural resource regimes within the province including forests and related forestry operations. Forest License (FL) holders are granted the right to harvest set volumes of Crown timber within a timber supply area or tree farm license area. The majority of FL's are granted for timber supply areas and have a maximum term of 15 years. There are two types of FL's, replaceable FL's which require the government to offer a replacement license anywhere between 5-10 years into the license term agreement, and direct harvest rights through a license specific AAC (Government of British Columbia, 2019c). Harvesting rights under non-replaceable FL's are directed by a maximum total volume of harvested timber and also specify an AAC. Although they cannot be offered a license replacement, the term of a non-replaceable FL agreement may be extended in certain circumstances (Government of British Columbia, 2019c). Forest licenses are most often competitively awarded through auction-style bidding, however, the Minister (or other delegated official) can direct-award an FL to a First Nations community or community representative under section 47.3 of the Forest Act.

The owners of forest licenses in B.C. take on significant forest management responsibilities regarding forest protection, road building operations, operational planning and reforestation initiatives. These responsibilities are tied in with signed tenure agreements that transfer the rights to forests in the assigned area from the public to private hands. As such, the owner of a forest license takes on the duty to maintain the economic and ecological integrity of the forests they operate in the public interest as directed by the government of B.C. and specifically the minister of forests and range. All forest harvest licensees are responsible for the preparation of a Forest Stewardship Plan (FSP), under the Forest and Range Practices act. FSP' s are a key element of forest management plan regimes, and are a necessary provision to exercise harvest rights under forest licenses (Government of British Columbia, 2005). If the owner of FL fails to honour the conditions of the licensee agreement with the government, they will be subject to fines and possible criminal prosecution under the Forest Act. FL's are responsible for meeting harvest practice

guidelines under not just the Forest Act, but also the Forest and Range Practices Act, and the Wildfire Act.

Forest Act - Division 2 Section 15:

(3) A forest license offered under this section must…

…(b) be for a term equal to

(i) 15 years, or…

…(d) subject to takings, reductions and deletions authorized or required under this Act, specify an allowable annual cut that may be harvested under it equal to the allowable annual cut under the existing forest license, and

(e) include other terms and conditions, consistent with this Act, the Forest and Range Practices Act, the Wildfire Act and any regulations or standards made under those Acts, set out in the offer.
(Government of British Columbia, 2019c) © Queens Printer Victoria, British Columbia

Appendix H

B.C. Tree-Farm Licenses.

Tree-Farm Licenses (TFL's) are area-based tenure agreements that grant companies holding them virtually exclusive rights to harvest timber and manage and conserve forests in a specific area of land (Government of British Columbia, 2019c). TFL's allow a larger degree of private control on the land than do the more popular forest licenses, they give the licensee the responsibility for road building, reforestation, and general forest management planning in a specified area. TFL's are long-term renewable tenure agreements with a 25-year term that is renewable. As long as the holder of the TFL has not violated any regulations or has been in This increases the control that private operations have on the forest land they are operating on with a TFL. Operators with TFL must still have their FMP approved by the Chief Forester in fulfillment of section 35.2 of the B.C. Forest Act. Considering the long-term nature of TFL's and the large amount of forest area they can represent, strong relationships between the owner of the TFL and the Chief Forester are established and developed over many years. Under the *Tree Farm License Management Plan Regulation* section 35.2 of the B.C. Forest Act, and subject to approval from the Chief Forester, Forest Management Plans must be developed by the licensee and contain, among other provisions:

"(c) the title, and a description, of each of the publicly available planning documents that are used to guide forest management and operations of the tree farm license holder in the tree farm license area, including

(i) forest stewardship plans approved under section 16 of the Forest and Range Practices Act,

(ii) landscape level plans, and

(iii) plans required by independent forestry certification schemes;

(d) A timber supply analysis that analyzes the short-term and long-term availability of timber for harvesting in the tree farm license area, including the impact of management practices on the availability of timber;

(e) supporting documentation for the timber supply analysis referred to in paragraph (d) that includes;

(i) inventories of the forest cover, terrain stability, recreation, visually sensitive areas, lakes, wetlands and stream riparian zones, ungulate winter ranges, wildlife habitat areas, old growth management areas, community watersheds, cultural heritage resources and archaeological sites in the tree farm license area,"

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In addition, TFL licensees must disseminate information regarding their FMP for public review and comment after providing the FMP to the chief forester for review and approval. What is clear is that climate change and forest carbon mitigation are not among the values specified by TFL's although numerous other values are addressed under the timber supply analysis requirement.

Appendix I

Alberta Timber Management Regulations Section 100:

(1) Every person who harvests timber on public land shall

(a) conduct timber operations in accordance with the approved annual operating plan and the rules referred to in subsection (2),…

… (d) remove and manufacture timber as it is cut,

(e) avoid excessive waste when cutting timber and manufacturing timber products,

(g) dispose of all limbs, tops and other debris in accordance with the requirements stated in the Forest and Prairie Protection (Ministerial) Regulation,

(j) avoid excessive damage to regeneration, advanced growth and residual trees, as those expressions are defined by or by the application of section 122.1.

(2) The Minister may establish rules respecting harvesting and reforestation operations for licensees and permittees. (Government of Alberta, 2019d) © Alberta Queens Printer

Appendix J

Section 3.0 Alberta's Timber Harvest and Operating Ground Rules

1. Approved Forest Management Plan (FMP), including;

a) Spatial Harvest Sequence (SHS) for first two 10-year periods

b) Approved Road Corridor Plan

2. Compartment Assessment (CA) – A CA shall be required when information or major issues are identified that in Alberta's opinion, have not been addressed in the FMP. In the event that the SHS is deemed by Alberta to be inappropriate due to a significant change in circumstances since the approval of the FMP, a compartment assessment describing current issues, shall be required.

3. General Development Plan (GDP) - The GDP gives a comprehensive description of a forest operator's proposed harvest strategy, road building plans, and reclamation operations for a five-year period, and includes all licenses and permits. The GDP is used to guide integration of activities.

4. Forest Harvest Plan (FHP) – The FHP is a map and associated report describing the laid-out harvest plan.

5. Annual Operating Plan (AOP) – The AOP describes the current year's operations through a series of plans, programs or schedules that are submitted together, or individually on a schedule approved by Alberta. These plans, programs or schedules include:

a) Operating Schedule and Timber Production Plan

b) Forest Harvest Plans

c) General Development Plan

d) Compartment Assessments as required

e) Reforestation Program

f) Fire Control Plan

g) Road Plan

(Edson Forest Products, 2014)

Appendix K

British Columbia's Forest Range and Practices Act Section 5:

Content of forest stewardship plan

5 *(1) A forest stewardship plan must*

(a) include a map that

(i) uses a scale and format satisfactory to the minister, and

(ii) shows the boundaries of all forest development units,

(b) specify intended results or strategies, each in relation to

(i) objectives set by government, and

(ii) other objectives that are established under this Act and that pertain to all or part of the area subject to the plan, and

(c) conform to prescribed requirements.

(1.1) The results and strategies referred to in subsection (1) (b) must be consistent to the prescribed extent with objectives set by government and with the other objectives referred to in subsection (1) (b) (ii).

(2) A forest stewardship plan must be consistent with timber harvesting rights granted by the government for any of the following to which the plan applies:

(a) the timber supply area;

(b) the community forest agreement area;

(c) the tree farm license area;

(d) the pulpwood area.

(3) A forest stewardship plan or an amendment to a forest stewardship plan must be signed by the person required to prepare the plan, if an individual or, if a corporation, by an individual or the individuals authorized to sign on behalf of the corporation.

(Government of British Columbia, 2002)

Appendix L

Alberta Provincial GHG Emission Table by IPCC Sector – From 2019 Canada NIR

Table A11–18 **GHG Emission Summary for Alberta, Selected Years**

Greenhouse Gas Categories	1990	2005	2012	2013	2014	2015
	$kt CO_2 eq$					
TOTAL	173 000	231 000	261 000	271 000	276 000	275 000
ENERGY	151 000	199 000	227 000	238 000	244 000	242 000
a. Stationary Combustion Sources	95 200	128 000	148 000	156 000	161 000	163 000
Public Electricity and Heat Production	39 600	51 900	45 900	48 100	49 100	51 300
Petroleum Refining Industries	3 000	4 000	4 100	4 200	4 500	4 700
Oil and Gas Extraction	29 200	49 700	70 700	76 100	79 300	82 000
Mining	248	298	271	232	161	127
Manufacturing Industries	10 500	8 860	10 900	11 800	11 400	10 200
Construction	238	171	289	306	298	297
Commercial and Institutional	5 040	5 660	6 200	6 210	6 340	5 770
Residential	6 850	7 620	8 750	8 780	9 160	8 260
Agriculture and Forestry	477	240	337	338	346	346
b. Transport[1]	22 300	34 000	40 200	42 800	44 000	41 800
Domestic Aviation	1 130	1 350	1 440	1 550	1 510	1 480
Road Transportation	11 900	19 400	25 700	27 300	28 300	26 400
Light-Duty Gasoline Vehicles	4 200	3 680	3 150	3 320	3 370	3 040
Light-Duty Gasoline Trucks	3 400	5 140	6 080	6 550	7 020	6 910
Heavy-Duty Gasoline Vehicles	1 720	3 200	3 280	3 570	3 390	3 180
Motorcycles	13	28	38	41	44	44
Light-Duty Diesel Vehicles	21	51	88	97	100	93
Light-Duty Diesel Trucks	16	52	80	85	107	122
Heavy-Duty Diesel Vehicles	2 180	7 200	12 900	13 600	14 200	13 000
Propane and Natural Gas Vehicles	395	97	2	2	0.97	0.96
Railways	1 760	2 780	x	x	2 910	2 530
Domestic Navigation	0.28	-	x	x	-	7
Other Transportation	7 460	10 400	10 000	11 000	11 300	11 300
Off-Road Agriculture & Forestry	2 520	3 430	3 080	3 090	3 030	2 870
Off-Road Commercial & Institutional	165	295	309	349	392	363
Off-Road Manufacturing, Mining & Construction	1 520	2 610	4 160	4 690	4 750	4 710
Off-Road Residential	20	128	115	116	126	119
Off-Road Other Transportation	1 940	751	520	543	611	606
Pipeline Transport	1 300	3 210	1 820	2 190	2 360	2 660
c. Fugitive Sources	34 000	37 000	38 000	39 000	39 000	37 000
Coal Mining	400	300	300	300	200	300
Oil and Natural Gas	33 000	37 000	38 000	39 000	39 000	37 000
Oil	4 000	4 300	4 400	4 400	4 300	4 100
Natural Gas	8 500	9 700	8 200	8 500	8 500	7 900
Venting	17 000	21 000	22 000	22 000	23 000	22 000
Flaring	3 560	2 010	2 900	3 440	3 180	2 860
d. CO_2 Transport and Storage	-	-	-	-	-	0.04
INDUSTRIAL PROCESSES AND PRODUCT USE	6 580	11 000	15 400	13 400	11 700	13 100
a. Mineral Products	1 100	1 500	1 300	1 200	1 200	1 200
Cement Production	790	1 100	980	900	890	940
Lime Production	110	120	120	110	120	110
Mineral Products Use	190	250	150	140	140	160
b. Chemical Industry[2]	-	-	-	-	-	-
Adipic Acid Production	-	-	-	-	-	-
c. Metal Production	-	-	-	-	-	1
Iron and Steel Production	-	-	-	-	-	1
Aluminum Production	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	0.27	710	1 300	1 400	1 500	1 700
e. Non-Energy Products from Fuels and Solvent Use	5 500	8 800	13 000	11 000	8 900	10 000
f. Other Product Manufacture and Use	17	38	43	44	48	52
AGRICULTURE	14 000	19 000	18 000	18 000	18 000	18 000
a. Enteric Fermentation	7 800	12 000	9 400	9 500	9 400	9 400
b. Manure Management	1 500	2 400	2 000	2 000	2 000	2 000
c. Agricultural Soils	4 100	4 500	5 600	6 000	6 000	6 000
Direct Sources	3 400	3 600	4 500	4 900	4 900	4 900
Indirect Sources	700	900	1 000	1 000	1 000	1 000
d. Field Burning of Agricultural Residues	4	0.70	0.60	1	1	1
e. Liming, Urea Application and Other Carbon-containing Fertilizers	300	400	700	800	800	900
WASTE	1 200	1 700	1 700	1 800	1 800	1 800
a. Solid Waste Disposal	1 100	1 500	1 500	1 500	1 600	1 600
b. Biological Treatment of Solid Waste	-	40	40	40	40	40
c. Wastewater Treatment and Discharge	63	86	120	120	120	120
d. Incineration and Open Burning of Waste	10	30	40	50	40	50

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and S provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and Pl result of by-product CF_4 emissions from the use of NF_3.

- Indicates no emissions
0.00 Indicates emission truncated due to rounding
x Indicates data has been suppressed to respect confidentiality

(Environment and Climate Change Canada, 2019b)

British Columbia Provincial GHG Emission Table by IPCC Sector – 2019 Canada NIR

Table A11–20 GHG Emission Summary for British Columbia, Selected Years

Greenhouse Gas Categories	1990	2005	2012	2013	2014	2015
	$kt CO_2 eq$					
TOTAL	51 600	63 100	60 400	61000	60 500	59 500
ENERGY	42 200	51 800	50 500	51200	50 900	49 900
a. Stationary Combustion Sources	19500	21 900	21 800	21 400	21500	19 900
Public Electricity and Heat Production	807	1340	510	596	578	504
Petroleum Refining Industries	1 200	500	610	520	570	590
Oil and Gas Extraction	2140	5390	8 200	8160	8230	7070
Mining	619	386	612	589	561	458
Manufacturing Industries	6520	6210	4 120	4120	4410	4430
Construction	307	114	100	68	66	71
Commercial and Institutional	2960	3180	2 970	2740	2650	2420
Residential	4590	4680	4 320	4270	4090	3950
Agriculture and Forestry	323	75	388	385	382	413
b. Transport[1]	18600	24 600	23 500	24300	24100	25 100
Domestic Aviation	1340	1580	1 300	1340	1300	1310
Road Transportation	9600	15500	15 300	16300	16300	16800
Light-Duty Gasoline Vehicles	3900	4450	3 620	3690	3680	3800
Light-Duty Gasoline Trucks	2110	3910	4 040	4200	4380	4650
Heavy-Duty Gasoline Vehicles	950	1860	1 760	1800	1750	1740
Motorcycles	15	21	23	24	25	27
Light-Duty Diesel Vehicles	44	93	114	128	121	131
Light-Duty Diesel Trucks	17	45	60	76	86	107
Heavy-Duty Diesel Vehicles	1940	4890	5 700	6390	6270	6300
Propane and Natural Gas Vehicles	624	214	23	14	7	6
Railways	1 430	430	685	534	664	665
Domestic Navigation	961	2400	2 610	2120	1900	1810
Other Transportation	5240	4710	3 620	3990	3960	4500
Off-Road Agriculture & Forestry	707	873	568	618	588	656
Off-Road Commercial & Institutional	243	330	331	361	356	359
Off-Road Manufacturing, Mining & Construction	1350	1460	1 250	1330	1260	1410
Off-Road Residential	35	183	157	154	165	169
Off-Road Other Transportation	2050	867	505	514	561	608
Pipeline Transport	863	998	806	1020	1040	1300
c. Fugitive Sources	4100	5 400	5 100	5500	5200	4 900
Coal Mining	800	1000	1 000	1000	1000	900
Oil and Natural Gas	3300	4400	4 100	4400	4200	4100
Oil	190	84	44	41	45	44
Natural Gas	870	880	660	810	760	770
Venting	1900	2700	2 900	2800	2600	2600
Flaring	345	691	499	666	724	700
d. CO_2 Transport and Storage	-	-	-	-	-	-
INDUSTRIAL PROCESSES AND PRODUCT USE	3 310	4 610	3 940	3880	3 780	3 630
a. Mineral Products	870	1 500	1 300	1200	1 200	1 200
Cement Production	650	1 300	1 100	980	970	1 000
Lime Production	170	190	180	170	180	170
Mineral Products Use	53	51	22	20	23	25
b. Chemical Industry[2]	-	-	-	-	-	-
Adipic Acid Production	-	-	-	-	-	-
c. Metal Production	1670	1 220	886	759	547	477
Iron and Steel Production	-	-	-	-	-	-
Aluminum Production	1670	1220	885	758	546	476
SF_6 Used in Magnesium Smelters and Casters	-	1	0.66	0.60	0.78	0.74
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	-	620	1 200	1200	1300	1 400
e. Non-Energy Products from Fuels and Solvent Use	690	1 200	530	660	680	450
f. Other Product Manufacture and Use	77	95	89	86	72	71
AGRICULTURE	2 200	2 700	2 100	2300	2 200	2 300
a. Enteric Fermentation	1400	1 800	1 300	1300	1300	1 400
b. Manure Management	310	440	380	390	390	400
c. Agricultural Soils	490	480	440	520	460	470
Direct Sources	390	370	340	420	360	370
Indirect Sources	100	100	90	100	90	100
d. Field Burning of Agricultural Residues	-	-	-	-	-	-
e. Liming, Urea Application and Other Carbon-containing Fertilizers	30	20	20	30	20	20
WASTE	3 900	3 900	3 800	3700	3 600	3 600
a. Solid Waste Disposal	3800	3 700	3 600	3400	3400	3 400
b. Biological Treatment of Solid Waste	-	50	80	80	90	90
c. Wastewater Treatment and Discharge	100	130	140	140	140	150
d. Incineration and Open Burning of Waste	20	-	-	-	-	-

Notes:

1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent provincial/territorial tables.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emi result of by-product CF_4 emissions from the use of NF_3.

(Environment and Climate Change Canada, 2019b)

Appendix M

Alberta Timber Management Regulations Section 141.1 and 141.2

141.1(1) Except where this Part otherwise provides or unless otherwise authorized by the Minister pursuant to this Part, the holder of a timber disposition shall, within 2 years after the end of the year of cut of each area of public land cut, carry out such reforestation as, in the opinion of the Minister, will be needed to ensure that the reforestation standards will be met in respect of the area cut.

(2) The director may order the holder of a timber disposition who is to reforest an area of public land to reforest it to coniferous, deciduous or mixed wood standards.

141.2(1) Subject to section 141.1, the director may establish reforestation requirements, including procedures and methods to be used to determine whether or not an area of public land that is required to be reforested is satisfactorily reforested, the requirements for establishment surveys and performance surveys and the methods and timing of conducting surveys under this Part. (Government of Alberta, 2017e) © Alberta Queens Printer

Appendix N

Section 2.1 of Alberta's Forest and Prairie Protection Act

Responsibility for fire fighting expenditures

2.1 (1) *For the purposes of any provision of this Act that entitles the Minister or any other person to reimbursement from any person responsible for a fire for the costs and expenses of fighting a fire or that requires any such person responsible to reimburse the Minister or any other person for the costs and expenses of fighting the fire,*

(a) the person who caused the fire,

(b) the person who directed the lighting of the fire,

(c) the person who was otherwise responsible for the fire,

(d) the person who owned the land on which the fire began and does not establish that the fire ignited or was lit without that person's consent, express or implied, and

(e) the person who was in control of the land on which the fire began and does not establish that the fire ignited or was lit without that person's consent, express or implied,

are jointly and severally liable to the Minister or that other person, as the case may be, for the reimbursement of the costs and expenses of fighting the fire.

(Province of Alberta, 2016) © Alberta Queens Printer

Appendix O

British Columbia Industrial Burning and Backyard Fire Guide.

Under the Wildfire Regulation, a Category 2 open fire is a fire that:

- *burns material in one pile not exceeding 2 metres in height and 3 metres in width; or,*
- *burns material concurrently in 2 piles each not exceeding 2 metres in height and 3 metres in width; or*
- *burns stubble or grass over an area that does not exceed 0.2 hectares (less than 2,000 square metres.)*
- *is not a campfire.*

Persons may light, fuel or make use of a Category 2 open fire within one kilometre of forest or grassland when:

- *Doing so is, and will continue to be, safe;*
- *There are no bans or other restrictions in place for doing so;*
- *A fuel break (sometimes called a fire break) is established around the burn area. A fuel break is a change in fuel type or condition, typically a strip of land cleared to mineral soil to reduce the likelihood of the fire spreading;*
- *While the fire is burning and there is risk of escape, the person*
- *maintains the fuel break,*
- *has an adequate fire suppression system available at the burn area,*
- *ensures the fire is watched and patrolled by a person equipped with at least one fire-fighting hand tool in order to prevent the fire from escaping, and*
- *ensures that the fire does not exceed the capacity of the people, fire-fighting tools, and heavy equipment that are on site in order to take timely action to prevent a fire from escaping;* (FLNRO, 2019)

Appendix P

Forest and Prairie Protection (Ministerial) Regulation

Section 6) ***Forest operations***

6(1) The holder of a timber disposition shall

(a) **reduce fire hazards created as a result of debris from the holder's harvesting operation to a safe level by one or more of the following methods** determined by the Minister:

(ii) **skidding of tree lengths with limbs attached to roadsides or landings with subsequent limbing and the burning of all debris**;

(iii) **burning slash placed in windrows and piles** in accordance with directions of the Minister;

(iv) **broadcast burning** in accordance with directions of the Minister;

(v) crushing by heavy machinery to a standard acceptable to the Minister;

(vi) limbing trees that are felled and scattering and making to lie flat on the ground the unused parts of the trees, including the limbs;

(vii) any other method determined by the Minister, and

(b) keep the area within 5 metres of the perimeter of the cut area clear of any accumulation of slash.

(2) The holder of the timber disposition shall comply with subsection (1) as soon as practicable, but **no later than 12 months after the harvesting operation has been completed,** unless otherwise authorized by the Minister. (Government of Alberta, 2017b) © Alberta Queens Printer 2017 *1973

Appendix Q

Annex I and Annex II Reporting Countries in UNFCCC

The UNFCCC has grouped all ratifying member countries, referred to as Parties to the Convention, based on their relative economic strength and degree of commitment into Annex I, Annex II, and Non-Annex I reporting countries. Annex I Parties include industrialized countries who were members of the Organization for Economic Co-Operation and Development (OCED) in 1992 and countries described as Economies in Transition (EIT) including states like the Russian Federation and other Central and Eastern European States (UNFCCC, 2019d). Annex II Parties have an increased role in UNFCCC as they are required to provide financial and technological support to developing countries in order to help them adapt to climate change. Annex II Parties are all Annex I Parties, excepting those defined as EIT. Funding provided by Annex II Parties is channeled through the UNFCCC's financial mechanisms (UNFCCC, 2019d). Non-Annex I Parties are developing countries that are considered vulnerable to the negative impacts associated with climate change. The convention emphasizes the need to increase activities and programs that respond to the needs and concerns of these countries and increase financial, social and technological investment to support these countries in achieving the long-term goals of the convention (UNFCCC, 2019d).

As an industrialized nation and active member of the United Nations, Canada is an Annex I and Annex II Party under the UNFCCC. Canada has committed to work internationally to combat climate change through the United Nations. Canada's obligations under the UFCCC as an Annex I, and Annex II country include:

- Providing greenhouse gas emissions data on an annual basis;
- Reporting on national progress in reducing net greenhouse gas emissions;
- Providing financial and technical resources to developing countries, especially the poorest and most vulnerable, to assist them in combating climate change; and
- Conducting scientific observations of the world's climate system and research on climate change and its impacts (Government of Canada, 2015).

Annex I reporting Parties are responsible for installing stringent national emission reporting standards that document Greenhouse Gas (GHG) emissions over multiple anthropogenic sectors,

and to meet this obligation Canada submits an annual inventory of its GHG emissions, reporting removals and emissions of direct GHGs (carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3)) from 5 distinct sectors, (Energy, Industrial processes and product use, Agriculture, Land Use, Land Use Change and Forestry (LULUCF) and Waste) to the UNFCCC. The GHG inventories include all years from the base year (1990) until two years before the report is due (UNFCCC, 2019c).