CATCHMENT AREA ANALYSIS: PINNACLE RENEWABLE ENERGY'S BURNS LAKE & HOUSTON MILLS

Wood Pellet Sustainability

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The cover picture shows mortality caused by the Mountain Pine Beetle near Burns Lake in the catchment area, in 2001. (Photo courtesy of Jim Thrower)

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Executive Summary

Drax Group plc is large energy company headquartered in the UK that generates increasingly decarbonized energy in the UK. Drax's portfolio of energy generation facilities include biomass, power production, and Drax both produces its own pellets and purchases pellets from other producers. Drax is committed to a zero-carbon future and aims to become carbon-negative itself by 2030. With this in mind, Drax wishes to ensure that the fibre procurement for the pellets it uses is not having a detrimental effect on forests, how they are managed, and on other aspects of the forest industry. This includes an interest in ensuring that fibre procurement contributes to its overall goal of becoming carbon negative.

Drax commissioned this study to provide evidence on how it is meeting its forest commitments related to fibre procurement by two of its supplier pellet plants, located in the Interior region of British Columbia (BC). The two mills, both owned by Pinnacle Renewable Energy Inc, are located 80 km apart in the towns of Houston and Burns Lake. The catchment areas of the two mills, which are the areas where their fibre originates, overlap considerably and so this analysis evaluates the impacts of fibre procurement on the combined catchment area for both mills.

The historical development of the forest landscape in this catchment area is one of primary forest that has been subject to repeated natural cycles of disturbance by fire and insect pests, followed by natural regeneration. The forest species are predominantly coniferous, with extensive areas of fire-origin stands of pure pine, and spruce and fir stands in higher elevation areas. Mixed stands are most common in the ecological transition zones. The harsh climate, particularly cold winters, results in relatively slow growth rates, with natural-origin stands requiring between 80 to 120 years to reach maturity.

While Indigenous people used fire to modify the forest, the extent of the impact of their activities is unknown. Europeans began to arrive in the catchment area in the mid-late 19-th century as prospectors and farmers, and commercial timber harvesting did not begin until 1912-13 when the first railway was built through the region. As in most other parts of the world, early harvesting tended towards exploitation of the resource for the highest value timber with little thought to long term sustainability. Sawmills and early processing industries developed in the 1930'sbut it was not until the 1960's that forest management became more professional.

In the late 1980s and early 1990s there was an increased global awareness of sustainability issues and the need for more sustainable and multiple benefit forest management (considering ecological and social impacts as well as economic). In particular, there were globally significant conflicts between environmentalists and the forest industry over forestry activities in the coastal old growth forests of BC. In 1995, the provincial government brought in a very closely

regulated system known as the Forest Practices Code and embarked on a Protected Areas Strategy that aimed to double the amount of protected area in the province. The Forest Practices Code has since evolved into a results-based system, where the objectives are set out in forest management plans and it is up to industry foresters to determine how to best achieve them. In addition, management approaches began to include voluntary third-party certification schemes such as the Sustainable Forestry Initiative (SFI) and the Forest Stewardship Council (FSC). These schemes aim to ensure that forest management is sustainable and continually improving. It is estimated that between 80-90% of the forest in the catchment area is certified under SFI and some under FSC.

Ninety-six percent of the land in the catchment area is provincially owned Crown land. These are public lands whose use is regulated by the provincial government, and the timber on these lands is a public resource regulated by government. The BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) is responsible for forestry and administers forest tenure, licensing, sets stumpage rates and enacts regulations regarding overall stewardship of the forests. The forest industry is responsible for preparing forest management plans, which must be approved by FLNRORD, and undertaking operations in a manner that is consistent with the forest plans and regulations. Renewal of harvested areas is an industry requirement, and managers must also meet provincial objectives regarding species at risk, maintenance of productive capacity, water quality and biodiversity. In this regime, the only deforestation that occurs caused by forestry is associated with road-building – the estimated amount in the catchment area is about 50 ha/year. Total deforestation is estimated at 300 ha/year, with conversion to agriculture as the biggest factor.

The forest industry of the catchment area is dominated by softwood sawmill that manufacture dimension lumber from conifer trees. Other users of forest fibre include "cant" mills, other specialty mills, as well as the pellet plants that use the lower grades of conifer fibre. Residual chips from sawmilling are transported to the nearest pulp mills in Prince George. There is almost no hardwood harvested in the catchment area; hardwood accounts for 0.17% of the harvest volume and may also be used by the pulp mills or an OSB manufacturer (the closest one is seven hours one way).

This study covers the period from 2000 to 2019, which spans the length of time that the pellet mills have been in operation. This period also covers the outbreak of mountain pine beetle (MPB) which killed hundreds of millions of cubic metres of lodgepole pine throughout the province. Prior the infestation, the forests of the catchment area had some of the highest proportions of lodgepole pine in the province and they were correspondingly one the most heavily impacted areas. In response, the government and industry combined to launch a massive salvage effort to use as much of the dead timber as possible. This completely altered the composition of the timber harvest. Prior to the salvage, the harvest consisted of live pine

and spruce but from 2002 or 2003 onwards, dead pine became a major part of the harvest stream and averaged 55% during the 2010-2019 period. As time passed, the dead timber deteriorated so that it became unusable by sawmills in 2019, and almost 20 sawmills have closed in the northern and central parts of BC as a result of the drop in timber supply (including one which closed in the catchment area in 2020).

Inventory data shows that during the study period, most of the mature lodgepole pine was killed by the MPB, which made the forest younger and increased the predominance of spruce and Abies fir, the two other principle commercial species. Allowable harvest levels have been declining since 2015 and are poised to fall further.

During the 2015-2019 period, for which the pellet mills were able to provide accurate data on their fibre intake, the harvest in the catchment area was 46.1 million m^3. Of this, 24.5 million m^3 (53%) was dead pine and the remainder a mixture of live spruce and Abies fir. During this same period, the two Pinnacle mills used the equivalent of about 7.5 million m^3, representing 16.3% of the fibre harvested. However, much of this fibre was sawmill residual; Pinnacle's use of roundwood was equivalent to about 1.6 million m^3 or 3.5% of the total harvest. Given this low level of roundwood consumption, and Pinnacle's use of low-grade fibre, Pinnacle's wood use has not affected harvesting levels in the catchment area.

Furthermore, given the structure of the industry and the large amount of residual and low-grade fibre, Pinnacle does not need to compete with other mills for fibre. The consultants were informed that Pinnacle pays the lowest prices for the lowest quality of fibre, which in the absence of the pellet plants, would be either left in the forest, burned at the forest landing, or otherwise disposed of by the sawmills.

A summary of this report's key findings is provided in the tables below:

Is there any evidence that bioenergy demand has caused the following?	***Analysis Findings***
Deforestation?	Deforestation data were unavailable specifically for the catchment area however the federal government tracks it by ecozone as part of its national Greenhouse Gas Inventory reporting requirements. The catchment area is in the Montane Cordillera ecozone and the Canadian Forest Service reports that between 1980 and 2017, the area of forest in the ecozone declined from 31,181,000 ha to 31,094,000 ha, a decline of 87,000 ha or 0.28 % of the forest area. Deforestation in the catchment area was estimated at 300 ha/year. Most deforestation in the ecozone occurred because of conversion to agriculture; mining, forestry and urban expansion were also contributing factors. The ownerships on which the deforestation occurred were not specified, however the majority of the conversion to agriculture and urban expansion would have occurred on private land. Forest road construction was estimated to have led to the loss of 50 ha of forest per year in the catchment area. Pinnacle has relied on sawmill residual fibre for 75-95% of its furnish up until 2019. The balance of its furnish comes from other low-grade wood and logging slash. Bioenergy does not contribute to deforestation because Pinnacle's demand for pellet feedstock does not drive any harvest activity.
A change in management practices (e.g. rotation lengths, renewal, species change in forest)?	The mountain pine beetle infestation has been the primary influence on forest management practices, including a significant increase in harvesting to salvage dead timber. This was supported by government significantly increasing the allowable cut within the catchment area and elsewhere where the infestation occurred. Between 2000 and 2019, deadwood made up a major part of the harvest, from as much as 90-95% during the 2004-08 period and declining to approximately 48% by 2019. The abundance of salvage material and its use in sawmills increased the supply of fibre available to the pellet mills; they benefited from these circumstances but did not drive them. Pinnacle's use of fibre has not influenced forest management practices, other than to reduce the extent of roadside slash burning, because some roadside slash is ground and used as feedstock for pellet production.

Is there any evidence that bioenergy demand has caused the following?	***Analysis Findings***
Diversion of wood fibre from other uses or markets?	Pellet manufacturers use the lowest-quality fibre in the market. During the study period, there was a sufficient quantity of this low-grade material produced as a by-product from sawmilling that consumption by pellet mills did not divert wood fibre from other uses or markets. In the hierarchy of wood grades, Pinnacle uses the lowest quality timber which also fetches the lowest price; contractors would not sell higher quality wood to Pinnacle when they can get a better price elsewhere. The supply of residual material from sawmills and other timber manufacturing has fallen in recent years as the overall rate of timber harvest has fallen. However, that shortfall is largely being taken up by recovery of fibre from slash and debris left in the forest that would other be burned. That recovery is achieved by hauling tree fragments into the plants for grinding on site or grinding in the forest and hauling that material directly to the plants. While some chips produced by the sawmills and cant mills are shipped to the pulp mills in Prince George, these mills are not major suppliers of pulp chips because the higher transport cost to Prince George outweighs the price premium paid by the pulp mills. The many large sawmills in Prince George are the primary suppliers of the pulp mills there and mills in Houston and Burns Lake are marginal suppliers at best. Pinnacle uses the remainder of the waste from the cant mills. In the absence of the pellet mills, the fibre they use would have been burned or landfilled.
An abnormal increase in wood prices?	Pellet manufacturers have not influenced timber prices in the catchment area because they do not compete with other users for low-grade fibre – they use only low-quality fibre that other users will not take. Timber prices in the catchment area have been most strongly influenced by lumber prices (which are influenced by US housing starts), the US:Canada exchange rate, and general economic conditions.
A reduction in the volume of timber in the forest?	The amount of growing stock in the forest has declined significantly from 2000 to 2020 primarily due to the mortality caused by the MPB. Within the catchment area, the MPB killed an estimated 157 million m^3 between 1999 and 2014, representing 42% of the estimated 377 million m^3 of timber in the catchment area in 1999. In addition, severe wildfires in 2018 burned an estimated 7.1 million m^3. The use of fibre by Pinnacle has meant that more of the timber that was

Is there any evidence that bioenergy demand has caused the following?	***Analysis Findings***
	harvested has been used, but it did not create any additional harvest activity. Pinnacle's demand for low-grade timber has meant that in some harvest blocks, more dead timber is removed than would otherwise be the case. However, provincial government regulations require minimum amounts of residual live and dead timber to be left on site, and these requirements continue to be met and exceeded on many blocks. In conclusion, the demand for fibre from Pinnacle has not impacted the volume of live timber left in a block or compromised the site's productivity.
A reduction in the rate of carbon sequestration?	There has been very little deforestation during the analysis period and harvest operations are monitored to ensure that site damage is minimized. Accordingly, the productive capacity of the land, and the long-term capacity of the forest to sequester carbon, has not changed. The major change in the catchment area affecting long-term sequestration capacity is that more land has been set aside for environmental and other reasons, so those areas will continue to store carbon until there is a natural disturbance of some kind. In the short- and medium-term, the mortality of the mature pine has created a younger forest which will have a more rapid growth rate owing to both its age and the impact of forest management (planting and spacing) and the use of improved seed. As a result, the short- and medium-term potential of the forest to sequester carbon has increased during the analysis period, and the long-term capacity has not changed.
An increase in harvesting above the sustainable yield capacity of the forest?	During the analysis period, the timber harvest exceeded the sustainable yield capacity of the forest. This occurred as the harvest was increased in an effort to salvage as much timber killed by the MPB as possible before it deteriorated and became unusable. This was a policy decision by the provincial government to deal with an extraordinary situation. However, the harvest during the analysis period contained high levels of dead wood, ranging from well above 90% between 2004 and 2008 and trending down to 48% in 2019. Historical growth figures are difficult to ascertain, as is the amount of dead and live wood harvested; accordingly it is difficult to compare with confidence the harvest of live timber with growth during the analysis period. The 2020 growth rate is estimated at 3.45 million m^3/yr. Given that almost no live wood was cut between 2004 and 2008 and roughly half of the 2010-2019 harvest (i.e. approx 5.0 million m^3/year) was live wood, it is reasonable to

Is there any evidence that bioenergy demand has caused the following?	***Analysis Findings***
	surmise that the harvest of live wood was close to the amount of growth between 2004 and 2019. Notably, Pinnacle's fibre procurement does not drive forest harvesting so that the operations of the pellet mills have had no impact on harvesting levels.

Impact of bioenergy demand on:	***Analysis Findings***
Volume of timber in the forest	Neutral. The volume of growing stock in the forest has declined significantly during the review period due primarily to the MPB, and secondarily due to extensive forest fires in 2018 and spruce bark beetle infestations. Bioenergy demand has meant that the timber which has been harvested is used more fully, but it has not led to an increase in overall harvest or increased the amount of live timber removed from a given harvest block.
Timber growth rates	Neutral. Timber growth rates have declined due to the natural disturbance factors cited above, however the large area of regenerating forest will cause the total amount of growth in the catchment area to increase over the next 20 years. The use of fibre for pellet production has not impacted how harvests are conducted but somewhat more dead and low-grade timber is removed from each timber block than would be the case in the absence of demand for fibre from pellet mills. This happens more frequently on blocks closer to the plants than those which are distant and have higher haul costs associated with them. In other words, utilization has improved due to the demand for fibre for pellets. However, because there is so much dead and low-grade fibre in the blocks being harvested, the additional amount that is used for pellet production does not reduce the productivity of the sites. Provincial government regulations require minimum amounts of residual live and dead timber to be left on site, and these requirements continue to be met and exceeded on many blocks. An additional change brought about by the demand from the Pinnacle mills is that on some blocks, slash that has been brought to the landing is being ground and brought to Pinnacle. However, in the absence of the pellet producer's demand, this would have either been burned or piled and left to decay. In conclusion, fibre procurement for pellet production has had no impact on forest growth rates.
Forest area	Neutral. The use of fibre for pellet production has had no impact on Crown forest area, since the procurement of fibre for pellets does not affect harvest levels or renewal approaches. The grinding of roadside slash will free up a small amount of area for prompt renewal, and so by reducing the amount of area where the slash would have been left to rot, there may be a marginal positive impact on future forested area.
Wood prices	Neutral. Because the fibre used by Pinnacle would not have been used by anyone else in the absence of the pellet plants, pellet production has not affected the overall wood price structure in the catchment area. Primary drivers of wood prices include factors which affect market demand for lumber,

	exchange rates, transportation costs and the costs associated with complying with regulatory requirements.
Markets for solid wood products	Positive. Because the pellet mills rely so heavily on sawmill residuals for their furnish, and this residual fibre would have otherwise been burned or landfilled, pellet production provides some support for the sawmills in the catchment area. In addition, the presence of the pellet mills has enabled manufacturers to build and operate cant mills that occupy a position in the value chain that is intermediate between the sawmills and the pellet mills. Pellet production did not divert fibre from other uses; there are no close OSB plants and the nearest pulp and paper mills are sufficiently distant that the higher cost of transport outweighs any higher price that they can offer or wood fibre. The pellet industry has also created demand for chipping and bush-grinding, which has fostered business opportunities and increased employment in the forest sector.

1 Introduction

1.1 Background

Drax Group is a British electrical power generation and supply company that runs Europe's largest biomass-fueled power station – the UK's largest decarbonisation project – supplying 7-8% of the country's electrical needs. Drax is among the world's largest single-point consumers of wood fibre and has committed to sourcing wood responsibly.

In accordance with Drax's initiative to monitor forest management and timber market trends in the jurisdictions where its supplier pellet mills operate, this report provides a review and assessment of the trends in management and wood products markets in the catchment area of two supplier mills in Burns Lake and Houston, British Columbia (BC). These two mills are operated by Pinnacle Renewable Energy Inc. and are located 80 km apart.

The Houston plant has been operating since 2006 and the Burns Lake facility since 2011. The Houston mill is a partnership between Canfor, Pinnacle and Witset First Nation. Pinnacle's 2020 Annual Report states that the annual capacity of the Houston mill is 220,000 ODMTs, while the Burns Lake facility is 380,000 ODMTs. Most of the wood fibre used in the Houston plant is residual fibre from the Canfor sawmill in Houston while the Burns Lake mill depends heavily on residual fibre from several nearby sawmills.

1.2 Report Goal

The goal of this report is to identify and assess the impacts that sourcing biomass for the two pellet plants has had on the forest, its management, and wood markets. This includes impacts on timber inventory, forest growth, forest removals, wood prices, forest management practices, and local wood fibre markets.

This report reviews the period 2000 to 2020, which coincides with an extensive outbreak of mountain pine beetle (MPB); the resulting mortality of large parts of the mature forest was the dominant factor affecting the forest and the industry during this period. The review period also covers the operational start-up of the two pellet mills and so provides an opportunity to identify potential impacts of fibre procurement for the mills.

1.3 Report Structure

The report is organized as follows:

i. Description of the Catchment Area (Section 2): The geographic and socio-economic characteristics of the catchment area are described.
ii. Forest Management Practices (Section 3): Approximately 96% of the forest in the catchment area is managed by the provincial government, thus government policy is reviewed,

including a discussion of how it has evolved since 2000. In addition, the impacts of the Mountain Pine Beetle outbreak are discussed.

iii. Description of the Forest in the Catchment Area (Section 4): This section describes the current state of the forest, both in area and volume terms, how harvesting is regulated, and how the forest has changed since 2000.

iv. Timber Growth and Removals (Section 5): The volume of timber growth is compared with the amount of timber removed through harvesting and natural disturbances.

v. Markets (Section 6): The markets for wood fibre in and around the catchment area are profiled.

vi. Pricing (Section 7): Describes the method used to calculate stumpage prices are described and local stumpage price trends examined.

vii. Summary of Key Trends and Outlook (Section 8).

viii. Annex 1 provides the analysis to establish the catchment area.

1.4 Project Consultants

Jeremy Williams, PhD, RPD (Ontario)

Dr. Jeremy Williams has extensive forest economics experience including reviews of timber markets, timber pricing including stumpage rates, timber product production costs, and rates charged by the Crown for property leases. Recent relevant experience includes reviewing forest management and timber markets in Nova Scotia, rental rates for Crown land in Ontario, preparing a Regional Risk Assessment for BC against the SBP standard (in draft) and assessing forest carbon offset protocols for the Ontario government.

In addition to these projects, Jeremy has completed numerous business cases, economic evaluations and reviews. He is also very knowledgeable and experienced with respect to forest carbon pricing and accounting and has extensive experience working with and advising Indigenous communities and organizations.

Dr. Williams earned a B.Sc.F. from the University of Toronto's Faculty of Forestry (1979) and a Ph.D. in from the same Faculty with a specialization in Forest Economics (1986). He is a principal of ArborVitae Environmental Services Ltd. and a Registered Professional Forester with the Ontario Professional Foresters Association.

Gary Bull, Ph.D.

Dr. Gary Bull has a background in commerce as well as three degrees in forestry, specializing in economics and policy. He has an interest in global forestry policy issues and is an expert on forest and timber markets in Asia and ecosystem services markets. In British Columbia, he has focused his efforts on working on sustainable business development with First Nations communities and sustainable fibre supply.

Dr. Bull worked for the Food and Agriculture Organization of the United Nations before moving back to Vancouver and joining the Faculty of Forestry at University of British Columbia. Gary is currently a full professor and head of the Forest Resources Management Department at the Faculty. Gary's specialities include Aboriginal forestry, forest carbon finance, economics and international trade. Gary has been associated with SBP for several years and was selected to be a member on SBP's Standards Committee and Working Group on Carbon. He also sits on the External Review Panel of SFI and is a Director of Nature Bank.

2 Catchment Area

2.1 Extent

A catchment area is the region from which a forest products mill sources its wood fibre. This assessment examines the catchment areas of two central BC pellet mills owned by Pinnacle Renewable Energy Inc. The mills are located in the towns of Houston and Burns Lake, which are about 80 km apart. Their catchment areas have extensive overlap, and hence in this review are considered as one large catchment area supplying the pair of mills.

Approximately 95% of the furnish used by the two pellet mills is procured as residual material from sawmills (mostly sawdust and planer shavings) also located in Houston and Burns Lake. These sawmills obtain most of their sawlogs from three management units – their catchment area consists of the Lakes Timber Supply Area (TSA), the Morice TSA, and the Vanderhoof Forest District, which is part of the much larger Prince George TSA. In this report we refer to these units as *Administrative Districts or Units*.

These supply dynamics mean that the catchment area of the sawmills is effectively identical to the catchment area for the pellet mills (See Figure 1). The data identifying the three Administrative Districts as the catchment area for the pellet mills is presented in Annex 1.

2.2 The Forest

Each Administrative District encompasses roughly 1.4 - 1.5-million ha, as shown in Table 1. About 94% of the catchment areas is Crown land, which is public land under provincial jurisdiction. Most of the remaining area is owned privately, and there is some land under jurisdiction of the federal government that is primarily Indian Reserves. Indigenous communities in the area do not own substantial lands outright but do have forest management and timber harvesting rights on some areas. The Crown forest management landbase (CFMLB), which is the part of the Crown landbase that supplies wood fibre to the forest industry, is approximately one-third of the total area. The derivation of the CFMLB is explained in more detail later in section 3.4 of this report.

Administrative Unit	Total Area (ha)	Crown Land (ha)	Private Land (ha)	Federal land (ha)
Lakes (ha)	1,577,488	1,502,949	71,600	2,939
Morice (ha)	1,509,113	1,477,882	28,902	2,329
Vanderhoof (ha)	1,387,323	1,237,182	144,209	5,932
TOTAL	4,473,923	4,218,013	244,711	11,200
		94%	5%	< 1%

TABLE 1. LAND OWNERSHIP STATISTICS FOR THE CATCHMENT AREA.

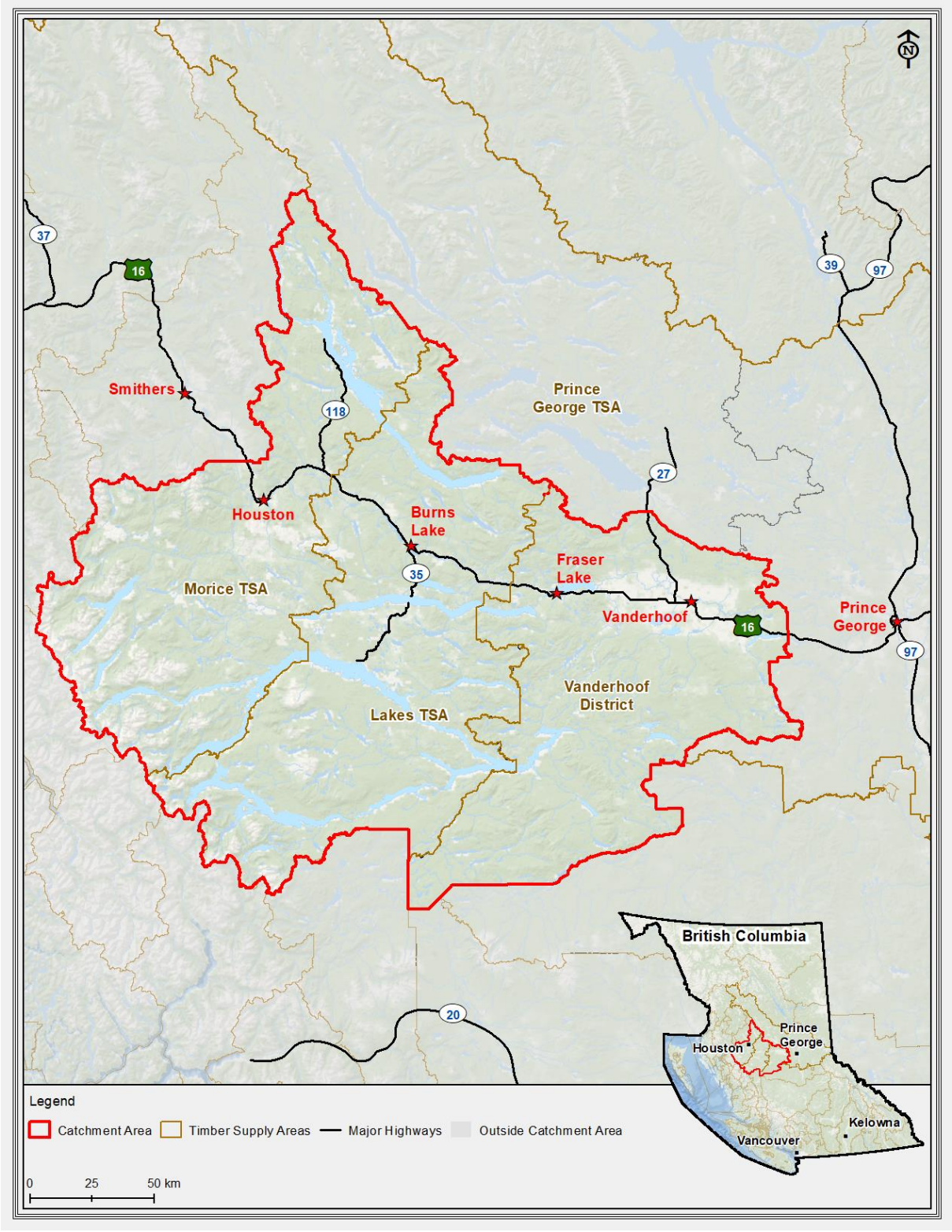


FIGURE 1: CATCHMENT AREA FOR THE BURNS LAKE AND HOUSTON PELLET MILLS IN CENTRAL BC.

Private and federal land contribute to the regional timber harvest however there are no inventory data or records of the amount of timber that originates from these ownerships; the province does not have jurisdiction over federal land and the federal government does not maintain a detailed forest inventory on lands it owns. As a result, this report does not include these lands in the catchment area analysis, however the extent of their contribution to the catchment area harvest and forest landbase is in line with their share of the total area and activities on these lands do not affect the trends and conclusions identified in this report.

2.3 Geography and Climate

The geography of the catchment area is dominated by gently rolling hills, large lakes, and small mountain ranges. The area has moderately warm summers with an average daily maximum of 17^{o}Candcold winters with average daily maximum of -7^{o}C.The average temperature and precipitation figures mask considerable extremes, as winter temperatures often reach -30^{o}C. Summers are moderate with temperatures seldom exceeding 30^{o}C.The average precipitation in Burns Lake (in the center of the catchment area) is about 50 cm, which includes approximately 30 cm water equivalent of snow. However, because parts of the area are rugged and there is considerable variation in elevation, the temperature and precipitation patterns vary throughout the catchment area and are strongly affected by aspect, elevation and other topographical characteristics.

2.4 Transportation Infrastructure

A paved two-lane highway (Highway 16) bisects the catchment area, connecting the main towns and villages and all major sawmills in the area, as well as the two pellet plants. As the main transportation artery through the area, Highway 16 joins Houston and Burns Lake with Vanderhoof and Prince George to the east and Smithers, Terrace, and Prince Rupert to the west. Highway 16 is also the primary route for hauling timber and wood fibre.

A single-track railway, owned and operated by the Canadian National Railway, roughly parallels the highway through the catchment area. The railway is used primarily to carry shipping containers, grain, and other commodities to the seaport at Prince Rupert. Pinnacle Pellet has a dedicated loading facility at the Prince Rupert port and most product from the Burns Lake and Houston pellet plants is shipped through that facility.

2.5 Development of the Catchment Area

Europeans began to settle in the valleys within the catchment area in the late 19-th century and prospectors began to explore the area, stimulated by a large discovery of gold in Barkerville, BC. The valleys were well-suited to agriculture and the first mining activity is reported to have occurred in 1910. Mining has always been a significant contributor to the local economies. Several large copper and molybdenum mines in the area have operated over the years; at

present, the Huckleberry copper mine is producing near Houston. Forestry, agriculture, mining and transportation have been the key economic sectors in the catchment area for many years.

Railway tie production was the first commercial forest products manufacturing in the catchment area, beginning around 1912-13 when the first railroad was being built. Both Burns Lake and Houston developed into major tie-cutting centres.[1]

During the 1930's and 1940's, there were a growing number of portable sawmills in the area (42 in the Houston district by 1949), which moved to where the timber was. In 1948, the first stationary mill was built near Houston, and later a planer, drying kilns and chippers were added. Another large (for the time) sawmill was built in Houston in 1969 but the company soon ran into financial trouble and was purchased by Northwood Pulp and Timber. This mill became what is now the Canadian Forest Products (Canfor) sawmill. Houston also had a second large sawmill (Houston Forest Products) which was owned by West Fraser Timber, however it closed permanently in 2014 as part of an industry rationalization brought on by the Mountain Pine Beetle infestation.

Today, the catchment area is sparsely populated. Burns Lake (just less than 2,000 residents) and Houston (approximately 2,100 residents) are the largest communities in the area. Smaller communities in the Vanderhoof Administrative Unit include Vanderhoof (2,000 residents) and Fraser Lake (1,000 residents). These figures exclude people living rurally outside of the town boundaries; the area also includes several scattered smaller communities. Statistics Canada shows that the population of Burns Lake declined by 13% between the 2011 and 2016 census dates while Houston's population was stable. The city of Prince George is the regional centre with a population of about 74,000 residents; in the past five years the city's population has risen by roughly 0.5% per annum.

2.6 First Nations

Numerous First Nations have traditional territory within the catchment area. The Lakes TSA overlaps the traditional territory of 13 First Nations while the traditional territory of eight First Nations extends into the Morice TSA (some First Nations have territory in both TSAs).The traditional territory of the Carrier Sekani and Takla Lake First Nations is centred in the Lakes TSA, and there are a number of politically and economically autonomous sub-groups living in local communities. The number of Aboriginal people in the catchment area is somewhat uncertain because the national census is typically challenged to obtain a high response rate on Indian reserves. The most recent census data, from 2016, shows that within Burns Lake, 900 people or approximately 45% of the population, identified as Aboriginal, while in Houston 375 people did so.

[1]See https://www.houston.ca/forestryfor an informative history of the Houston region.

Indigenous communities have significant forest management and timber harvesting rights in the area. The 2019 Lakes TSA discussion paper reports that First Nations are deeply involved in the forest sector through partnerships, community forests and as holders of forest licences. The Burns Lake Native Development Corporation is a 10% owner of Babine Forest Products and Decker Lake Forest Products while Witset First Nation is a partner owning 10% of the Houston pellet plant.

The local forest sector is a source of employment and the Carrier Sekani First Nations Collaboration Agreement with the provincial government provides a framework to deepen First Nation involvement in decision-making. In addition, the Omineca Environmental Stewardship Initiative Demonstration Project, a partnership between the Carrier Sekani First Nations and the Province of B.C., is underway with the goal of assessing the current state and cumulative effect of natural and development-related disturbance on moose, forest biodiversity, and several watershed values.

3 Forest Management

3.1 Legislation

The provincial Forest Act and its regulations set out the forest management framework on Crown land, including forest tenure, planning requirements, allowable cut determination, timber measurement and marking, and the setting of stumpage rates. The Forests and Range Protection Act (FRPA) is the primary provincial legislation regulating forestry practices and planning on Crown land. Under FRPA, the Forest Planning and Practices Regulation (FPPR) identifies objectives set by government for environmental values including fish, wildlife, biodiversity, soils, and water that must be addressed in Forest Stewardship Plans, which are the strategic planning documents required for Crown forests. The government may also establish orders under the Government Actions Regulation or the Land Use Objectives Regulation for specific land uses such as ungulate winter range, wildlife habitat areas, critical habitat for fish and old growth management areas.

On Crown land, the provincial government regulates forest planning and operations, including the determination of the allowable harvest. Government approves all forest management plans on all tenures. On area-based tenures, the plan preparer determines an allowable harvest which must be approved by the provincial government. On volume-based tenures, the Ministry of Forests, Lands, Natural Resource Operations and Rural Development's (FLNRORD) Chief Forester follows a rigourous process to establish the allowable cut. The province also monitors the performance of the licensees in conducting their operations in a way that does not cause damage to the site and meets requirements associated with biodiversity conservation.

3.2 Stumpage

Stumpage in BC is the price paid by anyone harvesting timber from Crown land. The stumpage rate is set by the Provincial Government using a market-based system. BC Timber Sales (BCTS), a branch of the Provincial Government, publicly auctions "blocks" of merchantable timber. The market prices paid for this timber are used to set the rates for similar types and qualities of Crown timber harvested by other forest operators under long-term harvesting rights granted by the Government. In BC, all timber scheduled for harvest undergoes a detailed field inventory process (timber cruising) to assess the quantity and quality of timber. The cruise and bid data from BCTS enables the government to develop regression equations that are used to set the stumpage rates on non-BCTS blocks. In this way, the provincial government receives a fair market-based stumpage for all of the timber harvested from Crown land. Stumpage rates for forest licensees are revised by the Government every four months to reflect changing market conditions.

3.3 Timber Supply Areas

The province is organized into 37 TSAs - nine along the Coast, 15 in the South, and 13 in the North. Within each TSA there are multiple forestry tenures. Some grant rights to harvest timber in a defined area (i.e., area-based tenures) and other forms of tenure grant rights to harvest a set volume (i.e., volume-based tenures) from within a given TSA. Area-based tenures within the catchment area include Community Forest licences, Woodlot Licences and First Nations Woodland Licences (FNWL).[2] An Annual Allowable Cut (AAC) is determined by the provincial Chief Forester for each area-based tenure. For the volume-based tenures, an AAC is determined by the provincial Chief Forester for each TSA and apportioned amongst the volume-based licence holders by the Minister of FLNRORD.

While volume-based tenures supply the majority of the timber harvest in the catchment area, a substantial amount of TSA area has been shifted from volume-based to area-based tenures during the past 20 years. The area-based tenures have been designated to more widely distribute the benefits of forestry and to provide for a variety of forest management approaches. This trend can be seen for the Lakes TSA in Figure 2, which was prepared by Agathe Bernard in the Nadina District FLNRORD office[3]. This transfer of land from volume-based tenures to area-based tenures represents a source of downward pressure on the AAC calculated for the volume-based portion of the TSA.

Licence Type	Lakes	Morice	Vanderhoof	Total
Community Forest	223,311	23,156	27,499	273,966
First Nations Woodland Licence	41,359	Incl Lakes	8,083	48,043
Woodlot Licences	25,107	20,121	22,214	67,442
TOTAL	289,777	43,277	57,796	390,850

TABLE 2. AREA (HA) OF AREA-BASED TENURES IN THE CATCHMENT AREA.

Table 2 shows the area in Community Forests, FNWLs, and Woodlot Licences in each of the Administrative Districts. Note that some of the FNWL areas span both the Lakes and Morice TSAs hence the total area in both is shown under the Lakes TSA. The area shown in Table 2 is gross area; most of this is forested, however the area available for timber harvesting will be somewhat less. As Figure 2 illustrates, the extent of these licence areas has grown over the years as new licences have been issued and existing ones expanded.

[2] There are no Tree Farm Licences, which is another form of area-based tenure, within the catchment area.
[3]Used with permission.

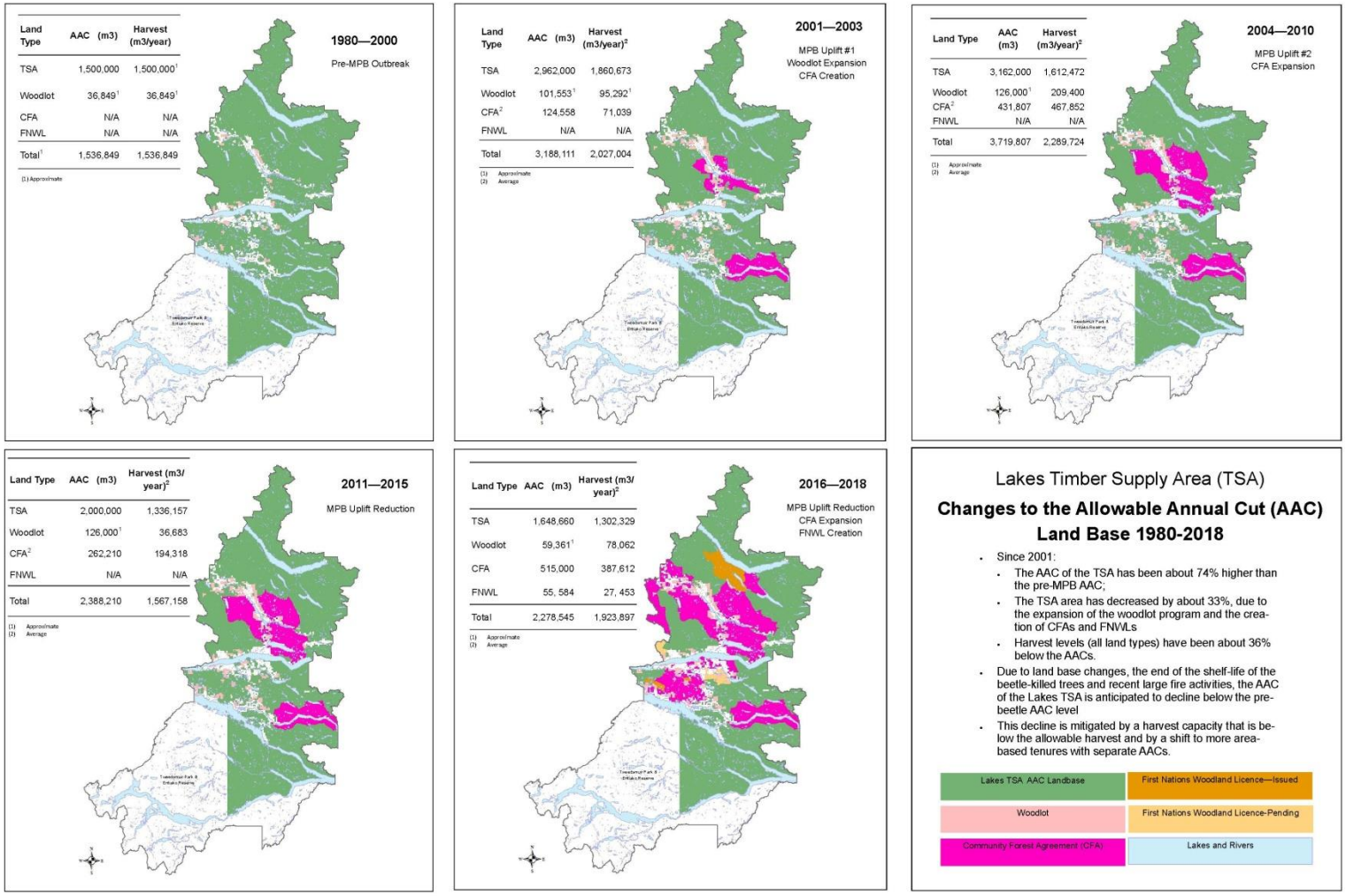


FIGURE 2. CHANGE IN AREA-BASED TENURE IN THE LAKES TSA: 2000-2018.

3.4 Netdowns

It has been mentioned above that a large percentage of the catchment area is unavailable for timber harvesting for operational and policy reasons. The Timber Supply Review (TSR), conducted by the Chief Forester to determine the AAC, includes a lengthy process of identifying the landbase that can support commercial timber production. This process, known as the "netdown", involves removing areas that are unavailable for timber harvesting from the forest landbase to arrive at the Crown Forest Management Landbase (CFMLB), which is the landbase used to calculate the AAC. Areas that are netted out include, but are not limited to, lands where timber harvesting is prohibited, such as parks, areas that do not support merchantable timber or which are inoperable due to topography or other factors, and ecologically sensitive areas (such as Old Growth Management Areas or OGMAs) and riparian areas.

Parks and conservation reserves are readily identifiable in the forest inventory and netted out (see Figure 3). In contrast, designating which areas are inoperable is a judgement call on the part of the Chief Forester and these areas are not formally identified in the forest inventory. Many types of reserves, such as ungulate winter range and recreational zones, are partially available for harvesting and the netdown process involves a review of department guidance and discussions with staff. The area that is netted out for these purposes is also not recorded in the forest inventory.

A netdown is only done as part of a TSR and in the catchment area, each of the three Administrative Units has a different vintage of TSR. The most recent TSR for the Morice TSA was done in 2013, the Prince George TSA had a TSR done in 2015 and the TSR for the Lakes TSA is in process. Each of these TSRs will have been done to somewhat different standards and in different regulatory environments, since TSR's are not revised every time there is a legislative change. Additionally, the TSR process only applies to the volume-based tenure lands, and as discussed, this area has been shrinking over time in the catchment area. In brief, there are many moving parts in a determination of the timber harvesting landbase in the catchment area and the applicable AAC; a detailed analysis is beyond the scope of this project.

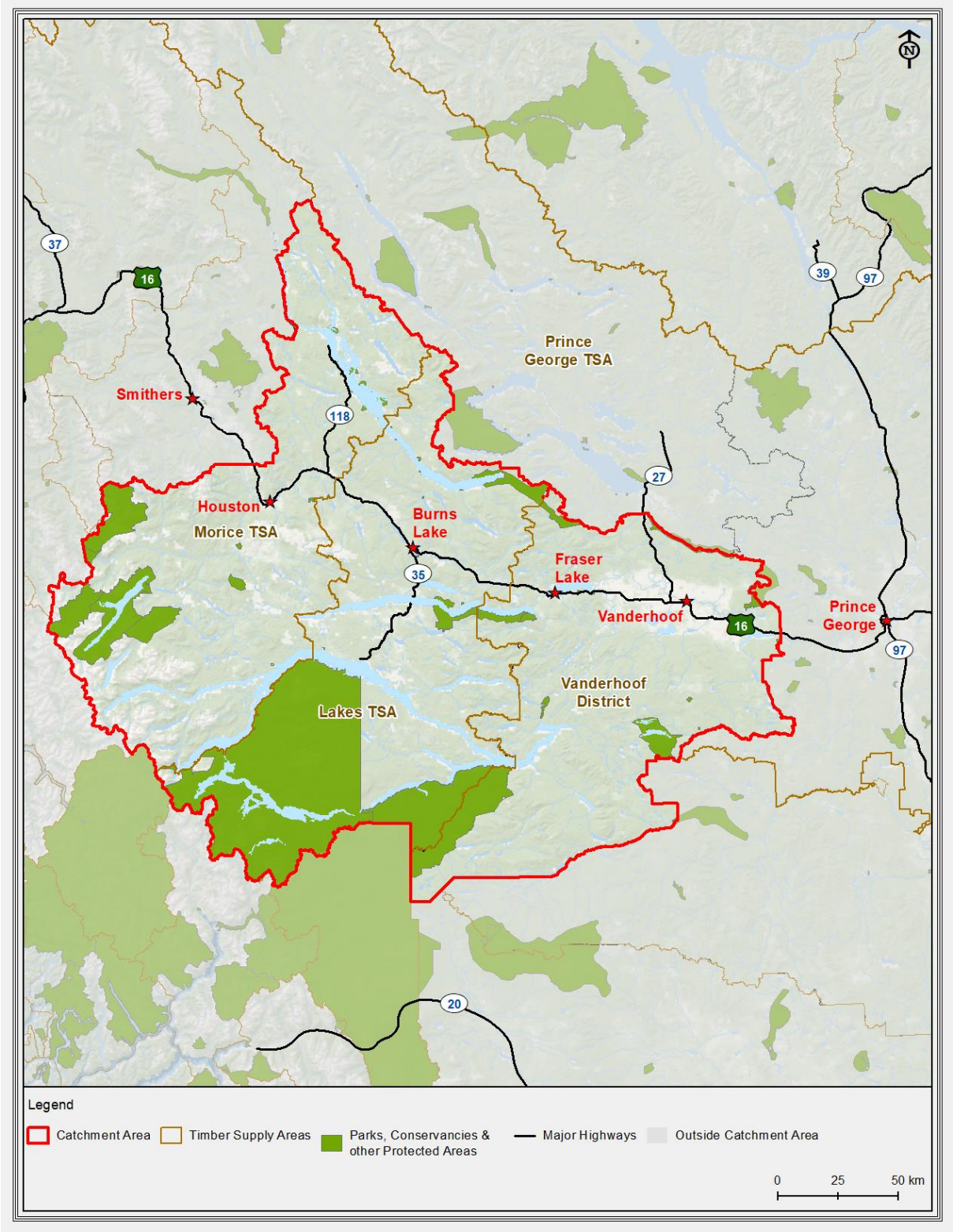


FIGURE 3. CATCHMENT AREA SHOWING EXTENT OF PARKS.

Instead, the consultants have reviewed the most recent TSRs for the three administrative units of the catchment area and approximated the amount of area removed from the forested landbase for the various reasons described above. The results are shown in Table 3, which is based on a compilation of information from the 2020 Lakes TSR, the 2013 Morice TSR, and the 2015 Prince George TSR. Note that because the Prince George TSR did not break out data separately for the Vanderhoof District, the numbers for the Vanderhoof District are based on pro-rating the total area in Prince George TSA by 17.4%, which is the proportion of the TSA area in the Vanderhoof District.

The second column of Table 3 shows the total area in each land designation and the third column shows the percentage of the total landbase in volume-based harvest licences in this designation. Accordingly, approximately 21% of the area in volume-based licences (at the time of the most recent TSR in each administrative unit) is non-forested or not sufficiently productive to grow trees. The fourth column to the right presents the amount of area in each designation that is considered unavailable, and the right-hand column shows the percentage of that designation that is unavailable. Of the non-forested and non-productive lands, 79% was considered unavailable in the three TSR analyses.

Land Designation	Total Area (ha)		Unavailable Area (ha)	
Non--forested and non--productive	1,178,159	21%	932,768	79%
Roads	37,678	1%	33,697	89%
Inoperable areas	613,262	3%	114,225	19%
Low productivity/problem forest types[4]	775,813	6%	254,884	33%
Parks and protected areas	255,433	3%	135,834	53%
Ecologically sensitive areas	458,390	7%	304,299	66%
Wildlife reserves	362,135	2%	83,774	23%
Total	3,680,870	66%	2,939,127	

TABLE 3. SUMMARY OF AREA (HA) UNAVAILABLE FOR INCLUSION IN CROWN TIMBER HARVESTING LANDBASE.

Roads are considered largely unavailable, while only 19% of areas that are considered inoperable were excluded (the Chief Forester left open the possibility that changes in harvest

[4]Problem forest type is the term used for stands that are physically operable and above minimum site quality yet are not currently utilized or have marginal merchantability due to quality, size or volume. In the catchment area, problem forest types consist of deciduous-leading-stands (since here is no demand for deciduous timber) and old, slow-growing ESSF and SBS stands.

equipment might enable some inoperable areas to be harvested; for example, one company has introduced a cable-tethering process to access steep slopes).

Table 3 also shows the areas of parks and other protected areas (shown in Figure 3), sensitive areas, wildlife reserves and low productivity forest that are removed from the timber harvesting landbase. Combining the results of the netdown processes in the three TSRs yields a CTHLB of roughly 34% of the catchment area landbase. (Note that the data in Table 3 was derived from the three TSR processes that took place at three different times: 2013 for Morice, 2015 for Prince George and 2020 for Lakes TSA. A 2020 determination of the CTHLB in the entire catchment area would yield somewhat different results as the assumptions used in the netdown process will have changed over time.)

3.5 The Mountain Pine Beetle Outbreak

As mentioned above, the MPB outbreak is the most significant factor that affected the catchment area forest (and indeed the provincial forest) during the past twenty years. MPB was already present in the catchment area in 2000, and the province responded by increasing AAC levels to permit salvage operations. These increases occurred as soon as 2001 in the Lakes TSA, when the Chief Forester added 1 million m^3/year to the AAC to "manage" the MPB infestation. During the 2002 TSR for the Prince George TSA, the Chief Forester added 3 million m^3 to the AAC for MPB salvage. By 2004, the outbreak had worsened dramatically, and an expedited TSR was conducted for Lakes, Prince George and Quesnel TSAs, which constituted the hardest-hit region of the province (Quesnel is a small TSA located south of the Prince George TSA). FLNRORD staff estimated that the MPB might kill as much as 160 million $m^3$of the existing467 million m^3 of pine volume in the three TSAs and a discussion paper prepared by FLNRORD for the 2004 TSR indicated that many mature lodgepole pine stands (i.e. older than 80 years) were infested, as were a number of pine stands in the 61-80 year age class.

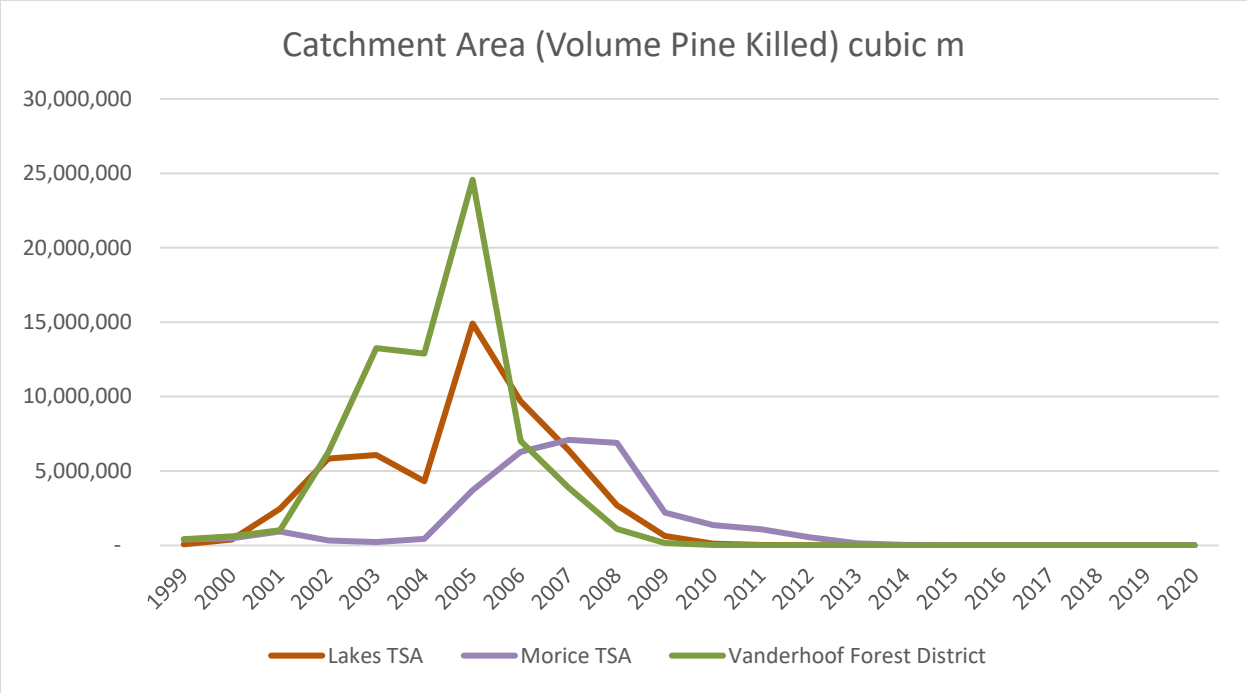


FIGURE4. ANNUAL MORTALITY DUE TO MPB IN THE CATCHMENT AREA (M3/YEAR).

4 shows the annual mortality, expressed in cubic metres[5], caused by the MPB within the catchment area; the very rapid escalation of mortality between 2002 and 2005 is evident. The decline in the annual rate of mortality was equally rapid; the infestation was so intense that the beetles quickly killed the majority of the pine in the susceptible age classes.

The AAC for the Lakes TSA, which had been almost doubled in 2001 from 1.5 million m^3/yr to 2.96 million m^3/yr, was increased again in 2004 to 3.16 million m^3/yr to facilitate salvage harvesting. Figure 5 shows the AACs for the Lakes and Morice TSAs and the pro-rated AAC for Vanderhoof District from 1999 to 2019.

[5]Source: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/mountain-pine-beetle/mpb-projections

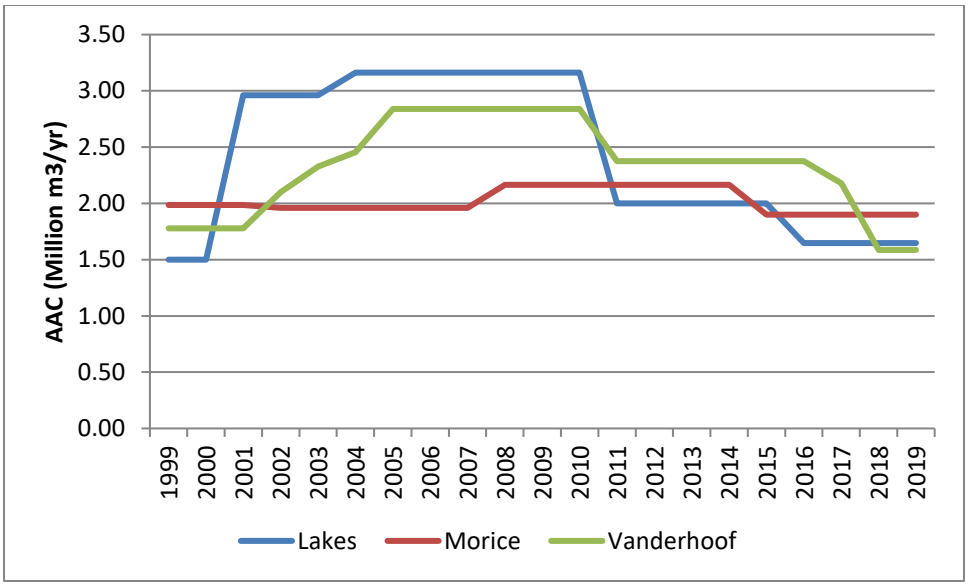


FIGURE 5. AACS IN LAKES AND MORICE TSAS AND VANDERHOOF DISTRICT.

The AAC for the Morice TSA was not increased in the same way as for Lakes and Prince George, but instead (for reasons unknown to the consultants) the allowable harvest was raised through a different mechanism outside of the TSR process (i.e., Innovative Forest Practices Agreement). Because of this, the AAC figure used in the Morice TSR does not provide an accurate assessment of the allowable harvest during this period.

Error! Reference source not found. shows the cumulative volume of pine killed in the catchment area due to MPB. The annual mortality rate peaked in 2005 or 2006, and the elevated AACs remained in place until 2011, when the Lakes and Prince George AACs were decreased somewhat.

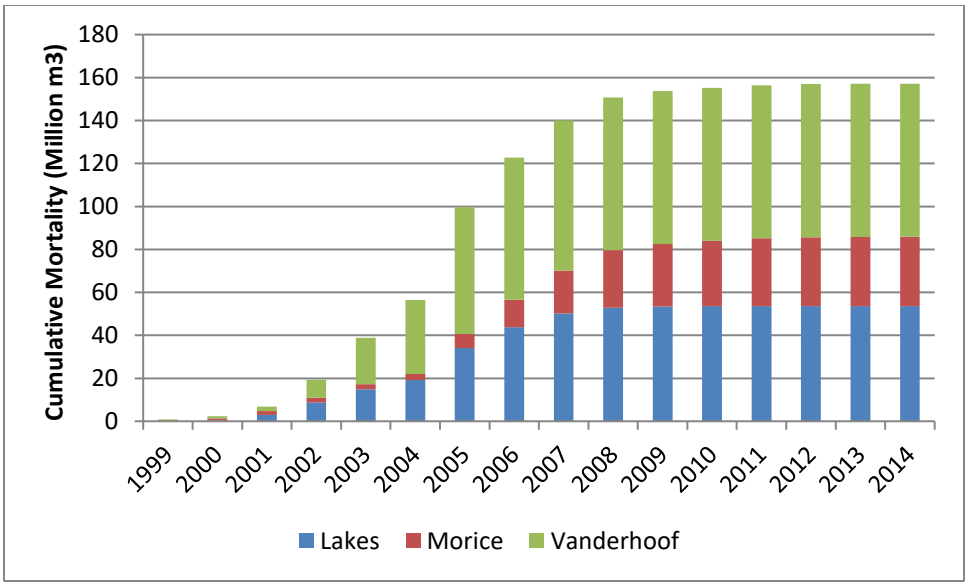


FIGURE 6. CUMULATIVE MPB MORTALITY IN THE CATCHMENT AREA (MILLION M3)

Table 4**Error! Reference source not found.** shows the proportions of pine in the growing stock on the CTHLB in 1999 – the amounts of pine are very high. In fact, Vanderhoof District had highest proportion of pine in province and Lakes TSA was third highest; Morice TSA was mid-range for interior forest areas. The relatively low abundance of pine in the Morice TSA meant there was less MPB mortality on both a total volume basis and as a percentage of the pre-outbreak amounts of pine.

Area	CTHLB Total Volume in 1999	CTHLB Pine Volume in 1999	Percent Pine	Mortality by 2014	CTHLB Pine Volume in 2014	Percent Pine Mortality
Lakes TSA	110.6	71.0	64.3%	53.6	17.4	75.5%
Morice TSA	132.9	57.1	43.0%	32.2	24.9	56.4%
Vanderhoof District	133.3	97.6	73.3%	71.3	26.4	73.0%
Catchment Area	376.7	225.8	59.9%	157.1	68.6	69.6 %

TABLE 4. GROWING STOCK VOLUME IN THE CTHLB, AMOUNT OF PINE AND PERCENTAGE PINE (MILLION M3).

Table 4 also shows the extensive loss of live volume caused by the MPB; Figure 7 shows a typical landscape with high levels of MPB mortality. Almost 75% of the pine volume in Lakes and Vanderhoof was killed, amounting to roughly half of the total 1999 growing stock in the Lakes TSA and 54% in Vanderhoof. The most susceptible stands were those with high proportions of mature lodgepole pine in them – mortality was usually close to 100% in these types of stands. The impact was lower but still substantial in Morice, which lost just over half of its pine and 25% of the 1999 total volume.

Figure 7 shows an aerial view of MPB mortality in the catchment area in various stages of progress, with the grey trees being dead and the red and yellow in stages of dying.

FIGURE 7. MORTALITY CAUSED BY MPB: THE RED TREES ARE DEAD AND DYING (PHOTO COURTESY OF JIM THROWER).

As 4 shows, the MPB outbreak had largely subsided by 2010, and there was relatively little new mortality. The decline occurred as the beetle had killed the majority of the most susceptible pine stands and the rate of spread varied with the terrain and was also slower in stands with a greater diversity of species. Salvage harvesting also began to slowly decline and the AACs in the Lakes and Prince George TSAs were lowered slightly in 2011. As salvage harvesting was completed, the Chief Forester began to institute much large reductions in the AAC, as seen in Figure 5. In 2018, the Prince George AAC fell by one-third to 8.35 million m^3, which is well below the pre-MPB level of 9.36 million m^3/yr. The 2015 Morice TSR lowered the AAC by 265,000 m^3/yr to 1.9 million m^3 until March 2020, when it made another step lower to 1.6 million m^3. The next Morice TSR is presently scheduled for 2025. The Lakes TSR is in process now and a hefty decline is anticipated.

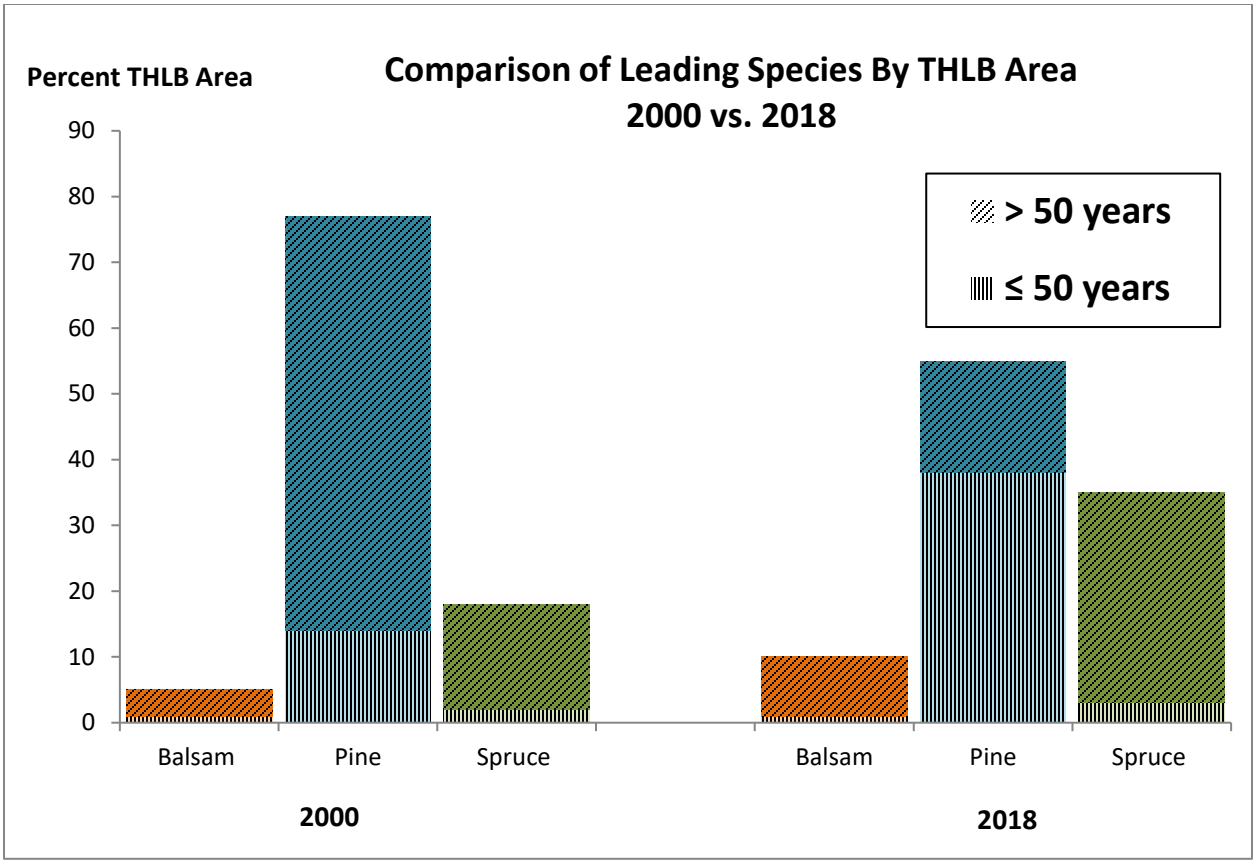


FIGURE 8. COMPARISON OF LEADING SPECIES COMPOSITION FOR THE LAKES TSA CTHLB AREA: 2000 VS. 2018.

Figure 8 illustrates how the MPB outbreak altered the species and age distribution of the forest in the Lakes TSA (FLNRORD 2019). The height of the bars represents the percentage species composition of the forest, while the upper portion of each bar represents the proportion of the forest in the leading species group older than 50. The vertically hatched portion of the bar represents the amount of forest less than 50 years old. The proportion of pine leading stands declined from 77% in 2000 to 55% in 2018, with the spruce-leading stands and balsam-leading stands doubling in abundance. The age composition of the pine also shifted to a much younger age; in 2018, 70% of the pine is less than 50 years old, as compared to 18% being that young in 2000. Very similar changes occurred in Vanderhoof and in the Morice TSA.

3.6 The Impact of the 2018 Wildfires

The forests in the catchment area are primarily fire-driven ecosystems, and the mortality caused by the MPB created perfect conditions for extensive fires. It is not surprising that 2017 and 2018 were British Columbia's two worst forest fire years ever, in terms of area burned. While the 2017 fires were largely outside the catchment area, the 2018 fires were concentrated in the catchment area, as shown in Figure 9. Of the 1.3 million ha burned that year, approximately 370,000 ha were burned in the catchment area.

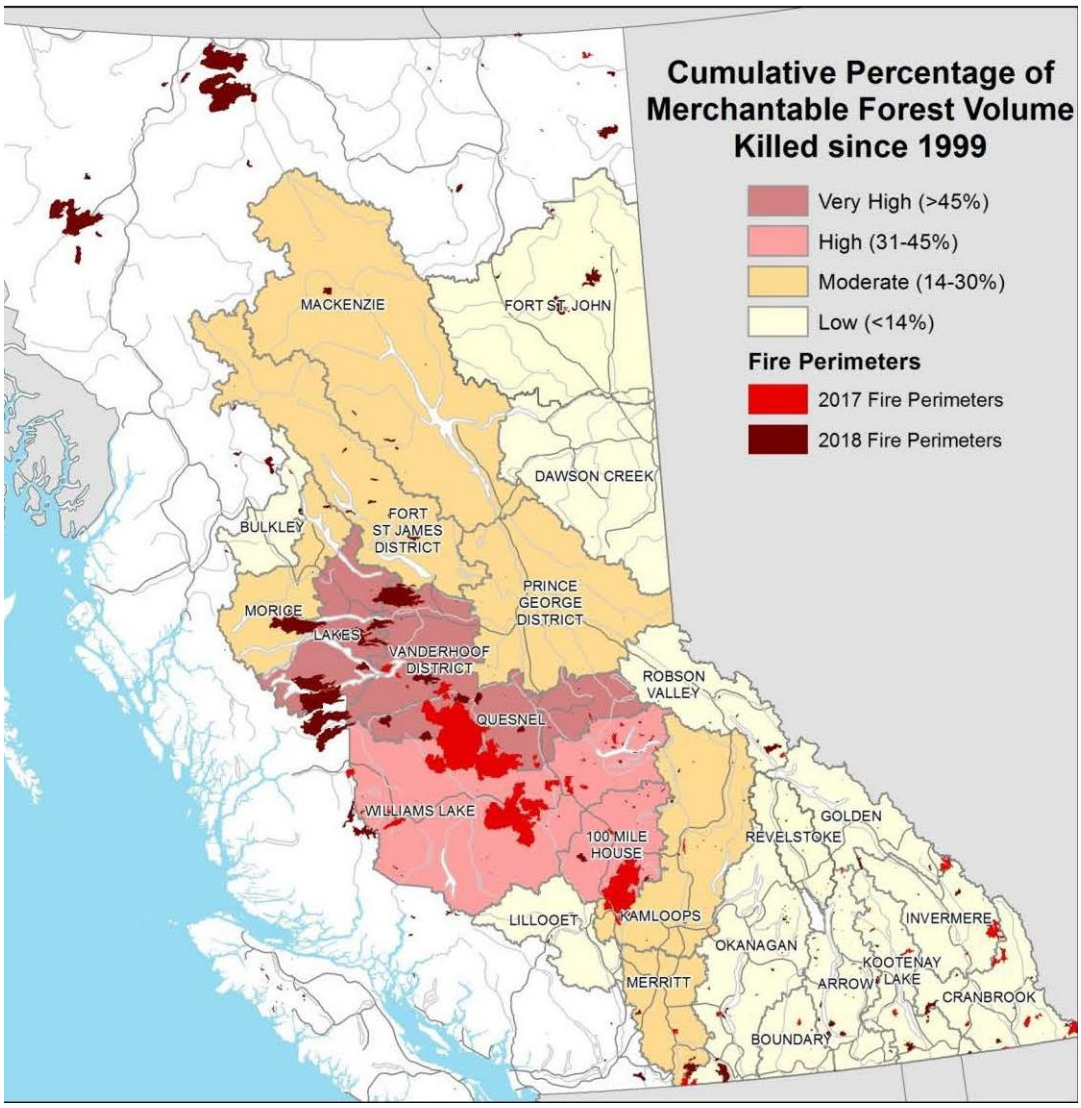


FIGURE 9. MAP OF 2017 AND 2018 FIRES.

Table 5 presents some key fire impact statistics for the catchment area, with the volume losses pertaining to the CTHLB only. There were additional losses in non-CTHLB areas, such as parks. Table 5**Error! Reference source not found.** shows that within the perimeter of the fire, roughly half of the volume was lost. Overall, the Lakes TSA and Morice TSAs lost 5% and 3% of their growing stock, respectively; the absolute level of loss was greatest in the Vanderhoof District. Data were not broken out by FLNRORD for the Vanderhoof District, however the majority of burn area in the Prince George TSA occurred in Vanderhoof, and thus the impacts on the District are likely to be similar to those on the two TSAs.

Area	Area burned (M ha)	% volume loss	Green timber loss as % CTHLB GS	Live timber loss (Million m3)	Dead timber loss (Million m3)
Lakes	175	45	5	1.7	0.75
Morice	73	54	2.9	2.5	0.82
Vanderhoof	123	46	N/A	2.9	N/A
SUM	371			7.1	

TABLE 5. IMPACTS OF 2018 FIRES ON THE CATCHMENT AREA.

Wildfires are variable in their intensity and within the perimeter, some trees are left alive, others are scorched and killed while others are partially burned. Depending on access, the living and scorched trees can be salvaged for sawlogs, with the unusable wood providing hog fuel and potentially some pellet furnish depending on the amount of char that is present.

4 Forest Inventory

4.1 Inventory

The analysis of the landbase and the forest in the catchment area has been derived from the provincial government's Vegetation Resource Inventory (VRI). The VRI is the provincial standard for forest inventory. It is based on digital aerial imagery captured periodically to delineate forest and non-forest areas. Attributes are attached to all inventory polygons and are updated annually for tree growth, natural mortality, and depletions such as timber harvesting, wildfires, and insect caused mortality.

The government has a program of periodic checks or audits of key inventory attributes using statistically design ground sample programs. Audits of forest stands greater than 50 years of age were conducted in the three administrative units in January 2020. Results showed that VRI estimates of volume were close in the Lakes TSA and Prince George TSA (of which the Vanderhoof District is a part), and slightly underestimated in the Morice TSA.

4.2 Ecosystem Types

For ecological purposes, BC has been classified into Biogeoclimatic zones (BEC zones). Each BEC is an extensive area with a broad homogeneous macroclimate that influences development of vegetation and soil. BEC zones in the catchment area are largely boreal, sub-alpine, and alpine in nature. A small portion of the Morice and Lakes TSAs is in two BEC zones that have coastal climate influences (CMA and CWH), however the catchment area does not include the Interior Cedar Hemlock (ICH) BEC zone, which has been considered by some as being synonymous with the interior temperate rainforest.

Two BEC zones in the catchment area account for 92% of the total area (Table 6). The SBS is the dominant zone, defined by lower elevations with gently rolling hills and moderate climate. The ESSF occurs at higher elevations with a more severe climate, shorter growing season, and lower forest productivity.

Code	BEC Zone	Area (ha)	
SBS	Sub-boreal Spruce	3,117,069	70%
ESSF	Englemann Spruce-Sub-Alpine Fir	979,664	22%
SBPS	Sub-boreal Pine Spruce	121,936	3%
BAFA	Boreal Altai Fescue Alpine	154,463	4%
MS	Montane Spruce	3,882	<1%
CMA	Coastal Mountain-heather Alpine	7,890	<1%
CWH	Coastal Western Hemlock	56,985	1%
MH	Mountain Hemlock	32,034	<1%
		4,473,923	100%

TABLE 6. AREA (HA) BY BEC ZONE IN THE CATCHMENT AREA.

Figure 10 shows the information in Table 6 in graphical format – the dominance of the SBS Zone is very evident. Note that the MS and CMA zones have been removed from Figure 10 for clarity. Interestingly, the BEC zone nomenclature references spruce and fir but not pine, which prior to the MPB epidemic, was the most abundant species in the mature forest.

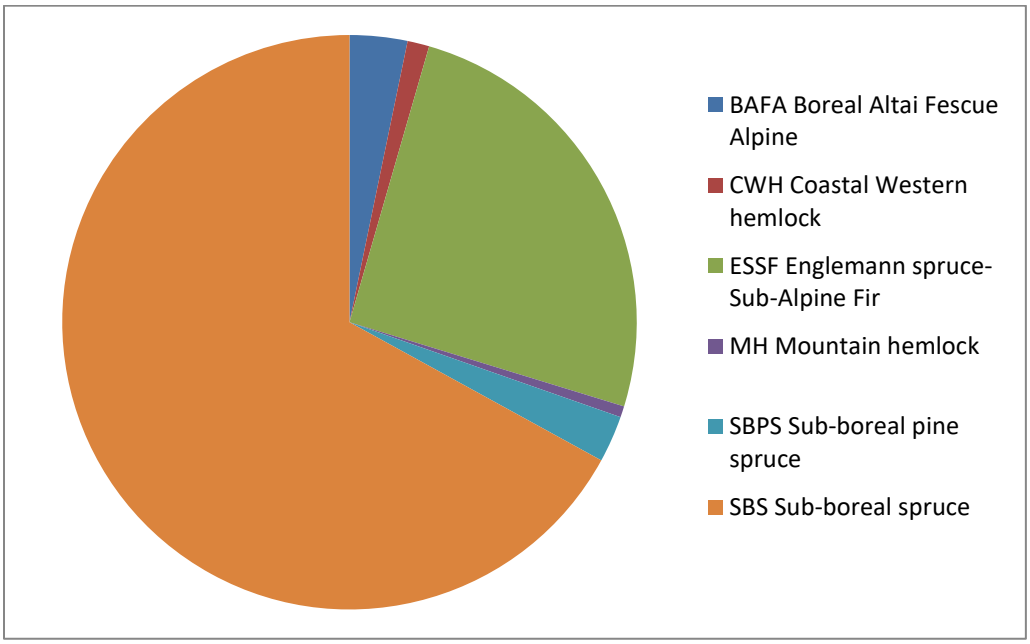


FIGURE 10. PROPORTIONAL AREA X BEC BEC ZONE IN THE CATCHMENT AREA.

4.3 Area

4.3.1 Leading Species

The catchment area forest is dominated by coniferous tree species, principally lodgepole pine, white and Englemann spruce, and sub-alpine fir (Table 7 and Figure 11). Spruce and pine-dominated stands account for 67% of the forest in the catchment area and Abies leading stands 23%. Hardwood stands account for about 10% of the forest area.

Leading Species	Area (ha)	
Pine	1,276,166	34%
Spruce	1,228,787	33%
Abies Fir	865,279	23%
Aspen	285,828	8%
Hemlock	62,715	2%
Birch	3,951	<1%
Douglas-fir	21,007	<1%
Larch	1,461	<1%
SUM	3,745,194	100%

TABLE 7. AREA X LEADING SPECIES IN THE CATCHMENT AREA.

The relative abundance of spruce has increased due to the effect of the widespread mortality of mature pine stands killed by the MPB (Figure 8 shows how MPB affected forest composition and age in the Lakes TSA). Nevertheless, there remains a substantial amount of pine leading forest in the catchment area, most of it in the younger age classes.

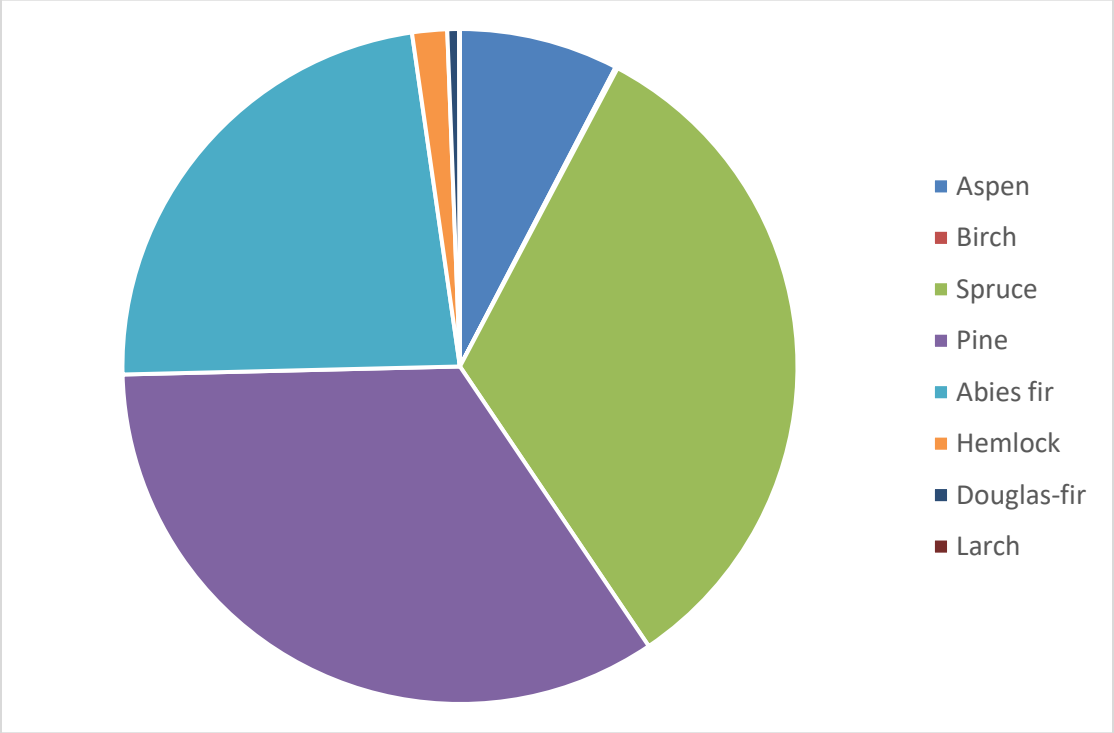


FIGURE 11. PROPORTIONAL AREA X LEADING SPECIES IN THE CATCHMENT AREA.

4.3.2 Age Class

The BC forest inventory uses an age class schedule that reflects historic conditions in the coastal forest: age classes 1-7 are twenty-year age classes, while age class 8 is stands that are between 141-250 years of age, and class 9 is older than 250 years. The majority of the forest in the catchment area is older than 100 years (Figure 12) and age class 8 (ages 141-250) has by far the largest area, reflecting in part the large range of ages included in it as well as a substantial area of low productivity and difficult to access stands. Classes 3 and 4 (ages 41-60 and 61-80) have relatively little area in them in part because fire suppression had been effective between 1940 and 1980 and there were no large natural disturbances during that period. Classes 1 and 2 (ages 1-20 and 21-40) are relatively large and consist mainly of renewal of harvested area. Most post-harvest regeneration is achieved through planting (generally 1-2 years after harvest) with some left for natural regeneration. Most of the un-salvaged MPB killed areas are

regenerating naturally.[6] Naturally and artificially renewed stands are often spaced, but very little commercial thinning is done in the BC Interior and there is almost none in the catchment area.

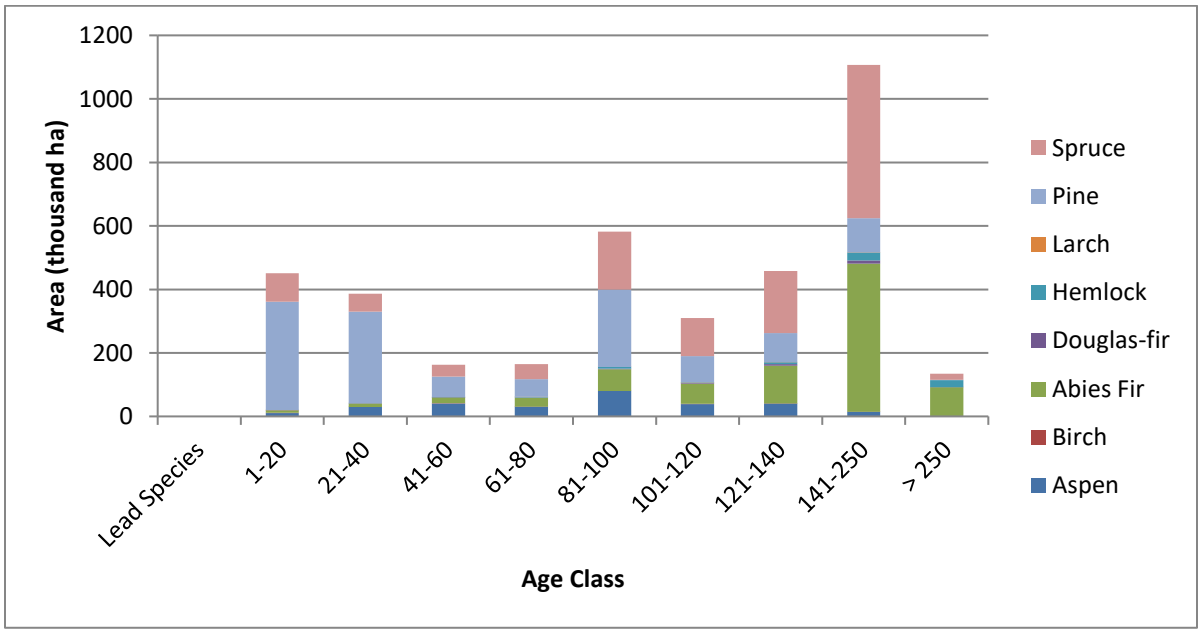


FIGURE 12. AREA X AGE CLASS FOR THE MAIN FOREST TYPES IN THE CATCHMENT AREA.

In the catchment area, most stands become merchantable around 80 years and peak in mean annual increment in age classes 5 or 6. While there is no firm rotation age in BC, conifer stands are usually harvested between 80 and 120 years of age.[7] In contrast, stands in age classes 8 and 9 are growing slowly if at all. Stands in these age classes are frequently in biological decline and are commercially unattractive in all but the most favourable timber markets.

The age class structure of the forest is imbalanced as a result of variations in operability and the lack of a hardwood market as well as the impact of natural disturbances – this is accepted by forest managers who do not have a mandate or a goal to "normalize" the age class structure of even the commercially available forest.

[6]Very little commercial thinning is done in BC, and there is almost none in the catchment area.
[7]Merchantable blocks of timber are usually scheduled for harvest based on strategic considerations, such as access construction, balancing haul distance, and operability.

Lead Species	Age Class									Total
	1 1-20	2 21-40	3 41-60	4 61-80	5 81-100	6 101-120	7 121-140	8 141-250	9 > 250	
Aspen	10.9	29.5	41.2	30.7	79.6	38.9	40.4	14.7	0.1	286.1
Birch	0.4	0.3	0.3	0.4	0.9	0.6	0.9	0.2	0.0	4.0
Abies Fir	8.2	11.1	18.2	27.5	67.6	63.9	118.9	466.3	92.0	873.6
Doug-fir	0.2	0.8	0.3	1.3	2.5	1.4	5.0	9.6	0.1	21.0
Hemlock	0.0	0.0	0.4	2.1	4.8	2.8	5.2	25.6	22.4	63.5
Larch	0.0	0.0	0.0	0.2	0.2	0.1	0.4	0.5	0.0	1.5
Pine	341.9	288.7	64.5	54.9	243.6	81.9	91.6	107.7	0.8	1277.7
Spruce	89.3	55.8	37.2	47.4	182.4	119.9	196.1	482.6	18.7	1230.4
SUM	450.9	386.1	162.2	164.4	581.6	309.6	458.4	1107.2	134.0	3757.7

TABLE 8. AREA BY AGE CLASS BY LEADING SPECIES IN THE CATCHMENT AREA (THOUSAND HA).

4.4 Volume

4.4.1 Forest Type and Species

Figure 13 shows the growing stock in stands classed by the leading species. The growing stock figures are calculated separately for each species identified in each stand, however the information is presented on the basis of the leading species. Stands that have douglas-fir, birch, hemlock, and larch have been omitted for simplicity of presentation as they cumulatively make up only 3% of the growing stock volume.

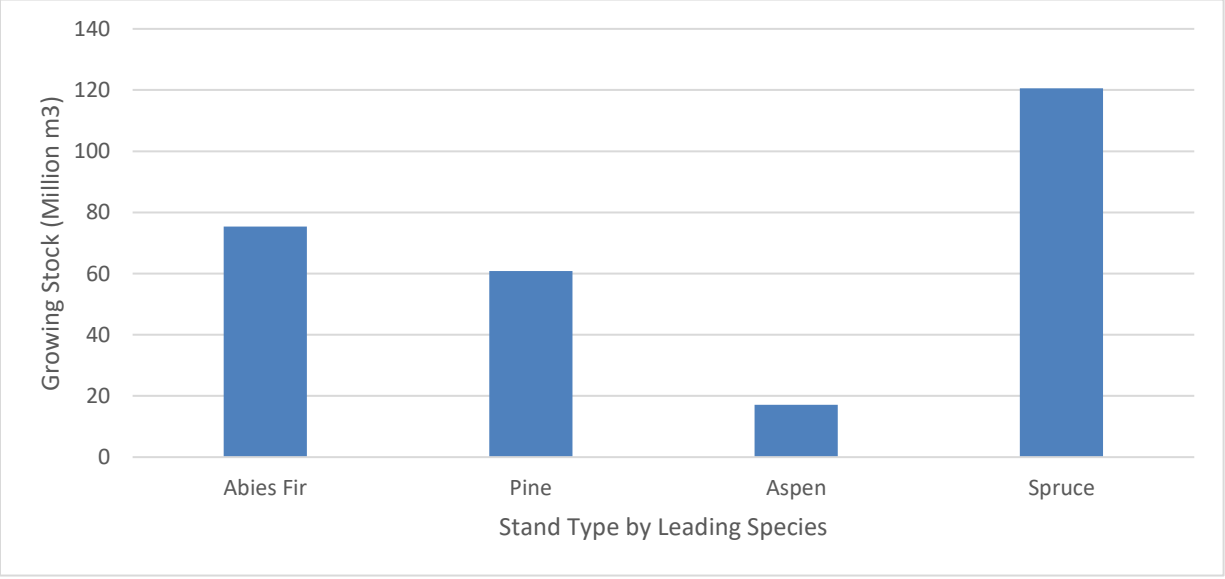


FIGURE 13. GROWING STOCK VOLUME OF KEY STAND TYPES IN THE CROWN FOREST (MILLION M3).

Since many of the stands in the catchment area are spruce-fir mixtures, there would be a considerable amount of spruce volume in the *Abies* fir growing stock in Figure 13, and vice-versa. The relative proportions of growing stock reflect the extensive mortality of pine due to MPB – formerly pine-dominated stands have moved into the fir, poplar or spruce-leading stand types once the pine mortality was inventoried.

The inventory also tallies the volume of dead timber in each stand. The total volume of dead timber in the inventory is 90.08 million m^3, equivalent to 24% of the live growing stock. The dead timber is not identified by species in the inventory but is primarily lodgepole pine killed by the MPB, which has proved to remain merchantable for sawtimber for as long as 15 years.

The volume of pine shown in Figure 13 is less than the 68.6 million m^3 of pine reported in the catchment area in 2014 (See Table 4); the difference reflects the differences in the basis of the volume determination (i.e. leading species and dead wood included in Figure 13 vs estimated actual live volume only in Table 4) and the impacts of the 2018 fires.

4.4.2 Age Class

Figure 14, based on current data from the BC forest inventory shown in Table 9, shows the amount of live growing stock by leading species and age class for the forests in the catchment area. As expected, there is little growing stock in the two youngest age classes, and also in age classes 3 and 4 (representing stands aged 41-60 and 61-80) due to the relative lack of area in those latter two classes. Fully 43% of the growing stock in the catchment area is in age class 8 (ages 141-250), equally divided between spruce and fir. Age classes 5 and 7 (ages 81-100 and 121-140, respectively) each have roughly 15% of the growing stock in the catchment area.

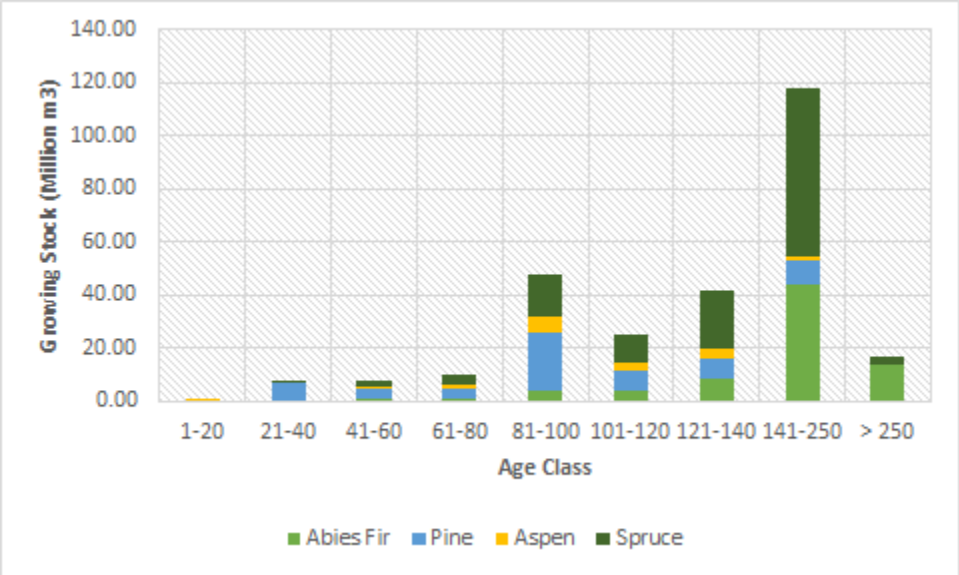


FIGURE 14. GROWING STOCK BY LEADING SPECIES X AGE CLASS FOR THE MAIN FOREST TYPES IN THE CATCHMENT AREA.

The forest is transitioning from first-growth natural-origin stands to second-growth stands which have been established after a harvest. Licensees have been responsible for basic silviculture since 1987, and since 2007, 100% of the spruce seed used has been genetically improved (FLNRORD 2019)[8]. Improved spruce is estimated to yield 20% more than the average natural stock. Improved lodgepole pine stock was used starting in 2009, and today 64% of pine stock is improved, with a 9% gain in yield expected.

	1-20	21-40	41-60	61-80	81-100	101-120	121-140	141-250	> 250
Abies Fir	0.00	0.04	0.51	1.07	4.17	3.80	8.25	43.58	13.97
Pine	0.01	6.58	4.03	3.82	21.56	7.61	7.88	9.34	0.04
Aspen	0.00	0.34	0.77	1.26	6.06	3.05	3.88	1.75	0.01
Spruce	0.00	0.67	2.48	3.44	15.77	10.81	21.49	63.34	2.58
SUM	0.01	7.63	7.78	9.58	47.55	25.26	41.50	118.00	16.60

TABLE 9. GROWING STOCK BY AGE CLASS AND LEADING SPECIES (MILLION M3).

On the Lakes TSA, there are roughly 23,000 ha of stands established prior to 1987, 63,000 ha established between 1987 and 2007, and about 50,000 ha regenerated since 2007.During the past four decades, approximately 67% of the renewal was planted.

The April 2019 Data Package for the Lakes TSA reports that many of the stands renewed prior to 1987 were planted, and some were naturally renewed and spaced and so are considered as managed. Pure spruce and pure pine were planted, as well as 80:20 mixtures of the two species, which pine leading sometimes and spruce leading other times. Area x planting composition data were not available.

Between 1987 and 2007, all renewal was through planting. Improved spruce seed was used for 75% of the planted spruce, with an average estimated genetic gain of 14%. No genetic gain was estimated for the planted pine. Mixed species were planted on all sites, at 90:10 and 70:30 spruce: pine and pine:spruce ratios, as well as a 40% pine, 30% spruce and 30% Abies fir combination. These changes were presumably made to add diversity to the second-growth forest. The widespread use of improved stock since 2007 has prompted FLNRORD to consider the post 2007 stands as growing according to different yield curves. A genetic gain of 20% has been applied to planted spruce and 9% to planted pine, and an even wider range of species mixtures has been planted.

[8]FLNRORD 2019. Data Package - Update. Lakes Timber Supply Area – Timber Supply Review. April 2019.

Approximately 9,000 ha of plantations were fertilized during the past decade. Most of the fertilized areas were pine-leading plantations around 35 years of age, however some areas of 50 – 70 year spruce was also fertilized.

4.5 Future Growing Stock

Due to the effects of the MPB and the 2018 wildfires, the growing stock and average age of the forest in the catchment area are at a cyclical low point; Figure 14shows a substantial amount of area in age classes 1 and 2 (1-20 and 21-40, respectively). These stands are young enough that they presently have little growing stock and in age class 1 the volume growth rates are relatively low.

As mentioned, a TSR is presently underway for the Lakes TSA and a discussion paper released in 2019 by FLNRORD as part of the process describes the projected state of the forest. Because there are no recent analyses for Morice and Vanderhoof, the Lakes TSA analysis is reviewed here in some detail since the results are representative of the entire catchment area.

The Lakes TSR discussion paper notes that the size of the Crown managed forest landbase is approximately 33% smaller (265,000 ha) than it was in 2000, due to the transfer of area from volume-based tenures to area-based tenures (see section 3.3). The AAC in the volume-based portion of the TSA is expected to decline significantly when the Chief Forester sets the new AAC, likely within the next year. The base case AAC in the discussion paper (FLNRORD 2019) shows the live volume portion of the AAC being reduced to 400,000 m^3/yr for 60 years before it rises to a long-term sustainable level of 900,000 m^3/yr. There is also a 400,000 m^3/yr harvest of dead wood planned for the first decade, that then varies between approximately 50,000 and 80,000 m^3/yr to year 60. The pathway of the total and merchantable growing stock[9] is shown in Figure 15 for the base case timber supply projection in the Lakes TSA. The base case is the scenario that captures current practice and seeks to balance objectives such as long-term sustainability, provision of timber, and optimal use of the remaining dead wood in the forest[10]; the AAC that is determined by the Chief Forester will likely be consistent with the base case.

[9] Merchantable stands are conifer-leading stands older than 80 years and containing more than 140 m^3/ha

[10] The Discussion Paper notes that there is a significant amount of dead wood remaining on the landbase however there is a great deal of uncertainty regarding its continued merchantability. The base case has not changed the assumed "shelf life" of the dead pine; the base case scenario reflects a sustainable live volume harvest with a focus on stands with the highest proportion of dead timber in them.

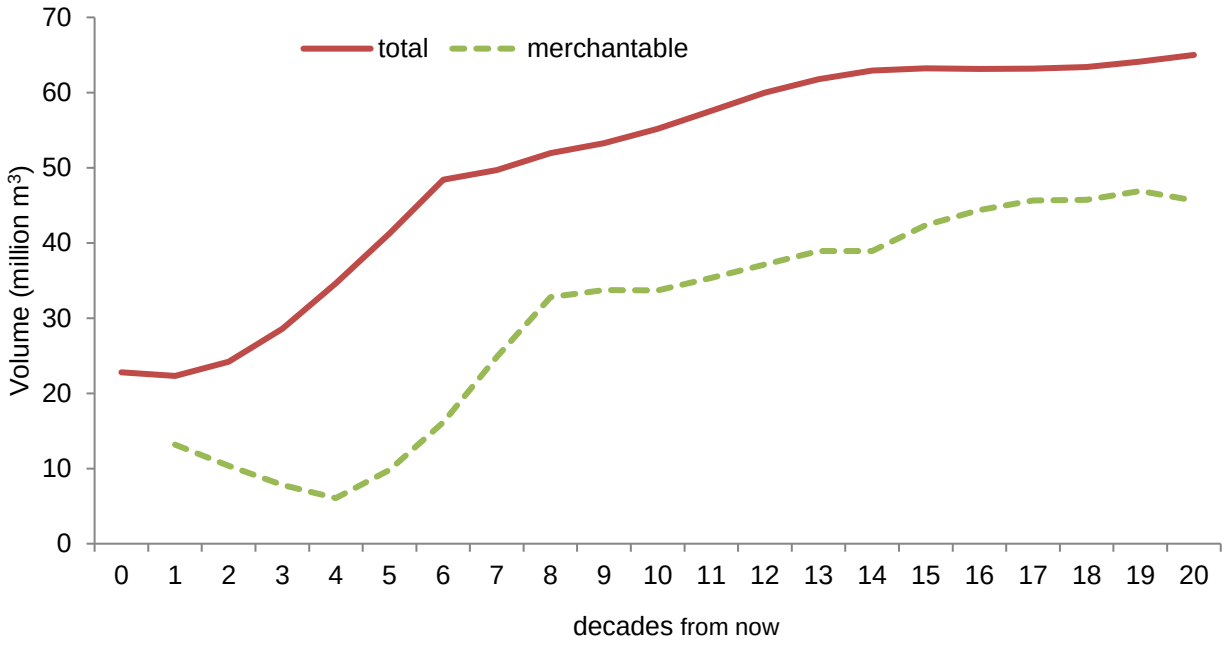


FIGURE 15. BASE CASE GROWING STOCK PROJECTION ON LAKES TSA.

The AAC determination also needs to consider the transition from the primary forest to the second-growth forest, much of which has been planted and tended and grows more rapidly than natural origin stands. Between the expected gain from using improved seed and the application of management, growth rates in the managed stands are roughly twice those of natural origin stands. The Lakes TSA base case shows the primary forest providing all of the harvest for the next 25 years, after which the second-growth becomes an increasing proportion of the harvest volume. By year 40, second-growth stands are expected to supply approximately 67% of the harvest volume, and by year 60 it will be more than 90%.

5 Timber Removals and Growth

5.1 Removals

During the study period (2000-2019), the three principle sources of removals were the MPB, wildfires, and harvesting. This assessment has reviewed the primary source of forest mortality, namely the MPB, as well as the 2018 wildfires in sections 3.5 and 3.6, respectively. This section will examine the harvest in detail.

5.1.1 Harvest

Like everything else, harvesting was greatly affected by the MPB outbreak during the study period; harvesting was elevated compared with previous periods due to the concerted effort to salvage MPB-killed timber. Salvage harvesting began to ramp up as early as 2001 and continued at substantial levels through most of the assessment period. The extensive salvage harvesting meant that in many years, well over 50% of the harvest consisted of dead pine.

Table 10 shows the volume harvested each year from 2010-2019 by species, and Figure 16 shows the same data for the three primary species. On average, the annual harvest was approximately 10 million m^3 between 2010 and 2019; 2011 and 2013 were the two highest years with harvests of 12.1 million m^3 and 11.4 million m^3, respectively. From 2017 to 2019, the harvest showed a declining trend, with the 2019 harvest being 7.7 million m^3.

Lodgepole pine made up the majority of the harvest, at 65% over the entire period, and spruce comprised 25%. Abies fir made up just less than 10%. Hemlock made up only 0.3% and the deciduous species accounted for less than 0.2% of the harvest.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	SUM
Aspen	38	16	16	8	2	15	5	5	14	28	147
Birch	3	1	2	0	0	2	1	0	1	8	18
Cottonwd	1	0	0	0	0	0	0	0	2	6	9
Lodgepole Pine	8245	8310	6933	7648	6439	7114	6295	5433	4635	3682	64734
Spruce	1947	2723	2383	2779	2201	2406	2428	3032	2719	2663	25281
Abies	681	1027	903	903	758	825	895	1170	1237	1256	9655
Douglas-fir	17	24	18	18	30	34	34	19	52	61	307
Rejects	15	4	2	2	2	4	1	1	4	0	35
Hemlock	0	0	0	0	0	0	0	1	3	3	7
Cedar	0	0	0	0	0	0	0	0	0	0	0
SUM	10905	12088	10239	11350	9430	10383	9653	9656	8650	7665	100019

TABLE 10. CATCHMENT AREA HARVEST VOLUME BY SPECIES (THOUSAND M3)

The proportion of pine in the harvest trended down gradually, from 75% in 2010, to between 65 and 69% between 2011 and 2016, before declining to roughly 55% in 2017 and 2018 and

thence to 48% in 2019. This reflects the trajectory of the salvage. On the other hand, the proportion of spruce trended higher during the past decade, rising from 18% in 2010 to an average of 30% between 2016 and 2019.

Harvest data from FLNRORD for the individual TSAs show that between 2004 and 2008, when the salvage was most intensive, 99.2% of the volume harvested in the Lakes TSA was pine, primarily dead and dying timber. About two-thirds of the harvest in the 2010 and 2019 period was pine (Figure 17). Between 2012 and 2018, 13% of the Lakes harvest was live pine (average of 167,844 m^3/year), 58% was dead pine (737,750 m^3/year on average) and the remaining 29% was live timber of other species (average was approx 360,000 m^3/year). Like the Lakes TSA, a considerable amount of pine salvage occurred in the Morice TSA; data provided by FLNRORD show that 46% of 2015 harvest was dead timber, which declined in subsequent years to reach 29% in 2019.

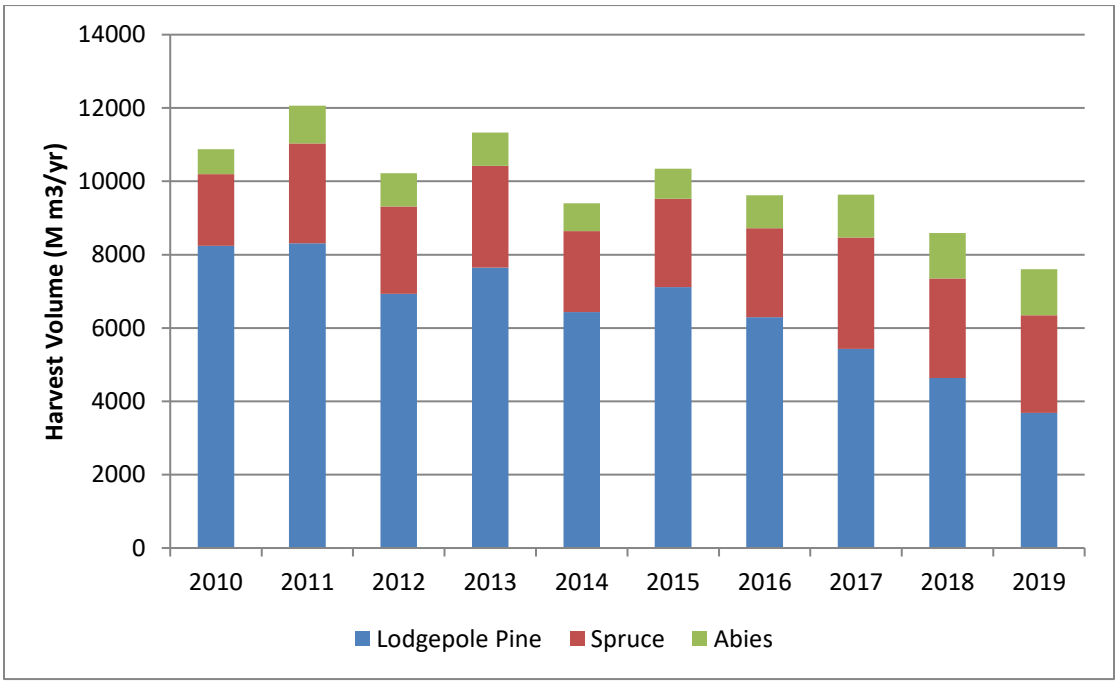


FIGURE 16. CATCHMENT AREA HARVEST VOLUME BY PRIMARY SPECIES (M M3).

Figure 17 shows the proportion of the three main species groups in the total harvest between 2010 and 2019.

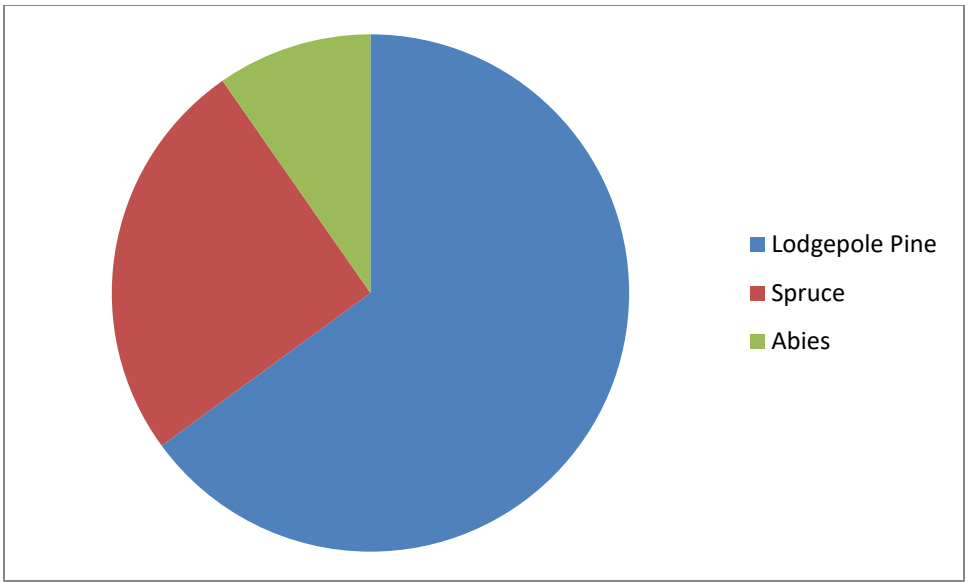


FIGURE 17. PROPORTIONS OF 2010-2019 TOTAL HARVEST VOLUME BY PRIMARY SPECIES.

Figure 18 summarizes harvested volumes for the past ten years by two broad quality classes. The sawlog grade represents the best quality timber whereas the low-grade timber consists of logs with defect and rot, small logs and other lower grade materials that cannot be processed in a sawmill (See section 6.3 for more detail). The sawlog grade timber is the most valuable and is processed by the sawmills.

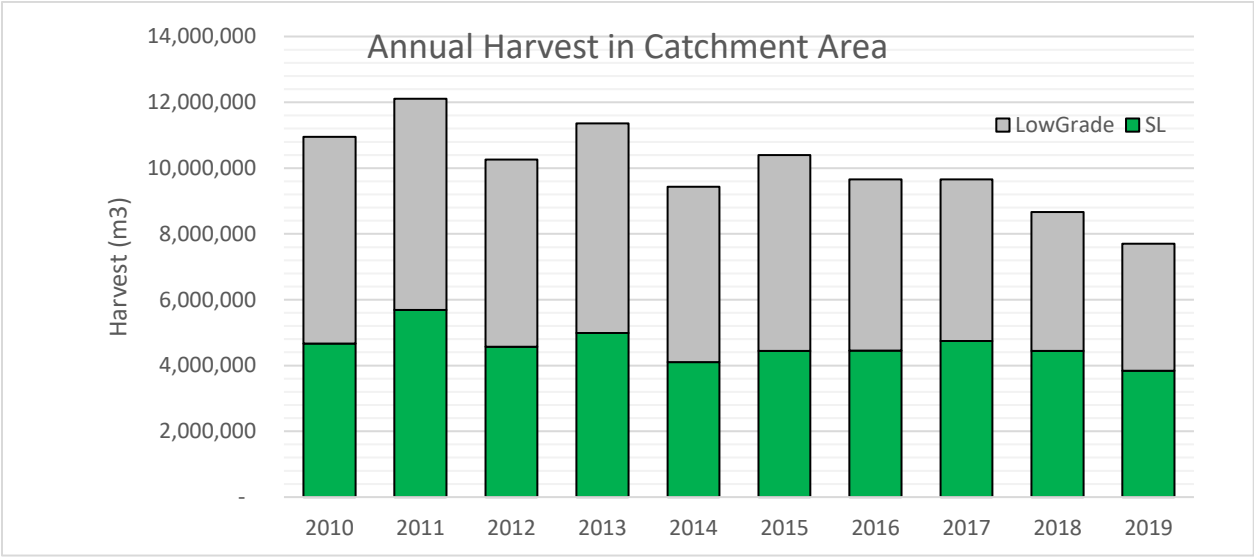


FIGURE 18. ACTUAL HARVEST IN CATCHMENT AREA.

On average, 95% of the sawlog grade was live timber and 5% was dead. Even though dead, the wood could be sawn in a sawmill and met the quality specifications for the grade.

In contrast, 95% of the low-grade wood was dead and only 5% was living. Sawmills were using some of the grade 4 dead wood while that which they couldn't process went either to the cant mills or, if its quality was very poor, directly to the pellet mills. The proportion of dead wood in the harvest between 2010 and 2019 ranged between 50 and 59 %, averaging 55% over the period; this suggests that 5.5 million m^3 of dead wood was cut on average each year.

5.2 Deforestation

Deforestation is the removal of forest cover as the land is converted to a different use other than forestry. Timber harvesting followed by renewal of the forest is not deforestation - clearing forest for agriculture is. BC does not report on deforestation and the BC forest inventory does not readily allow one to determine the rate of deforestation, primarily because each time the inventory is updated with new photography, the assessment of what is and is not forest changes for areas that are borderline forests, typically sub-alpine and alpine areas in the case of the catchment area.

However, the Canadian Forest Service (CFS) tracks deforestation to meet Canada's obligations for national greenhouse gas reporting. These data are tabulated by ecozone, which are very large areas. The catchment area is in the Montane Cordillera ecozone and the CFS reports that between 1980 and 2017, the area of forest in the ecozone declined from 31,181,000 ha to 31,094,000 ha, a reduction of 87,000 ha or 0.28 % of the forest area. The amount of deforestation averaged 2,350 ha/yr, with approximately 300 ha/yr occurring in the catchment area. The leading causes of deforestation have been conversion to agriculture (40%), urban expansion (17%), forestry roads and landings (17%) and mining (15%). The ownerships on which the deforestation occurred were not specified, however the majority of the conversion to agriculture and urban expansion would have occurred on private land. Forest roads and landings accounted for a loss of approximately 400 ha per year in the ecozone; since the ecozone is approximately eight times as large as the catchment area, this translates to a loss of 50 ha/year in the catchment area. While forest companies are required to renew harvested lands, and thus not contribute to deforestation, provincial policy in general is neutral in terms of whether it encourages or discourages deforestation.

5.3 Growth

The VRI estimates the annual growth rate of each stand based on its species composition and site characteristics. These growth rates are all modelled in the VRI as if the stands renewed naturally, which is not the case. For the past fifty years, many of the stands in the catchment area have been renewed by planting followed by a spacing operation, and some naturally renewed stands have been spaced. In addition, as mentioned above, improved seed has increasingly been used to grow the planting stock. As a result, the VRI underestimates the current rate of growth.

To obtain a more realistic rate of growth for the forest management landbase, the consultants re-estimated the growth rates of young stands using managed stand yield curves. In the absence of the ability to accurately determine how stands originated, all stands less than 50 years old were assumed to be managed. The results of this assessment are shown in Table 11.

To simplify the presentation, Table 11 shows the results for four age classes in the portion of the forest that is identified in the inventory as the forest management landbase. The Regen age class is recently harvested and renewed area that has not been assessed as free-to-grow and so has not been assigned stand characteristics. Most of the Regen area is less than 10 years old.

The row labelled CAI (Current Annual Increment) shows the total annual volume growth in each age class and the row labelled Avg CAI shows the average annual growth per hectare by age class. These data are portrayed in Figure 19. Despite being 31% of the area, the 1-50 year age class accounts for 62% of the total growth. Overall, the average growth rate is 1.2 m^3/ha/year; the large amount of area in the oldest age class greatly lowers the increment for the forest management area as a whole.

Values	Regen	1-50 yrs	51-100 yrs	101+ yrs	Total
Area (ha)	56,273	829,497	533,159	1,224,027	2,642,956
CAI (m^3)	0	1,708,700	1,060,182	680,045	3,448,927
Avg CAI (m^3/ha)	0	2.1	1.9	0.6	1.2
CMAI age	0	84	117	139	119
CMAI (m^3)	0	3,640,813	809,891	1,452,778	5,903,482
CMAI (m^3/ha)	0	4.3	1.4	1.1	1.9

TABLE 11. CURRENT ANNUAL INCREMENT (M3/HA), AREA AND TOTAL INCREMENT IN THE FOREST MANAGEMENT AREA.

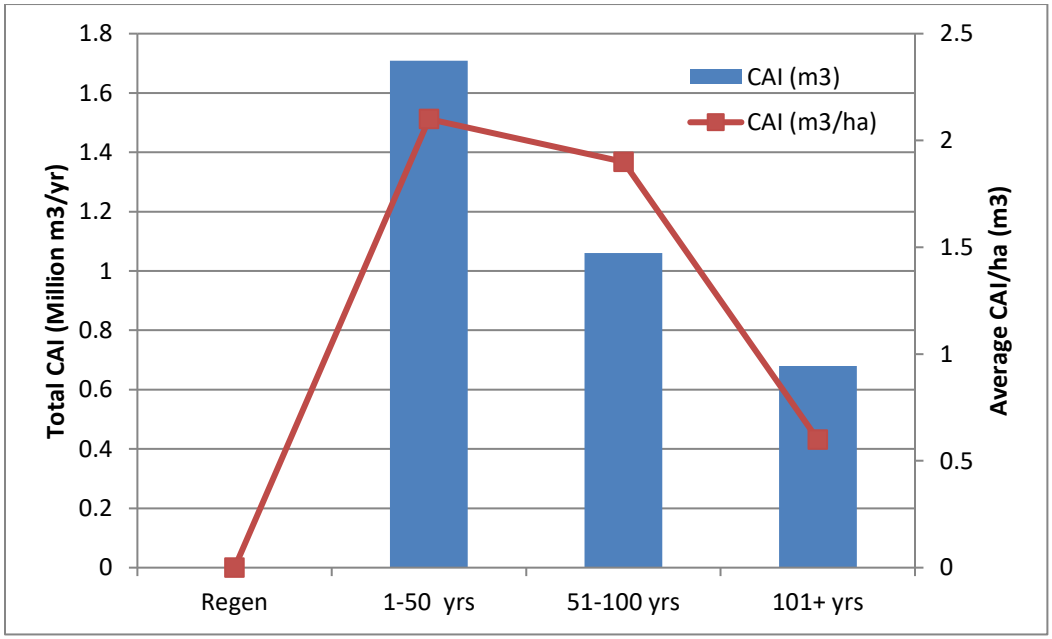


FIGURE 19. CURRENT ANNUAL GROWTH.

The growth rates in the stands older than 50 years have been reduced by the MPB. While many of the high percentage pine stands have been salvaged and renewed, stands that were a mixture of pine and spruce have experienced a loss of pine volume but the remaining species continue to form a stand. Likewise, some of the area within the 2018 fire zones was only partially killed, leaving stands in a similar under-stocked condition. These depleted but "unsalvaged" stands will have low rates of growth because the stocking has been so reduced. As a result, the current growth within the TSA is below the capacity of the forest, however the large area of young managed stands will provide for a sizeable boost in growth rate over the next several decades.

Table 11 provides an indication of the potential growth rates by showing the CAI at the age when the Mean Annual Increment peaks, or culminates (i.e. the age of CMAI). These average ages of CMAI are shown, as well as the average total annual increment at CMAI, and the per hectare increment at the same time. These data are graphed in Figure 20.

As time goes by and natural origin forest is harvested and the regenerated areas grow according to the managed yield curves, the area in the 1-50 age class will move into its most productive age. As this happens, the total amount of growth and the average increment per ha in the forest will rise. The managed stands achieve peak MAI at 84 years on average, while the unmanaged stands achieve peak MAI at ages 117 and 139, respectively. Stands are generally harvested when they are near peak MAI. The total increment achieved by the current stands at the age of peak MAI is 5.9 million m^3/year, which provides an indicator of future levels of growth from the forest management landbase.

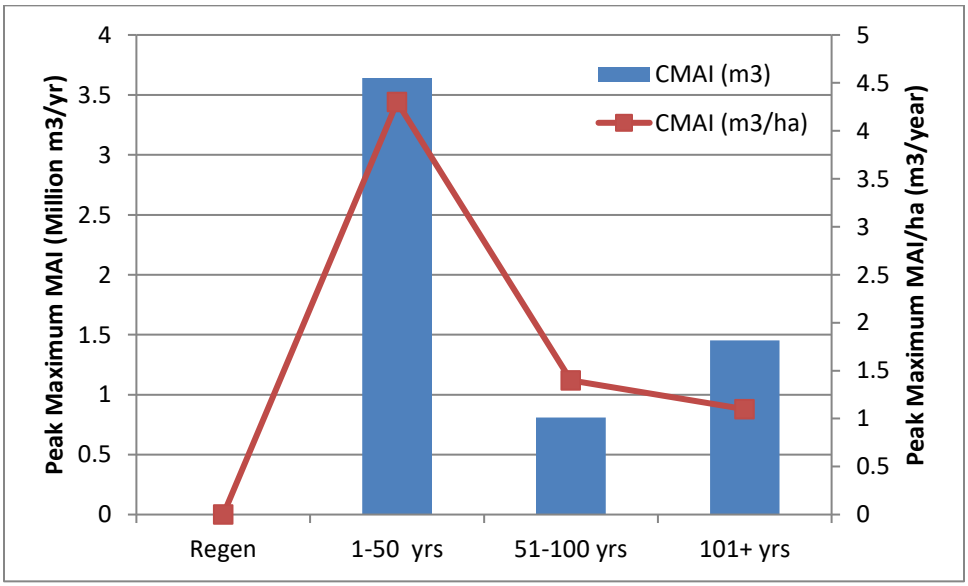


FIGURE 20. PEAK POTENTIAL ANNUAL INCREMENT BY AGE

5.4 Growth to Removal Ratio

During the 2010-2019 period, the primary source of removals from the catchment area was timber harvesting, which accounted for 100.2 million m^3 during the period. MPB mortality was minimal, as the majority of it occurred during the previous decade. The 2018 wildfires are estimated by FLNRORD to have killed 7.1 million m^3 in the catchment area.

Table 11 shows that the current annual growth on the forest management landbase is 3.45 million m^3. Since annual growth rates are not available for previous years, the growth over the ten-year period can be approximated as ten times the 2020 figure, or 34.5 million m^3.

Thus, the total removals of 107.3 million m^3 during the period handily exceeded growth. However, approximately 55 million m^3 of the harvest consisted of dead wood, so the removal of live wood was only 52.3 million m^3, or 17.8 million m^3 more than estimated growth.

In the prior decade, 2000-2009, MPB killed 157 million m^3 however a much greater percentage of the harvest was dead pine during the period – as much as 98% in some years. As a result, it is likely that the growth rate during 2000-2009 exceeded the removals of live timber from harvesting.

The growth to removal ratio has been greatly affected by the impacts of MPB on the forest and the harvesting response. The growth rate for the catchment area is near a cyclical low point due to the mortality caused by the MPB, which has created the conditions for the recent fires and bark beetle infestations. As the large area of young managed forest grows and reaches the ages of rapid growth, the growth increment in the catchment area will increase significantly.

At the same time, the allowable harvest is presently near 8.0 million m^3/yr and being reduced. Figure 5 shows that in 2000, the AAC for the volume-based licence area was roughly 5.3 million m3, and one may anticipate that the live portion of the harvest will soon be reduced to or below this level. There is still a deadwood component in the harvest, although it is relatively minor, and the total growing stock is projected to decrease for another 10-15 years, while merchantable growing stock will decline for another 30 years. There will be a long period of adjustment after the-MPB infestation. As a result, the growth to removals ratio is not an especially accurate indicator of trends in the forest or of the overall sustainability of forest management.

Between 2015 and 2019, the catchment area harvest was 46.1 million m^3. Pinnacle's use of fibre was equivalent to 7.5 million m^3, representing 16.3% of the harvest volume[11]. However, much of this was sawmill residual; Pinnacle's use of roundwood was equivalent to 1.6 million m^3 or 3.5% of the total harvest. Given this low level of roundwood consumption, and Pinnacle's

[11] One ODT = 2.45 cubic metres.

use of low-grade fibre, the consultants conclude that Pinnacle's wood use has not affected harvest levels.

The consultants believe that before long, growth will exceed the volume of live timber harvested. The growing stock in the catchment area will enter a long period of increase given the commitment to silvicultural and forest management investments. Demand for fibre by pellet mills will not be driving this trend or any related decisions.

6 Market Profile

6.1 Overview

The forest industry is the primary driver of the economy in the catchment area. The foundation of the industry is the production of solid wood products, i.e., dimension lumber manufactured in sawmills. Most of the timber harvested from the catchment areas is processed by local mills, although some sawlogs from the Vanderhoof District are shipped to Prince George. About two-thirds of the lumber produced in BC is exported to the US.

Sawdust and shavings from sawmills, as well as chips and trim blocks, are the main supply of fibre for pellet plants. The chips and trim blocks are ground and represent a minor proportion of the sawmill residuals. More recently, "hogfuel" from sawmills (miscellaneous waste fibre, mostly tree bark) is being used by pellet plants and biomass powered generators.

The catchment area also has secondary manufacturing facilities and speciality mills (e.g. telephone poles and cedar mills). In Burns Lake and Houston, low-grade logs that do not meet the quality specifications of the sawmills are processed in local 'cant' mills, where the logs are squared into cants, which are put into containers as 'squares' and exported to Asia.

Most of the waste from the cant mills goes to the pellet mills however there is demand from pulp and paper mills in Prince George for the chips produced from the sawmills. Approximately 55-60% of the volume of wood processed in sawmills is recovered as lumber, 35% as chips, and the remainder as sawdust, shavings, and hogfuel. The nearest Oriented Strandboard (OSB) mill is even further, located near Fort St. John, seven hours from Burns Lake. The pulp and OSB mills draw only a minor amount of their furnish from the catchment area and are incidental to the local forest sector, leaving the pellet mills as the primary destination for sawmill residues produced in the catchment area.

Figure 21 shows the location of the main forest products mills in the catchment area and the surrounding region. Small sawmills with a capacity of less than 94,390 m^3/r[12] and other small speciality mills, such as the cant mills, are not shown. There is a string of large sawmills along Highway 16 from Houston to Prince George; they are indicated by a single symbol regardless of whether there is one or more mills of the same type in a community (e.g. Burns Lake and Prince George). Similarly, the pulp mill symbol on Prince George represents the four pulp and paper mills in that city. Table 12 lists the mills by type, company, location and capacity. The capacity data was obtained from FLNRORD 2020.[13]

[12] Equivalent to 40 million fbm.

[13] FLNRORD. 2020. Major Primary Timber Processing Facilities in British Columbia 2018. Forest Policy and Indigenous Relations Division, FLNRORD, BC. April 2020.

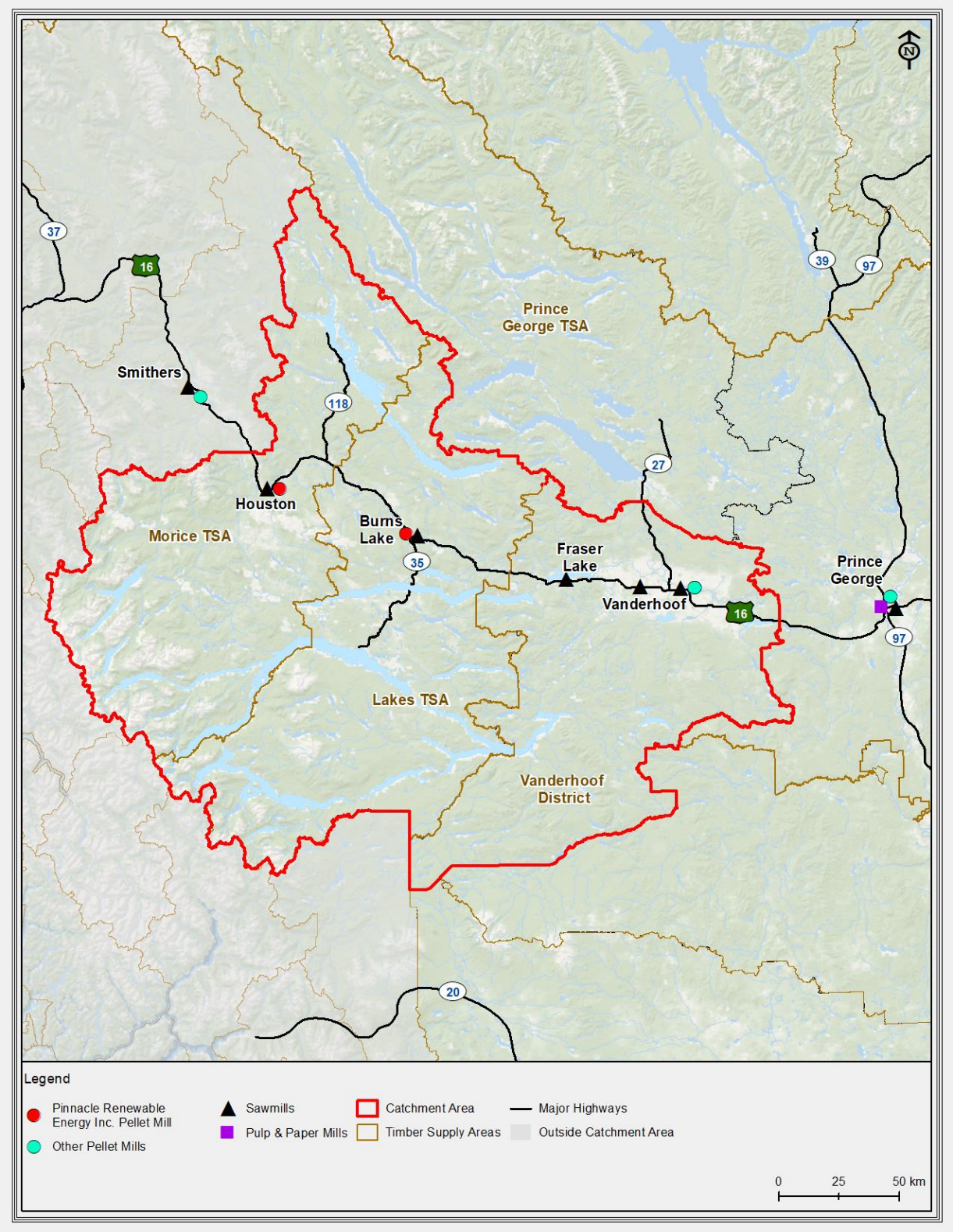


FIGURE 21. MILL LOCATIONS IN CATCHMENT AREA.

Company	Location	Capacity
Catchment Area		
Sawmills		
Babine Forest Products Ltd	Burns Lake	361 M m^3
Canadian Forest Products Ltd.	Vanderhoof (Engen)	762
Canadian Forest Products Ltd.	Houston	707
West Fraser Mills Ltd.	Fraser Lake	398
Decker Lake Forest Products	Burns Lake	127
Nechako Lumber Co.	Vanderhoof	386
Pellet Mills		
Pinnacle Renewable Energy	Burns Lake	383 M ODTs
Pinnacle Renewable Energy	Houston	204
Premium Pellet	Vanderhoof	207
Adjacent to Catchment Area		
Sawmills		
Canadian Forest Products Ltd.	Prince George	554 M m^3
Carrier Lumber Ltd.	Prince George	491
Lakeland Mills Ltd	Prince George	230
West Fraser	Smithers	412
Pulp Mills		
Canadian Forest Products Ltd.	Prince George	333 M tonnes
Canadian Forest Products Ltd.	Prince George	316
Canadian Forest Products Ltd.	Prince George	563
Chip Mills		
Canadian Forest Products Ltd.	Prince George	596 million ODTs
Pellet Mills		
Pacific Bioenergy	Prince George	285 M ODTs
Smithers Partnership	Smithers	33

TABLE 12. MAJOR FOREST PRODUCTS MILLS IN THE CATCHMENT AREA AND SURROUNDING REGION.

Much of the forest area in the catchment has been certified to the SFI standard, which has been adopted by Canfor and many of the other licensees. The Burns Lake Community Forest is the main area within the catchment that has been certified to the FSC standard. In all, between 80-90% of the forest is certified. Additionally, Pinnacle's two pellet mills have been certified to the

Sustainable Biomass Program standard, which includes requirements associated with the sustainability of fibre sourcing.

6.2 Pellet Plants

Pellet mills in the catchment area include the two Pinnacle mills as well as a smaller facility in Vanderhoof (Premium Pellet). The Vanderhoof plant is located immediately adjacent to a sawmill, which represents almost the entire the source of furnish for that mill. A new pellet plant was commissioned in 2018 in Smithers, to the west of the catchment area. That plant, which is a partnership between Pinnacle (70%) and West Fraser (30%), was built on the site of a former particleboard mill. The new plant sources its fibre primarily from a large sawmill in Smithers and from other sawmills to the west of Smithers. Pacific Timber, part of the larger Tahtsa Group, is a relatively new company that was started to make use of salvage timber that was killed by the MPB epidemic. Its pellet mill in Prince George primarily sources from local sawmills. Distances between sawmills and pellet mills are generally less than 100 km.

As detailed below, the pellet mills rely on residuals from the sawmills and use the lowest grades of fibre that the other mills do not or cannot use. Thus, the pellet mills play an important role in supporting the local mills by providing a sales destination and revenue for the low-grade fibre and residuals. Prior to the pellet mills, sawmill residuals were burned in beehive burners.

The pellet mills obtain a minor part of their furnish (typically less than 5%) from the use of logging slash, which consists of the tops, branches, dead wood, and other non-merchantable material. Slash is the woody debris left after harvested trees are processed into logs at landings along forest access roads; once the logs have been removed, the slash is ground into fibre and trucked to the pellet mill. Haul distances generally range from 10 to 100 km. The relatively low price for the bush grind material cannot support haul distances much beyond that. Demand from the pellet plants gave rise to bush grinding; before that, this material was piled and burned or left to rot.

6.3 Log Market

There is a well-defined correspondence between the grade of a log and the type of mill that uses it. BC's log grading system is summarized in Table 13.

grade 1: premium sawlog (large good logs).
grade 2: sawlog (the log has 50-100% firmwood, little defect, generally good condition).
grade 4: lumber reject (the log has <50% firmwood and defects such as checks, spiral grain, etc.).
grade 6: undersize (less than 10 cm diam)
grade Z: firmwood reject (lots of rot, very poor form, etc.).

TABLE 13. BC GOVERNMENT LOG QUALITY CLASSES.

There are five grades, with grade 1 the highest and grade Z lowest. There are few grade 1 logs in the catchment area – grade 1 usually applies to logs from the coast which are larger than those from the catchment area. The majority of quality sawlogs in the catchment area fall into grade 2; these logs have little defect and any defects that are present are minor, and at least 50% of the log is firmwood. (Firmwood excludes all rot, char, holes and missing wood; detailed grade specifications can be found in the BC Interior Scaling Manual.)

Grade 4 timber has less than 50% firmwood and more significant defects, such as checks and spiral grain. Grade 6 timber is small-sized wood and Grade Z is the lowest quality of log. Grades 4, 6 and Z are known collectively as low-grade wood, which is not used by sawmills. One of the limitations of this grading system is that it does not distinguish dry and green logs.

The widespread mortality caused by the MPB, and to a lesser extent by the wildfires, created a large supply of sawlogs from dead and dying trees. The dead mature pine stayed standing for as long as 15 years, drying and remaining usable as lumber, although steadily deteriorating in quality. The sawmills ran at levels close to full capacity during this period, and some increased their capacity, creating an abundant amount of residual fibre for the pellet mills.

Until the end of 2018, dry dead sawlogs were in high demand and fetched a decent price at the sawmills. The consultants estimate that as much as 75% of the MPB deadwood was grade 2; the remainder either went to the cant mills, got burned on the landing, or was left in the block.

The low-grade logs are sorted and used by the local 'cant' mills. The remaining, even lower grade logs or residuals such as broken pieces and dead wood are processed through a grinder for pelletizing. A portable grinder operates on the Burns Lake pellet mill site.

In 2019, sawmills stopped using the deadwood as it had deteriorated beyond the point where they could use it. This phenomenon occurred throughout the BC Interior; the substantial reduction in supply has caused as many as 20 sawmills to close permanently in BC and others have reduced the number of shifts or taken downtime. This change in the supply has reduced the amount of mill residual fibre available to Pinnacle, and the data in Figure 22 and in Figure 23 show that the pellet mills responded by increasing their use of roundwood. In discussions with the Burns Lake community forest manager, it is also apparent that the forest still contains large volumes of these dry dead trees which can only now be used as cants or as fibre furnish for wood pellets.

Most recently, Canfor temporarily closed its sawmills in Houston and Vanderhoof from March 30 to June, due to the slowdowns associated with COVID-19. In May 2020 it also announced the permanent closure of its Isle Pierre sawmill near Vanderhoof (capacity 472,000 m^3). Since June, lumber prices have risen dramatically and the surviving sawmills are at full production.

6.4 Pinnacle's Fibre Intake by Source

Fibre source data for the two Pinnacle mills was obtained from the government's Harvest and Billing System data. Figure 22 and Table 14 show the furnish source data for Burns Lake while Figure 23 and Table 15 show the Houston mill data. Table 14 and Table 15 indicate that both mills rely heavily on sawmill residuals; until 2019 more than 70% of the fibre used by Burns Lake was mill residual and the Houston plant used an even higher percentage of mill residual. The effect of the supply shift described above is evident in 2019, as both facilities greatly increased their use of alternate fibre sources.

The wood labelled as "Roundwood" in Table 14 and Table 15 consists primarily of low-grade timber. Logs that are trucked to the pellet mill are often too short to go through a sawmill but long enough to stay on the bunks of the truck. Another component of the roundwood is tops; sawlogs are taken to a 4" top and what remains can be delimbed and brought to the mill. None of the material has an alternate use in the catchment area.

The fibre labelled as "bush grind" is produced by flails that break down the logging slash left at roadside, which typically includes butt sections that are rotten or twisted, tops that are too small to recover for any other product, branches, broken pieces, etc. This material has no other commercial use and if it is not ground, it is either burned or left to rot. "Yard grind" represents the low-grade timber that is trucked to the pellet mill yard and ground there.

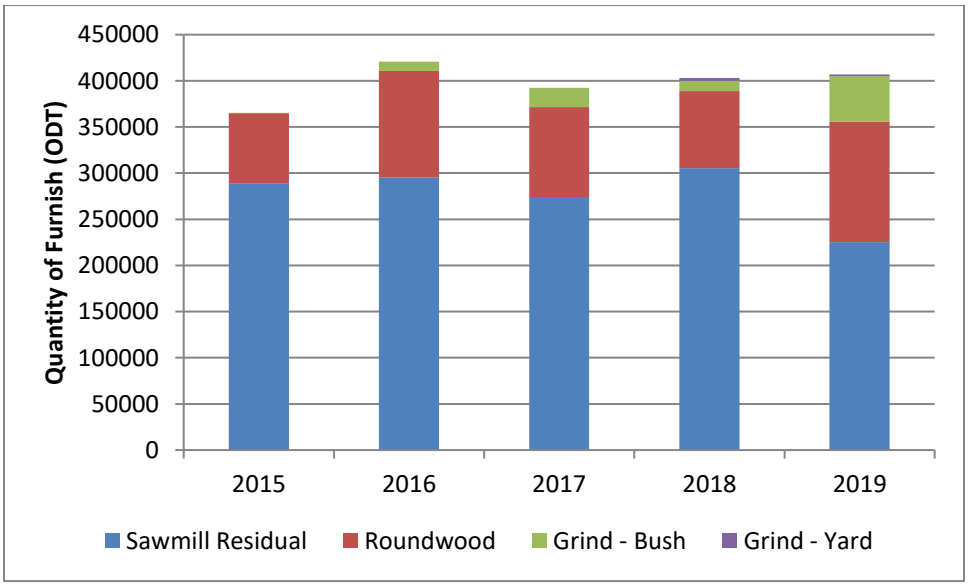


FIGURE 22. WOOD FIBRE FURNISH FOR BURNS LAKE PELLET PLANT, BY TYPE.

	2015		2016		2017		2018		2019		Total	
	ODT	%	ODT	%	ODT	%	ODT	%	ODT	%	ODT	%
Sawmill Res	289,221	79	295,178	70	274,162	70	305,405	76	225,148	55	1,389,115	70
Roundwood	75,809	21	115,440	27	97,251	25	83,641	21	130,637	32	502,778	25
Grind -Bush	355	0	10,032	2	20,911	5	10,918	3	49,216	12	91,453	5
Grind - Yard	0	0	0	0	0	0	3,133	1	1,769	0	4,901	0
Sum	365,385		420,650		392,324		403,097		406,770		1,988,247	

TABLE 14. WOOD FIBRE FURNISH FOR BURNS LAKE MILL, BY TYPE.

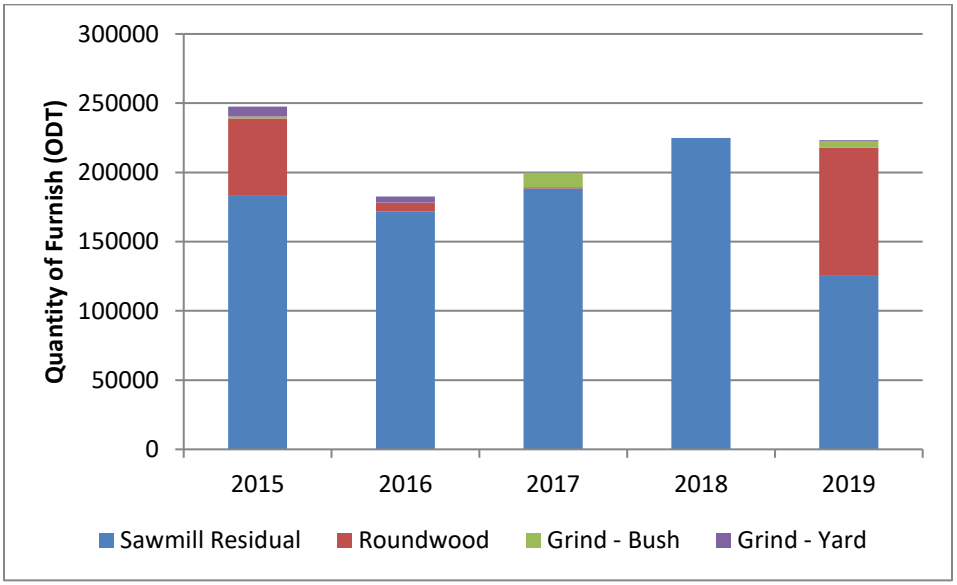


FIGURE 23. WOOD FIBRE FURNISH FOR HOUSTON PELLET PLANT, BY TYPE.

There is an abundant supply of sawmill residuals and low-grade wood such that the pellet mills do not compete with other facilities. Local loggers and forest managers informed the consultants that Pinnacle pays the lowest prices for timber of all catchment area mills, which is evidence of lack of competition. To date, Pinnacle has not taken the additional step of conducting its own logging operations – all of the fibre that it has purchased has been a by-product of traditional harvesting in the catchment area for either saw or cant mills.

	2015		2016		2017		2018		2019		Total	
	ODT	%	ODT	%	ODT	%	ODT	%	ODT	%	ODT	%
Sawmill Res	182,951	74	171,878	94	188,393	94	224,891	100	125,190	56	893,303	83
Roundwood	56,117	23	6,411	4	853	0	0	0	92,692	42	156,072	14
Grind -Bush	1,222	0	0	0	10,526	5	0	0	4,535	2	16,283	2
Grind - Yard	7,255	3	4,203	2	0	0	0	0	794	0	12,252	1
Sum	247,545		182,492		199,772		224,891		223,211		1,077,910	

TABLE 15. WOOD FIBRE FURNISH FOR HOUSTON MILL, BY TYPE.

7 Timber and Product Pricing

7.1 Stumpage Prices

Stumpage prices for grade 1 and 2 sawlogs have generally risen in the catchment area since 2010, as shown in Figure 24, unadjusted for inflation. The stumpage rates shown are the amounts paid to the Crown after the deduction of tenure costs associated with cruising, planning, silviculture, roads, etc. (In contrast, stumpage for salvage sawlogs (grade 4) remained at $0.25/m^3 throughout the period.)

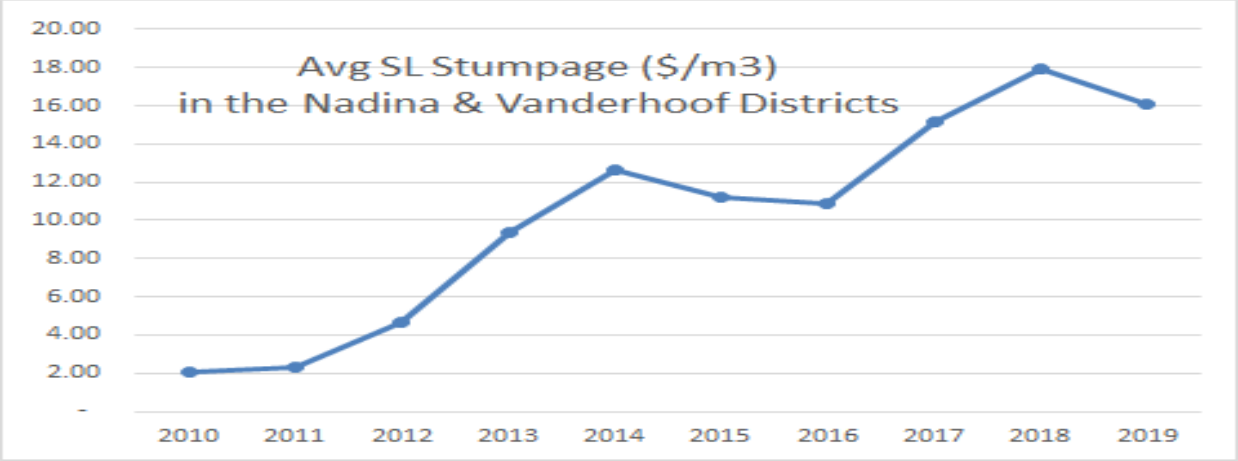


FIGURE 24. AVERAGE GRADE 1 AND 2 SAWLOG STUMPAGE PRICES ($CDN/M3).

The stumpage price increase during the 2010-2014 period can generally be attributed to the recovery in the global economy following the 2008-09 recession, which most severely affected US homebuilding. As the economy recovered, US homebuilding levels and the Asian economy improved, and lumber prices rose (Figure 25). Stumpage prices rose in tandem (Figure 24). In addition, the US dollar notably appreciated against the Canadian dollar from 2014 onwards, adding additional impetus to increases in stumpage prices and Canadian lumber prices.

2018 marked the end of the cyclical rise in lumber prices; the price spiked from US$ 200/m^3[14] in January 2018 to a peak of US$ 279/m^3 in June and ended the year at US$ 139/m^3. Thus, the average price for 2018 masks considerable volatility throughout the year. From March to May 2020, the worldwide closures of national economies sent lumber prices lower, only to reverse in May and reach record highs above US$ 400/m^{3}for western 2x4'sin September.

[14] Prices converted from fbm to cubic metre basis using a 2.36 conversion factor.

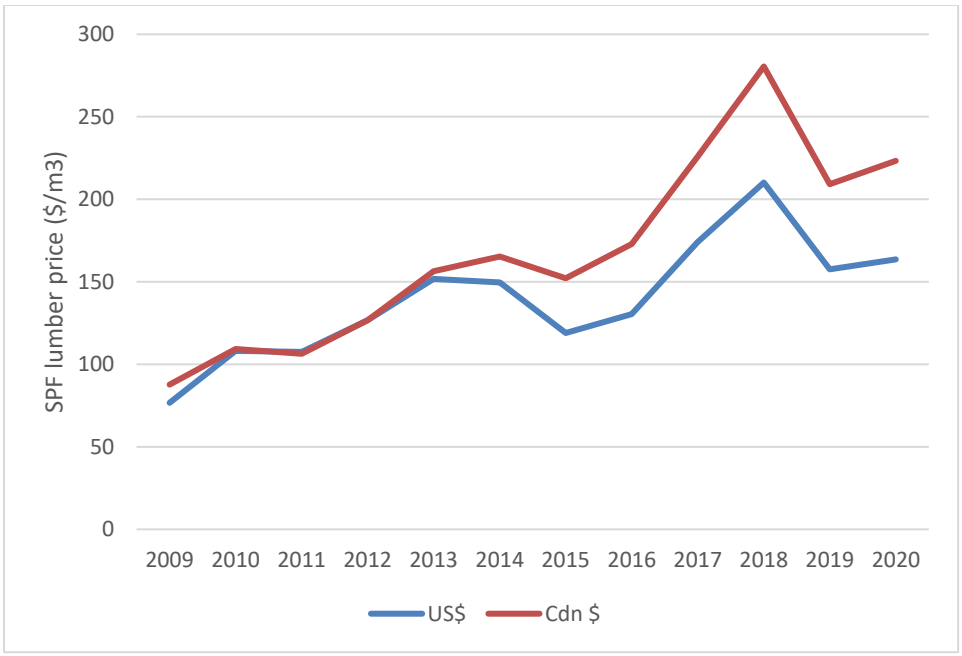


FIGURE 25. AVERAGE ANNUAL PRICES OF 2X4 RANDOM LENGTHS KILN-DRIED #2 OR BETTER SPF.

A contributing factor to the rise in stumpage is that sawmills in BC increased capacity to use the MPB salvage, and as the availability of salvage timber decreased, mills looking to replace the salvage put upward pressure on sawlog stumpage rates through higher bid prices for BCTS sales.

The presence of BCTS and the licensing arrangements in BC make it almost impossible for any company or mill to corner the market for timber. Because licensees are all allocated a portion of the volume-based harvest, and the holders of area-based tenure have control over how they dispose of timber, there are too many players that control some part of the market to enable any one player to develop any degree of market power. The harvest contractors who hold licences and are free to sell their timber as they see fit also play a role in keeping markets balanced – no contractor wants to alienate a purchaser and so they would be reluctant to shift too much of their harvest to any one buyer.

There is no evidence that the rising stumpage prices were driven by the pellet industry. As one very experienced industry consultant noted: "In the Interior, the scarcity of timber supply (a legacy impact of the mountain pine beetle and wildfires) is having a strong influence on stumpage, driving up timber sale bids and stumpage rates." He concluded that the "Interior stumpage rate has fluctuated based on the interplay of lumber prices and high bids" (Grieg 2019). Given the abundance of sawmill residuals and low-grade timber, the pellet mills have not bid on Crown timber since they would always be the lowest bidders on any timber sale.

7.2 Sawmill Residue, Pulp Chip, and Pellet Prices

Sawmill residue is an important component of the feedstock used by pulp mills and pellet mills. The chip component of the residues is trucked to Prince George, where the nearest pulp mills to the catchment area are located. The pellet mills, on the other hand can co-locate with sawmills, at a much lower capital outlay. They take sawdust, planer shavings, and other low-grade residual fibre. In addition, pellet facilities can use forest residues and very low-grade logs salvaged from fires and insect outbreaks.

Figure 26 shows average pellet delivered feedstock prices in the US and Canada. Since most of Canadian pellet production occurs in BC, the Canada index will be generally reflective of the prices of sawdust and shavings in BC. The delivered cost of pellet feedstock was stable at US$55/ODMT until early 2018, when it began rising to reach US$70/ODMT in 2020.

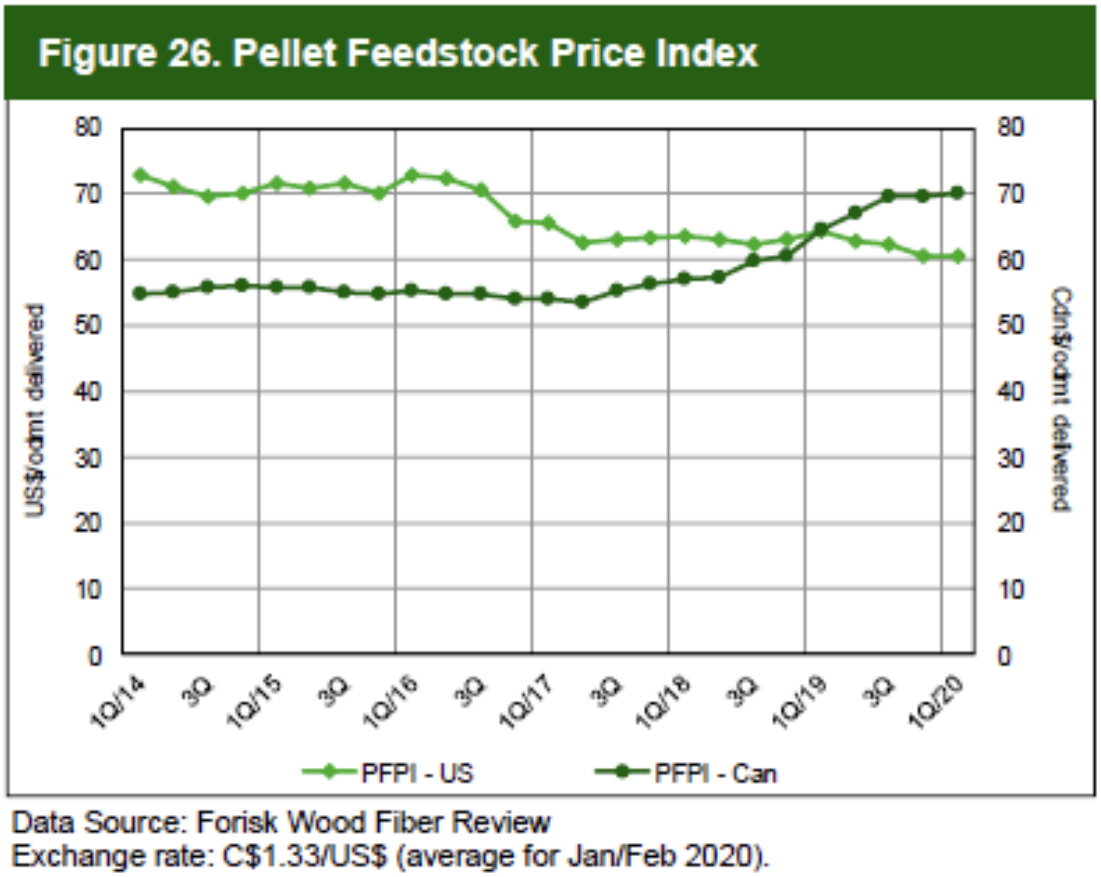
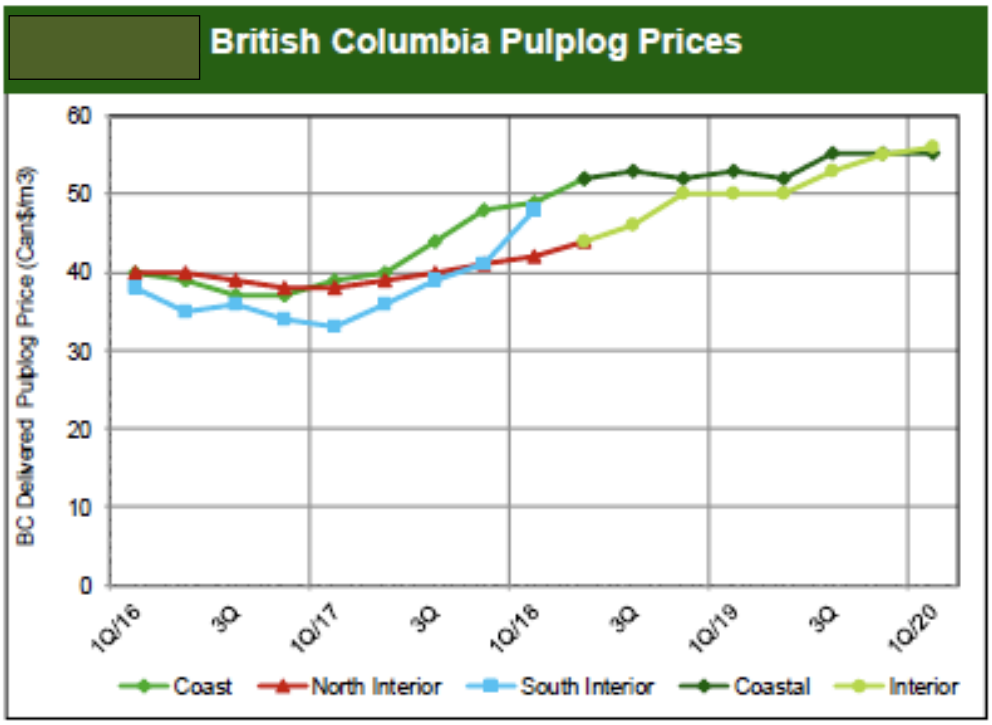


FIGURE 26. PELLET FEEDSTOCK PRICE INDEX FOR CANADA AND THE US.

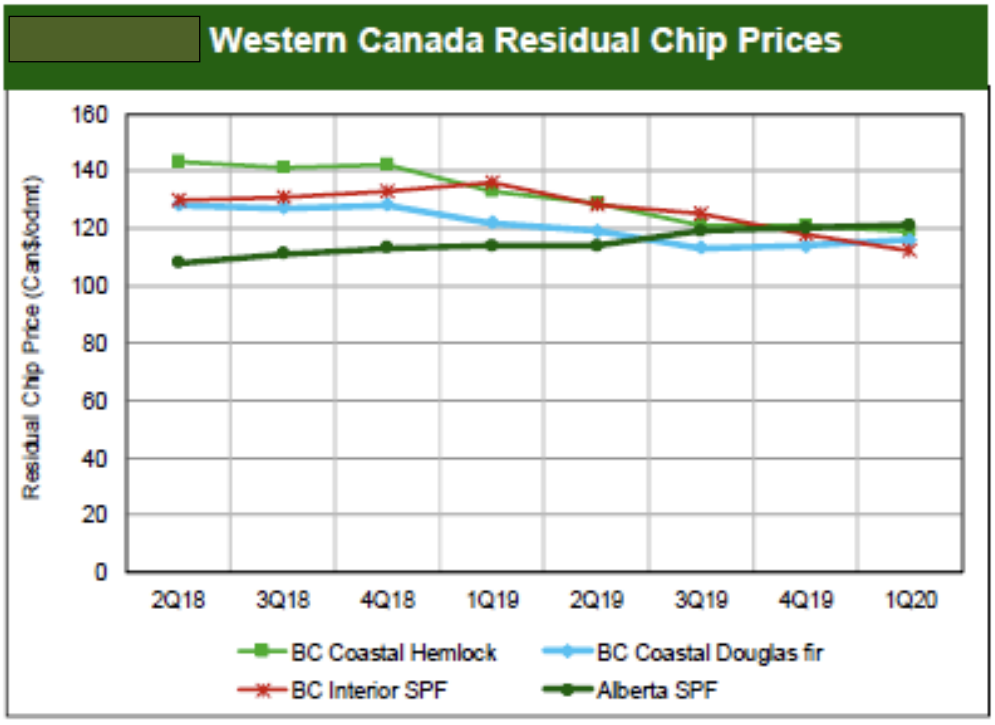
A report in Canadian Biomass[15] attributed the rising feedstock price to a reduction in sawmill residuals due to sawmill closures and curtailments, as the BC industry grappled with the end of the MPB salvage harvesting. After more than two years of increases, the pace of rising fibre costs slowed in Q4 2019, as mills reduced their operating rates and diversified their feedstocks. Many pellet mills are upgrading to allow more flexibility in feedstock inputs to counteract the reduced volume of sawmill residues. Figure 27 shows that BC pulp log prices in the Interior region have followed a similar pattern as pellet feedstock prices – both categories of fibre are low end and are subject to similar supply constraints.

In contrast, the lower panel of Figure 27 shows that residual chip prices have been stable to slightly decreasing, and there is no indication of pricing pressure due to demand from pellet mills because the pellet mills use different components of the fibre supply (i.e. sawdust and shavings).

[15] http://biomassmagazine.com/articles/17003/canadian-wood-fiber-availability-and-impacts



Data Source: Forisk Wood Fiber Review



Data Source: Forisk Wood Fiber Review

FIGURE 27. PRICES FOR PULPLOGS AND RESIDUAL CHIPS IN BC, 2018-2020.

8 Summary of Key Trends and Outlook

8.1 The Forest

The analysis period covers the MPB outbreak which killed hundreds of millions of cubic metres of lodgepole pine throughout the province; the catchment area was the hardest hit part of BC. Not only was the harvest level increased, the effects also included a reduction in the abundance of pine in the forest and a reduction in the average age of the forest.

During the review period, there were additional measures put in place to protect biodiversity and key ecological elements of it, including ungulates and old growth. These measures have resulted in partial withdrawals of land from timber harvest availability – in some areas harvesting is prohibited whereas in others it may proceed on a modified basis. As a result of these measures, the CTHLB has been reduced over time, however the total area of forest has been unaffected. There are indications that further restrictions are in the offing – caribou herds in BC continue to be threatened, and the Premier has appointed a two-person panel to review the management of old growth in the province. The Old Growth panel released its report in September 2020 and has recommended additional protection for old growth timber.

Forestry is a small driver of the deforestation that does occur (15%) due to the building of road networks and landings which are necessary for active forest management. The government requires forest licensees to renew the areas that they harvest, and this is done well. As a result forestry companies cause some deforestation through the construction of access roads, but the extent of it is estimated by the consultants to be on the order of .03-.04 % per annum, and the rate is declining as the forest access network is largely in place. The majority of deforestation on Crown land is due to infrastructure development associated with agriculture, mining, energy, and transportation. Deforestation rates on private land are unknown, however given the low levels of private land in the catchment area, it does not have a material impact on the forest.

8.2 The Industry

The forest sector in the catchment area is based on the production of solid wood products, virtually all of which is lumber. Prior to the arrival of the pellet mills, there was only a small market for sawmill residuals and low-grade wood – these were generally burned at the mill and in the bush, respectively. Thus, the pellet and cant mills have created a market for low value fibre that did not exist previously, and in this way they have supported the existing sawmills, as well as forest contractors and associated businesses.

As a result of the MPB, government and industry combined to enable a massive salvage effort, which completely altered the composition of the timber harvest. Prior to the salvage, the

harvest consisted of live pine and spruce and but from 2002 or 2003 onwards, dead pine became a major part of the harvest stream and averaged 55% during the 2010-2019 period.

Industry's response to the MPB outbreak included boosting sawmill capacity was increased to use salvaged timber. This created an abundant supply of low-cost sawmill residuals which provided Pinnacle with favourable conditions for it to construct the two pellet mills.

In 2019, the MPB-killed wood declined below the sawlog quality threshold, which has led sawmills to close or curtail their production by reducing the number of shifts or taking down time. Across BC, as many as 20 sawmills were expected to close permanently by 2019 and 2020, and the COVID-19 pandemic has put added pressure on the weaker facilities. Sawmill capacity will adjust to balance with the available harvest and residuals will continue to flow to pellet mills, however pellet mills have had to source more fibre from low-grade roundwood and bush grind.

Industry dynamics are not driven by pellet mills since they cannot and do not process sawlogs and their cost structure will not enable them to harvest their own fibre. Pellet mills remain users of the lowest valued fibre and do not compete with pulp mills, cant mills or sawmills for fibre. If anything, the market for residuals provided by pellet mills has provided support for sawmills to continue operations.

The COVID-19 pandemic has created major economic disruptions across the world, and since we are still in the pandemic, and infection rates are worsening in the US as well as countries such as Brazil and Russia, the extent of its impact is far from clear. While losses of employment and GD in Q2 2020 were worse than those in the Great Depression, recovery scenarios range from unrealistically rosy (i.e. a V-shaped recovery) to very pessimistic (the recovery period may take until 2023 or 2024). The 2008-09 recession forced the BC solid wood sector to increase its diversification away from the US, so that China and Japan are the second and third most important markets for the industry, and their relative importance has increased vis-a-vis the US market. This provides ground for optimism that the sector will be able to sustain itself during the next couple of years, now that it has adapted to the post-MPB harvest levels and forest conditions.

ANNEX 1- DEFINING THE CATCHMENT AREA

The consultants were able to delineate the catchment area using wood fibre scaling data. The Burns Lake facility has its own weigh scale run by Pinnacle, and so the company has detailed records of the incoming furnish for its mill. The scale records are linked back to the harvest location through the use of a 'timbermark' and Pinnacle provided the consultants with these data for 2015 to the end of 2019. (A timber mark is a code that identifies the ownership of logs in BC and helps prevent theft of timber from Crown land.)

Pinnacle's current information management system has been in place since 2015, and earlier records were no longer readily available. Pinnacle's management informed the consultants that prior to 2015, sawmill residuals made up an even higher proportion of the furnish for each mill. Our interviews with logging contractors confirmed this is the case.

Table A16 shows the amounts of biomass used by Burns Lake each year by source, and the percentage of total fibre use from each source. (Note that the percentages do not always add to 100% due to rounding.) As one would expect, the primary source area was the Lakes Timber Supply Area (TSA), which is where the mill is located. Vanderhoof District in the Prince George TSA was the other main source, providing almost one third of the fibre used by Pinnacle. There is a high degree of consistency, on an annual basis, in Burns Lake's sourcing. Bulkley TSA, which is a small TSA to the north of the Morice TSA, is a distant third in terms of supply, and the Kispiox TSA, which is located north of the Bulkley TSA, provides a minor contribution. The Other source areas include Kalum TSA (located west of the Morice and Bulkley TSAs) and the province of Alberta.

Table A17shows the source locations of the fibre entering Pinnacle's Houston mill. It is weighed at one of two scales owned by other companies, under an arrangement with Pinnacle. These data were obtained from Pinnacle and compiled by the consultants. For this mill, the home TSA, Morice, provides the majority of fibre used by the mill, with a minor contribution from Bulkley.

Table A18 shows the sourcing of fibre for the two Pinnacle mills combined – 90% of the sourcing comes from Lakes, Morice and Vanderhoof, and hence these three areas were identified as the catchment area for these two pellet mills. Figure 28 shows the catchment area in the regional context.

	2015 ODTs	%	2016 ODTs	%	2017 ODTs	%	2018 ODTs	%	2019 ODTs	%	Total ODTs	Total %
Lakes	204,396	56%	197,476	47%	220,423	56%	201,925	50%	246,384	61%	1,070,605	54%
Vanderhoof	104,151	29%	165,211	39%	108,336	28%	120,511	30%	109,073	27%	607,282	31%
Morice	391	0%	3,958	1%	10,272	3%	12,841	3%	19,316	5%	46,778	2%
Bulkley	39,890	11%	21,050	5%	37,319	10%	47,816	12%	2,742	1%	148,816	7%
Kispiox	5,748	2%	15,694	4%	7,266	2%	9,993	2%	10,782	3%	49,485	2%
Other	10,808	3%	17,261	4%	8,708	2%	10,011	2%	18,473	5%	65,261	3%
SUM	**365,384**	**100%**	**420,650**	**100%**	**392,324**	**100%**	**403,097**	**100%**	**406,770**	**100%**	**1,988,227**	**100%**

TABLE A16. SOURCES OF BURNS LAKE FACILITY FIBRE

	2015 ODTs	%	2016 ODTs	%	2017 ODTs	%	2018 ODTs	%	2019 ODTs	%	Total ODTs	Total %
Lakes	541	0%	91	0%	0	0%	0	0%	1,558	1%	2,190	0%
Vanderhoof	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Morice	233,293	94%	178,393	98%	185,097	93%	207,772	92%	221,008	99%	1,025,564	95%
Bulkley	8,547	3%	2,147	1%	10,714	5%	16,253	7%	475	0%	38,136	4%
Kispiox	4,496	2%	772	0%	1,709	1%	0	0%	0	0%	6,977	1%
Other	668	0%	1,089	1%	2,251	1%	867	0%	169	0%	5,044	0%
SUM	**247,545**	**100%**	**182,492**	**100%**	**199,771**	**100%**	**224,892**	**100%**	**223,210**	**100%**	**1,077,911**	**100%**

TABLE A17. SOURCES OF HOUSTON FACILITY FIBRE.

	2015 ODTs	%	2016 ODTs	%	2017 ODTs	%	2018 ODTs	%	2019 ODTs	%	Total ODTs	Total %
Lakes	204,937	33%	197,567	33%	220,423	37%	201,925	32%	247,942	39%	1,072,795	35%
Vanderhoof	104,151	17%	165,211	27%	108,336	18%	120,511	19%	109,073	17%	607,282	20%
Morice	233,684	38%	182,351	30%	195,369	33%	220,613	35%	240,324	38%	1,072,342	35%
Bulkley	48,437	8%	23,197	4%	48,033	8%	64,069	10%	3,217	1%	186,952	6%
Kispiox	10,244	2%	16,466	3%	8,975	2%	9,993	2%	10,782	2%	56,462	2%
Other	11,476	2%	18,350	3%	10,959	2%	10,878	2%	18,642	3%	70,305	2%
SUM	**612,929**	**100%**	**603,142**	**100%**	**592,095**	**100%**	**627,989**	**100%**	**629,980**	**100%**	**3,066,138**	**100%**

TABLE A18. SOURCES OF FIBRE FOR HOUSTON AND BURNS LAKE FACILITIES, COMBINED.

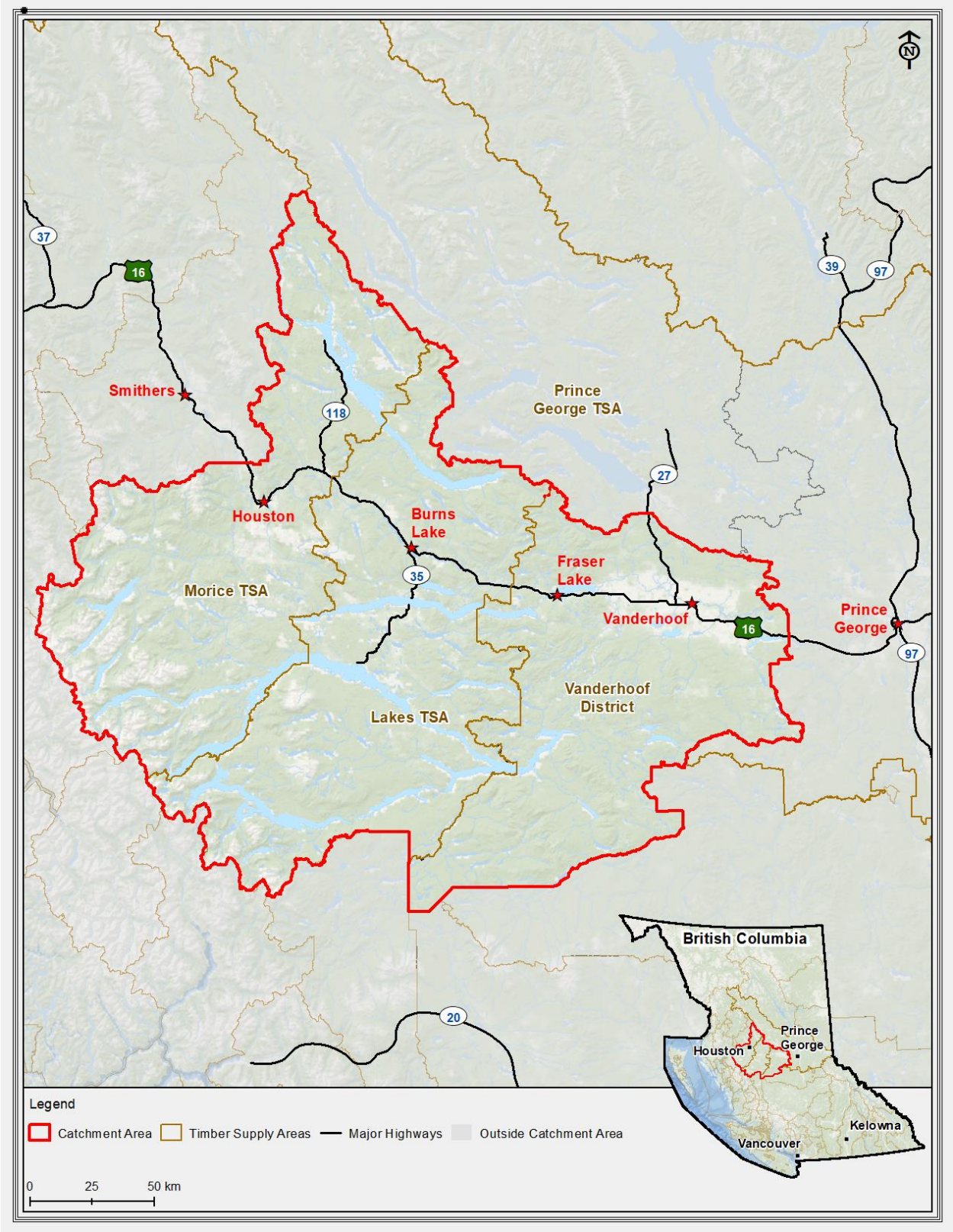


FIGURE 28. THE LAKES AND MORICE TSAS AND THE VANDERHOOF DISTRICT OF THE PRINCE GEORGE TSA.