Forest Management Plan

Daiya-Mattess Keyoh

April 2011

Produced by:

The *Daiya-Mattess* Forest Group

Forestry 424: Sustainable
Forest Management

Executive Summary

Planning for Future Generations

This management plan was created to help Ken Sam and his family manage and restore the *Daiya-Mattess Keyoh*. The *keyoh*, located east of Fort St. James, has been part of Canfor's operating tenure for over three decades and during this time much of the area has been harvested against the wishes of the Sam family. After a site visit and consultation with Ken and his family it was determined that the immediate priority objectives for the *keyoh* were to protect the aquatic ecosystems, restore the wildlife habitat and protect culturally significant areas. To meet these objectives, a range of scenarios was produced, using the latest land use planning decision support tools, to describe management options for Ken and his family to consider.

Through analysis, it was demonstrate that the land management objectives could be met with a restoration management strategy that includes the partial deactivation of roads, the replanting of non-satisfactorily restocked blocks and a unique future timber harvest zoning. Methods to fund this management plan include carbon analysis, harvesting scenarios and external funding.

It was concluded that the expanded harvest zone is the best option to pursue. Having the largest area available to harvest, it would generate a good source of revenue and maintain habitat for species requiring early seral stages. By choosing the expanded harvest zone, culturally significant areas and water quality would be protected through the application of buffers.

Disclosure Agreement

This project was created as part of a University of British Columbia Faculty of Forestry course, FRST 424, and that all content and work associated with this project is confidential.

The research and analysis of this project was conducted for training and educational purposes and further validation would have to be undertaken to support the analysis and results.

"In order to practice conservation, members of my family move around the keyoh. We concentrate our actions in different areas according to season, using the entire keyoh. Our actions may involve hunting, fishing, gathering of food, and trapping. Movement around the keyoh for resource gathering allows areas to rest and recover from over usage. We would trap with our neighbours in times of intensive fur trading, and let entire keyohs rest. Trapping on any one keyoh would allow the animals a chance to regenerate. This is important to maintain the natural balance. According to our legends and transgressions, if you take too much, bad things will happen."

- JIM MUNROE, ON BEHALF OF KEN SAM, 2011

Acknowledgements

We would like to thank Ken Sam, Jim Munroe, and their families for sharing their knowledge and traditional values about their *keyohs.* Without their help, this management plan would not have been able to represent them as we feel it now does.

We would also like to thank John Nelson and Gary Bull for their help and hours spent towards the creation of this plan, as well as the anonymous donor who sent us to Fort St. James to meet Ken Sam and see the *Daiya-Mattess Keyoh*.

Figure 1: Ken Sam (right) with his family and fellow *keyoh* holders

Table of Contents

1.0 Introduction

The *Daiya-Mattess Keyoh* is located approximately 40 kilometers (km) east of Fort St. James (Figure 2). The *keyoh* has been rich in timber in the past, but has been affected by the mountain pine beetle. This forest management plan outlines measures to restore the forest, enabling it to provide wildlife habitat for culturally important animals.

The objectives for the *keyoh* were to protect the aquatic ecosystems, restore the wildlife habitat and protect culturally significant areas. This plan evaluates the habitat needs of specific animals and ensures ecosystem processes are fully functioning by examining several criteria and their respective indicators.

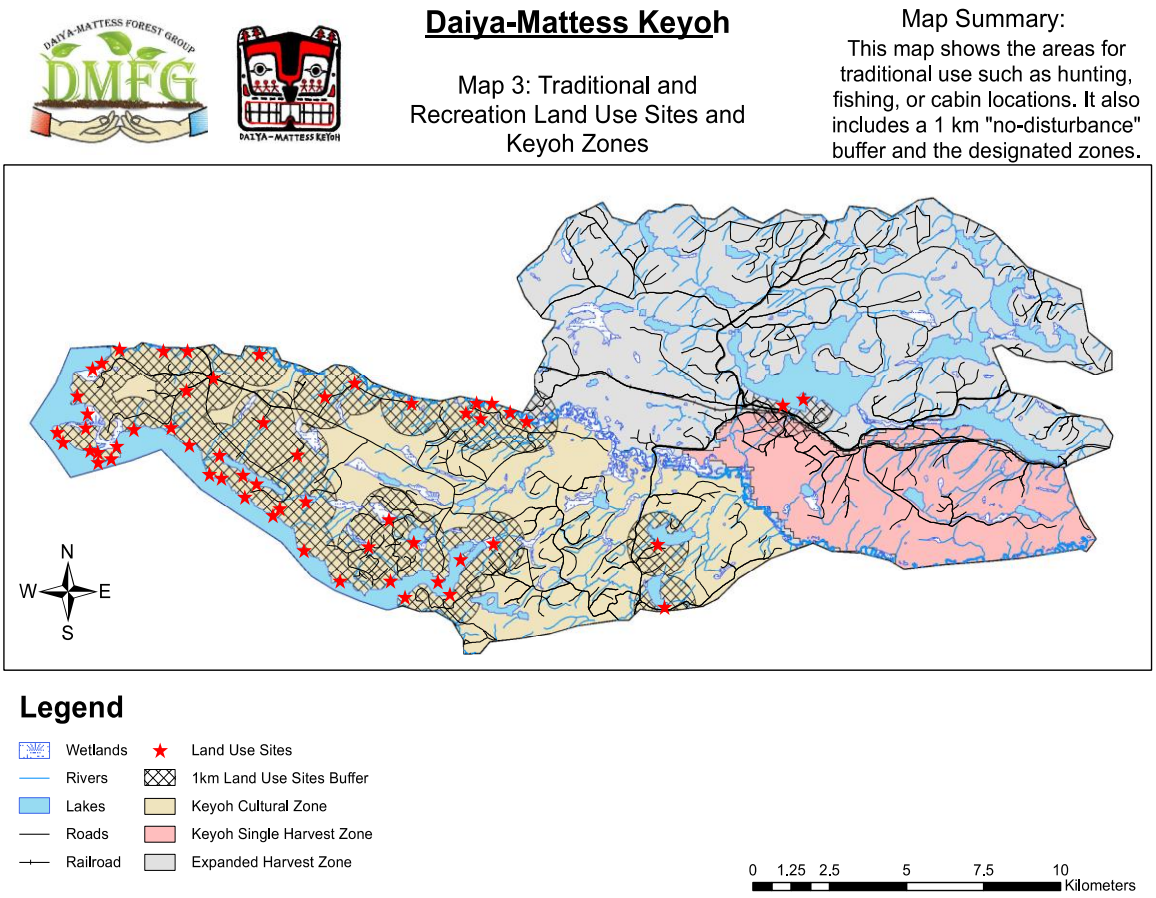


Figure 2: The *Daiya-Mattess Keyoh* is located along the south-eastern side of Great Beaver Lake, to the west of Bugle Lake.

For the *Daiya-Mattess Keyoh*, a structure similar to the provincial Timber Harvest Land Base was used for the determination of available land to harvest. Using ArcGIS tools we deducted areas that were protected, unproductive, inoperable, or uneconomical. With the areas we determined that were harvestable in each scenario we were able to compare with the land available if left to the provincial determination.

This document is meant to provide guidance and information for the future management of the *Daiya-Mattess Keyoh.* Background, socio-economics and ecological information have been given to better understand the landbase within the *keyoh.* The document goes further to describe the methodology behind the criteria and indicators, and how they were applied to the modelling scenarios. Lastly, this management plan gives examples of some potential scenarios and conclusions for the Ken Sam family, before leading into a business plan proposal.

1.1 Cultural Background

1.11 Keyoh and Dakelh People

Keyohs[1][2]

Keyohs are defined as "territory" and can be used interchangeably with "trapline." *Keyohs* are the traditional territories of *Dakelh* people. The area surrounding Stuart Lake is divided into *keyohs* which each belongs to an extended family. As stated in *Dakelh* law, this title is not "granted, delegated or derived from an Indian Band or some other authority." The families have title to the *keyohs* and the land is passed down each generation to a successor, which is customarily the first male child. In the case of several sons, the *keyoh* was used jointly between them. If the *keyoh* holder had no sons, the land was given to the nearest relative in the male line. A chief with no relatives was allowed to choose whomever he wanted. The leader of a *keyoh* is known as "*Keyoh* Holder" or "*Keyohoduchun*." The *keyoh* holder's duties include managing the hunting, fishing, trapping and gathering in his *keyoh*. While aboriginal rights and title have not been ceded, *keyoh* holders understand they have title. There is high respect and regard for other *keyohs* and their territories. This was imperative to ensure a strong social network including trade relations between families and loyal allies in time of war. There were exclusive hunting rights on each *keyoh*. One could not hunt or trap on another's *keyoh* without explicit permission, although game could be pursued across boundaries. The *keyoh* holders decided how many beavers were to be trapped annually, which colonies to target and which part of the trapline to use. The *keyoh* and its holder are the traditional basic political and economic unit of the Stuart Lake Carrier.

Dakelh[3]

Dakelh are a group of Carrier First Nations. The name *Dakelh* was given by the *Sekani*, a neighboring First Nations tribe. The *Dakelh* are situated near Fort St. James and are divided into four clans each containing a number of extended families. Traditionally, the *Dakelh* were the most active during the summer when they collected berries and fished for salmon. The main staple of their economy was fish, primarily salmon, which was preserved through smoking. Hunting was also common to provide food from meat, fur for clothes and bone for tools. Surprisingly, plants played a relatively minor role as food aside from berries[4].

---

[1] Keyoh Huwunline. (n.d.). Retrieved Feburary 5, 2011, from http://www.keyoh.net/respect_and_responsibility.html

[2] Dewhirst, J. (2009). *The Historical and Cultural Contexts of The Central Carrier Keyoh, a Family Ancestral Territory, With Reference to The Maiyoo Keyoh at Great Beaver Lake, B.C.* Retrieved Feburary 5, 2011, from https://sites.google.com/site/keyohforestgroup/home/untitledpost/MAIYOOKEYOHABORIGINALINTERESTSREPORT.pdf

[3] Dakelh. (n.d.). In *Wikipedia*. Retrieved Feburary 5, 2011, from http://en.wikipedia.org/wiki/Dakelh

[4] ibid

1.12 *Daiya-Mattess* Family Background

The following is a summary of a history of the *Daiya-Mattess Keyoh* based on dialogue with the *Daiya-Mattess Keyoh* holder Ken Sam and *Maiyoo Keyoh Society* President Jim Munroe. Past management and values of *Daiya-Mattess Keyoh* holder Ken Sam are explained.

Historical Ownership[5]

The *Daiya-Mattess Keyoh* was originally part of another larger *keyoh* held by Daiya. When Daiya passed away around 1900, he divided his *keyoh* in two and gave half the land to his nephew, Louis Mattess (Figure 3). Louis Mattess named the *keyoh* the *Daiya-Mattess Keyoh.* Louis Mattess passed the *keyoh* on to his son, Isadore Louis (Figure 4), who passed it on to Ken Sam who is the current *keyoh* holder.

Figure 3: This is a selection of a large map from Julian Steward's notes[6]. This selection displays hand-drawn boundaries for the keyohs in the Great Beaver Lake area. The Daiya Keyoh (Daiya II) was divided in two, with one half given to Daiya's friend (g' on the map) and the other half given to Daiya's nephew (g'' on the map). The boundaries today remain very similar to those seen on the map.

Past Management

In the past, the *Daiya-Mattess Keyoh* has been used for fishing, hunting and trapping. The only traditional historical logging on the land was restricted to the trees felled to build dugout canoes and deadfall traps, or similar other uses, on the *keyoh*.

[5] Steward, J. (1940). Miscellaneous Notes. 36. National Anthropological Archives Smithsonian Institution.
[6] Steward, J. (1940). Miscellaneous Notes. National Anthropological Archives Smithsonian Institution.

Family Values

Land stewardship is of the utmost importance to Ken Sam. Water quality, wildlife habitat and ecological health are all important components of land stewardship. The aforementioned values are key values that Ken Sam has emphasized for protection, rehabilitation and maintenance.

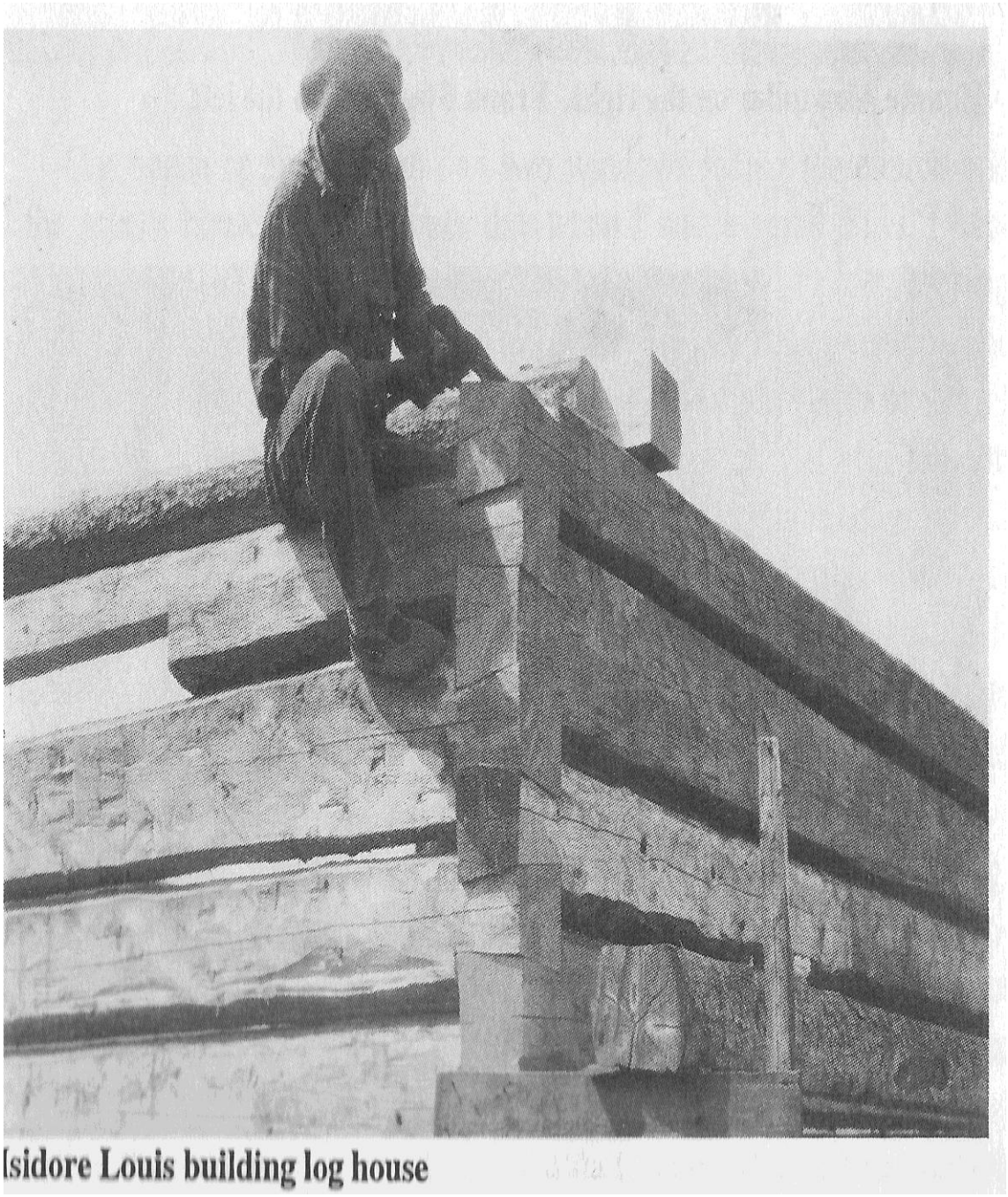


Figure 4: Isidore Louis Mattess was born in 1893. He raised the current *Daiya-Mattess* Keyoh holder Ken Sam.

1.2 Socio-Economics

3.1 The Fort St. James Region

Fort St James, a town located 152km North of Prince George, British Columbia, is home to a small population of people, including several First Nations bands, and a wide array of wildlife. Forestry is currently responsible for 46% of basic employment, and provides over 39% of the basic Incomes throughout the Fort St. James Forest District[7]. This has a potential to change however as a mine is being built in the adjacent forest district of Mackenzie, which should lead to big economic developments for Fort St. James.

The forest sector plays a crucial role in the economics of the community of Fort St. James as well as the Forest District. Pre-Mountain Pine Beetle, the region was developing at a quick rate but then was hit hard by the pest infestation simultaneously with the market downturn. Services and industries faced challenging conditions but seem to have made it through the toughest times and are anticipating a quick recovery.

Demographics and Employment of Fort St. James[8]

Fort St. James is among the larger communities located within the Prince George Timber Supply Area (TSA) with a population of over 4700. The Fort St. James Forest District has 5% of the TSA's population, of which 44% lives within the community of Fort St. James. During the time from 1996 to 2000, the population of Fort St. James did not increase, it actually decreased by 0.2%, and the Forest District population decreased by 0.8%. Fort St. James is very dependent on logging and forestry activities for it's economy, 54% of the communities' employment is made up of logging, forestry, and forest product manufacturing. Since 1996, the Forest District saw an increase of 14% in the labour force, while at the same time having an unemployment rate of 16%. During the 6 years following 1990, the employment in logging and forestry services sub sector increased by about 43% where as the Prince George Forest District only grew by 2% in that same time. Since 1996, there has been a decrease in Fort St. James forest products manufacturing sector. In comparison to Forestry and related serviced in the Forest District, travel and public services employed only 33%. Fort St. James also received an employment multiplier of 1.28-1.36 during 1996. This number means for every 100 full-time forestry related jobs, 28-36 indirect or induced jobs are created or needed.

[7] Ministry of Forests and Range. (2011). *Fort St. James Forest District*. Retrieved January 23, 2011, from Welcome to Fort St. James: http://www.for.gov.bc.ca/DJA/OldFiles/page2.htm

[8] Ministry of Forests. (2001). *Prince George Timber Supply Analysis Report: Timber Supply Review.* British Columbia, Timber Supply Branch.

Industry Involvement in the Fort St. James Forest District

In 2000 there were about 30 solid-wood mills throughout the TSA, during the downturn, several mills underwent temporary shutdown, now in 2011 there are 28 mills operating again which consume approximately 11 million m^3 of wood. It is forecasted that cycle times for wood loads will exceed 7 hours because of decrease in the timber supply and harvesting lower volume stands further than 1.5km from existing roads will increase.

Around Fort St. James several large industrial forestry companies are harvesting and milling timber for dimensional lumber, pulp and paper, plywood and OSB, as well as newer technologies like pellets for energy. Some of the larger companies include Canadian Forest Products Ltd. (Canfor), Conifex Timber Inc., Pope & Talbot Ltd., Apollo Forest Products Ltd., among others. The area also provides services to several different logging contractor operations.

Fort St. James Forest District AAC Timber Supply[9]

For the Prince George Timber Supply Area (TSA) the chief forester will determine the Allowable Annual Cut (AAC) for specific areas, which is measured, based on a number of factors[10]. The AAC is always determined for a specific Timber Harvest Land Base (THLB), which is defined as the area of productive land available for timber harvesting. Over the last decade, the Allowable Annual Cut has fluctuated from 12.2 million cubic meters to an uplift of 14.9 million m^3; it now sits at 12.5 million m^3 for the Prince George TSA. An example of the THLB for the *Daiya-Mattess Keyoh* can be seen below in Figure 5 and Figure 6.

Figure 5: THLB on the *Daiya-Mattess Keyoh*

[9] Snetsinger, J. (2011). *Prince George Timber Supply Area. Rational for Allowable Annual Cut (AAC) Determination*. British Columbia Ministry of Forests, Mines, and Lands

[10] Ministry of Forests and Range. (2008, November). *Prince George Timber Supply Area Timber Supply Review: Data Package*. Retrieved on March 20, 2011 from: http://www.for.gov.bc.ca/hts/tsa/tsa24/tsr4/24ts08dp.pdf

In Prince George, the THLB was determined to be 5,242,481 ha[11], and the Fort St. James THLB was determined to be 1,344,976 ha[12]. See Appendix 3 (Table 12) for Fort St. James THLB Determination. For the *Daiya-Mattess Keyoh* we only had a few features we could use for reduction in the total area, when we took away lakes, roads, and unproductive areas we were left with 18,322 ha. See Table 1 for the Daiya-Mattes Keyoh THLB Determination. From this land area, most licensees would harvest the pine stands, see Figure 7 Forest Cover by Leading Species, as well as those stands that are pure leading species, see Figure 8 Pure Stands and NSR Blocks. In most cases a harvesting operation would go for those stands that meet the above criteria as well as being in an older age class, see Figure 9 Forest Timber History (Stand Age).

Table 1: *Daiya-Mattess Keyoh THLB Determination*

	Area (ha)
Total Area	28,278
Lakes	3,024
Road and Right of Way	976
Non Commercial (Crown Closure <10%)	5,956
Current Timber Harvesting Landbase	**18,322**

Figure 6: THLB for the *keyoh*

[11] Snetsinger, J. (2011). *Prince George Timber Supply Area. Rational for Allowable Annual Cut (AAC) Determination*. British Columbia Ministry of Forests, Mines, and Lands

[12] Fort St. James Sustainable Forest Management Public Advisory Group, BCTS Stuart-Nechako, Canfor Carrier Lumber, Takla Track & Timber Ltd. (2010). *Fort St. James Sustainable Forest Management Plan*. v3.7

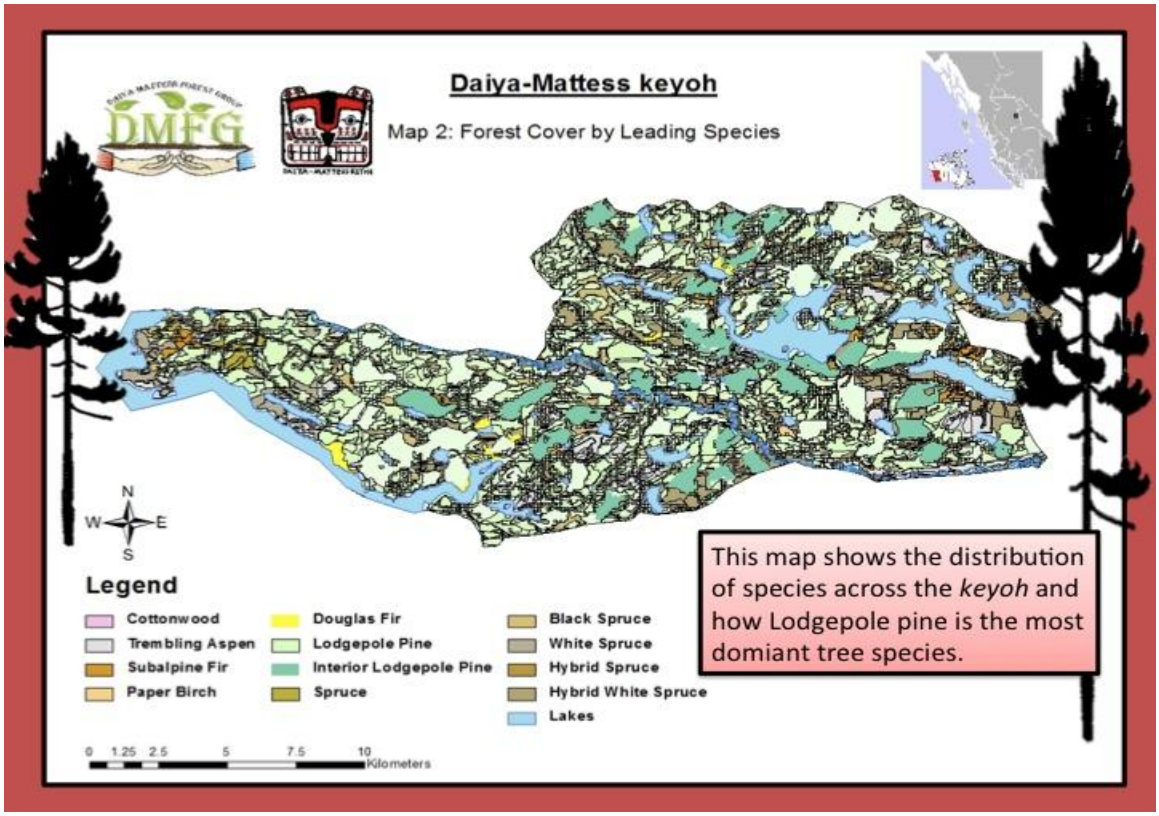


Figure 7: Map showing the Forest Cover by Leading Species

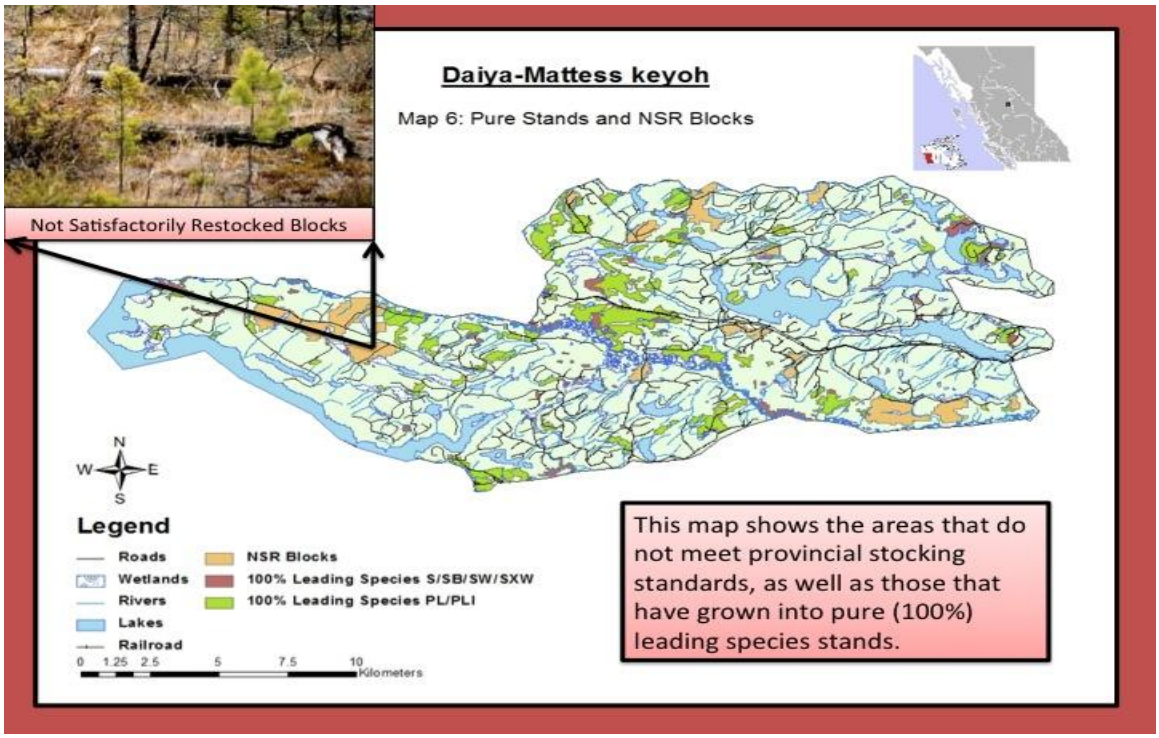


Figure 8: Map Showing Pure Stands and NSR Blocks

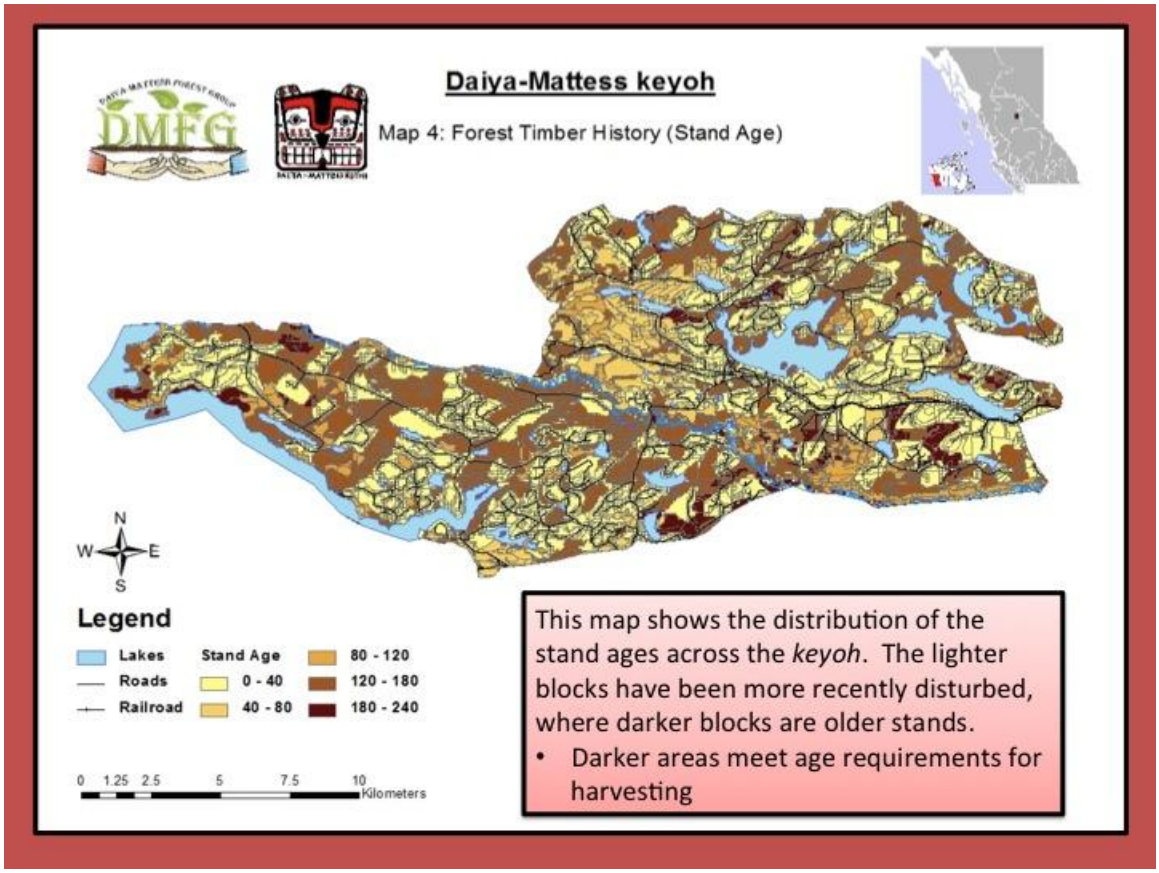


Figure 9: Map Showing the Forest Timber History within the *keyoh* (Stand Age)

1.3 Ecological Background

1.31 Biogeoclimatic Classification of the *Daiya-Mattess* Keyoh

Climate

The entire *Daiya-Mattess Keyoh* falls within the biogeoclimatic zone variant SBSmk1, also known as the mossvale variant. This moist cool variant of the Sub-boreal spruce (SBS) zone is thought to be the most zonal of any the other variant in the SBS with its long snowy winters and moist cool summers. The growing season of these rolling hills is notably short and seasonal temperature extremes are not uncommon (Table 2). The demure topography of the keyoh is dominated by gently rolling hills with low-lying wet areas composed of lakes, swamps, and streams. To the west is the SBSdw3, a drier and warmer variant. To the East is the SBSwk, a variant even moister and cooler than the mk1. The *keyoh* falls within the Fort. St. James Forest District as seen by Figure 12.

Table 2 Summary of climate and location data for the SBSmk1 variant.[13] MAT: Mean annual temperature, MAP: Mean annual precipitation, GSP: Growing season precipitation

	Elevation (m)	MAT (°C)	Frost Free days	MAP (mm)		GSP (mm)
Mean	850	1.5		73	727	273
Range	750-1070	-.2 – 3.3		43 – 92	628 – 838	197 – 432

Vegetation

The following **four site associations** are most commonly found in the SBSmk1 (Figure 10):

- Hybrid spruce – Huckleberry (Figure 11) – Highbush-cranberry (Site Series 01)
  - Mature stands stocked with hybrid white spruce, lodgepole pine and subalpine fir
  - Soils are a mixure of Brunisolic Gray Luvisols, Orthic Humo-Ferric Podzols, Orthic and Eluviated Dystric Brunisols. Hemimors are the most common humus form
  - Shrub layer = black huckleberry, thimbleberry, highbush-cranberry and sitka alder
- Lodgepole pine – Huckleberry – Cladonia
  - Soils are predominantly Orthic Humo-Ferric Podzols and Eluviated Brunisols. Humus forms are thin, crusty Xeromors
  - Lodgepole pine with poorly developed shrub and herb layer
  - Sparse tree regeneration mainly of lodgepole pine, subalpine fir and hybrid spruce
- Hybrid spruce – Oak fern (Site Series 07) (Figure 11)
  - Fresh nutrient poor sites
  - Gleyed soils with various humus forms

[13] Reynolds, G. (1989). *Climatic data summaries for the biogeoclimatic zones of British Columbia*. B.C. Min. For., Research Branch, Victoria, B.C.

- Subalpine fir and hybrid white spruce are the climax tree species
- Well developed herb layer dominated by oak fern

- Hybrid spruce – Devil's club (Site Series 8)
  - Most, nutrient rich sites
  - Large, wide spaced hybrid white spruce and subalpine fir (good growth)
  - Many mosses and a dominant shrub layer

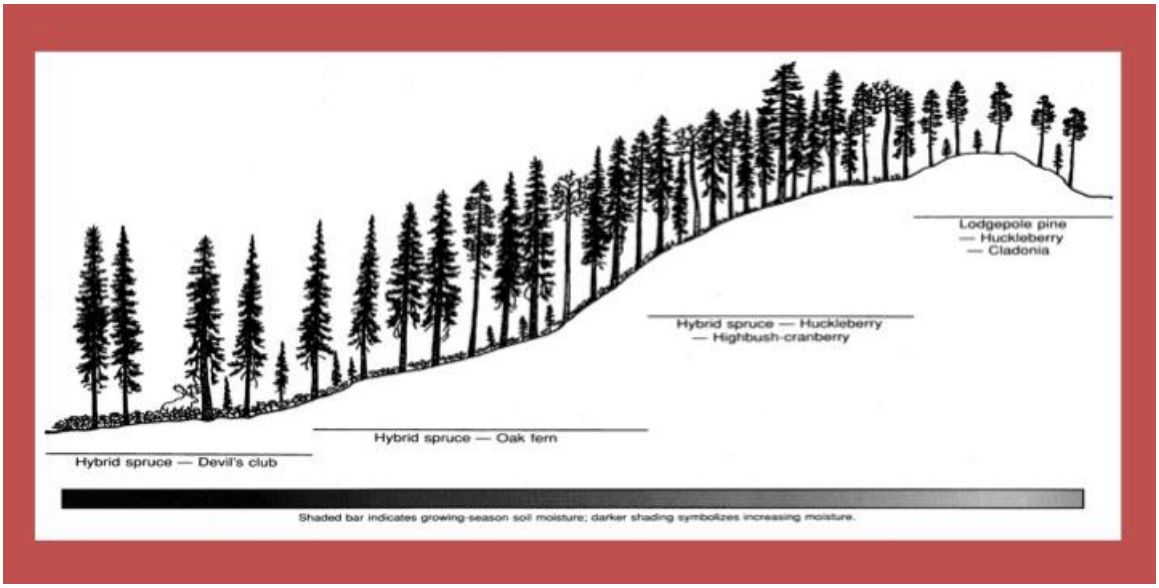


Figure 10: Simplified schematic diagram of topographic relationships among four common site associations of a moist, cool subzone of the Sub-Boreal Spruce moist and cool variant.

Figure 11: Common Vegetation for the SBSmk1 zone. Right: Red Huckleberry (http://www.portlandnursery.com/plants/nativePicks/vaccinium.shtml). Left: Oak Fern (http://bolt.lakeheadu.ca/~borfor/ferns/fern7.htm).

Forest District of the Daiya-Mattess Keyoh

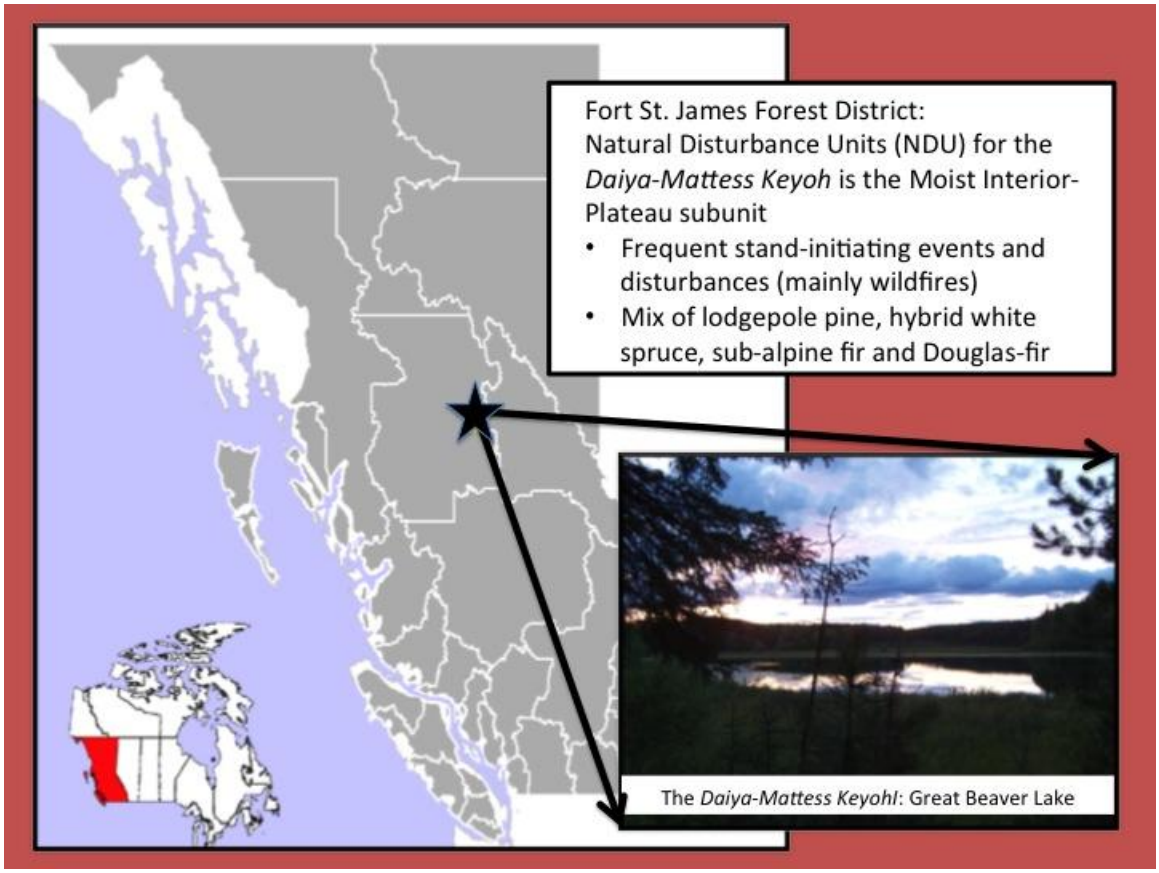


Figure 12: Forest Districts of BC (http://www.ask.com/wiki/Fort_St._James,_British_Columbia)[14][15][16]

1.32 Wildlife

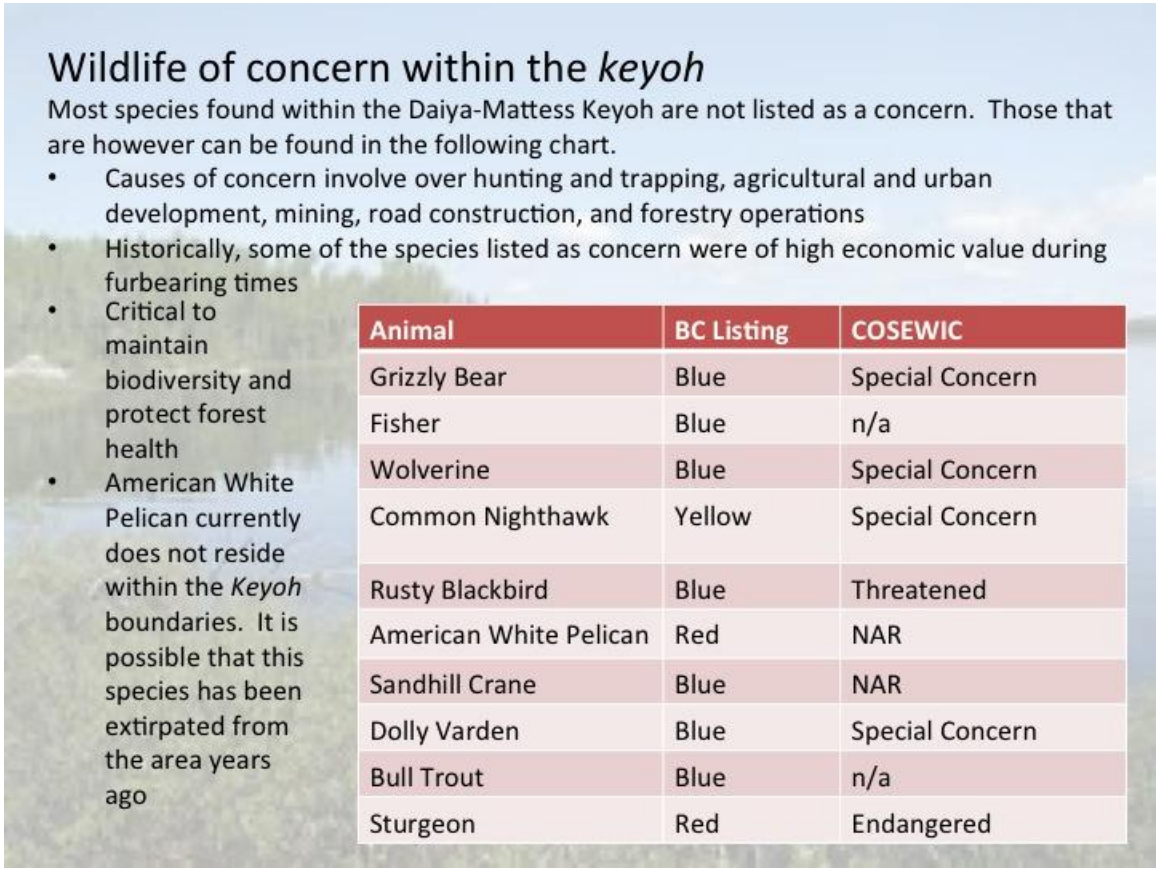
The *Daiya-Mattess Keyoh* is home to a variety of wildlife species including the kokanee salmon, moose, beaver, wolverine, caribou, sandhill crane and the fisher among many others. These species are considered culturally significant to the *Daiya-Mattess* people because they were historically hunted and trapped for recreation and subsistence purposes. Culturally significant wildlife was classified according to the *Maiyoo Keyoh* Land Use and Occupancy map and Julian H. Steward's field notes.

[14] BCTS, Carrier Lumber, CANFOR, FSJ SFMG. (2010). *Fort Saint James Sustainable Forest Management Plan.* Retrieved March 10, 2011, from http://www.carrierlumber.bc.ca/docs/fsj_sfm_plan_v3.7_FINAL_23feb10-web.pdf

[15] Ministry of Forests. (n.d.). *The Distribution of NDT's across British Columbia.* Retrieved March 10, 2011, from http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/fig5.htm

[16] Reynolds, G. (1989). *Climatic data summaries for the biogeoclimatic zones of British Columbia*. B.C. Min. For., Research Branch, Victoria, B.C.

Species of concern within the *keyoh* boundary can be seen below in Figure 13. For a more detailed description of the wide range of wildlife species with the *Daiya-Mattess Keyoh,* please refer to Appendix 1.



Animal	BC Listing	COSEWIC
Grizzly Bear	Blue	Special Concern
Fisher	Blue	n/a
Wolverine	Blue	Special Concern
Common Nighthawk	Yellow	Special Concern
Rusty Blackbird	Blue	Threatened
American White Pelican	Red	NAR
Sandhill Crane	Blue	NAR
Dolly Varden	Blue	Special Concern
Bull Trout	Blue	n/a
Sturgeon	Red	Endangered

Figure 13: Wildlife concerns within the keyoh[17][18]

1.33 Aquatic Ecosystems

Protection of aquatic ecosystems has been expressed as a main concern and objective of Ken Sam and his family. Six species of fish are found within the *Daiya-Mattess Keyoh's* streams, lakes and rivers. A visual example of two of these fish, the Salish sucker and White sturgeon can be seen in Figure 15. The main river and lakes within the *keyoh* are highlighted in the base map diagram below in Figure 14. Table 3 below summarizes the species found within the *keyoh* along with their habitat requirements, potential threats and current status. Current status for these fish species was considered according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), as well as the

[17] COSEWIC. (2011). *Wildlife Species Search.* Accessed April 10, 2011, from http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm

[18] Ministry of Environment. (2011). *BC Species and Ecosystems Explorer.* Accessed April 10, 2011, from http://a100.gov.bc.ca/pub/eswp/

Ministry of Environments provincial red and blue lists. For a more detailed description of the six species of fish, please see Appendix 2.

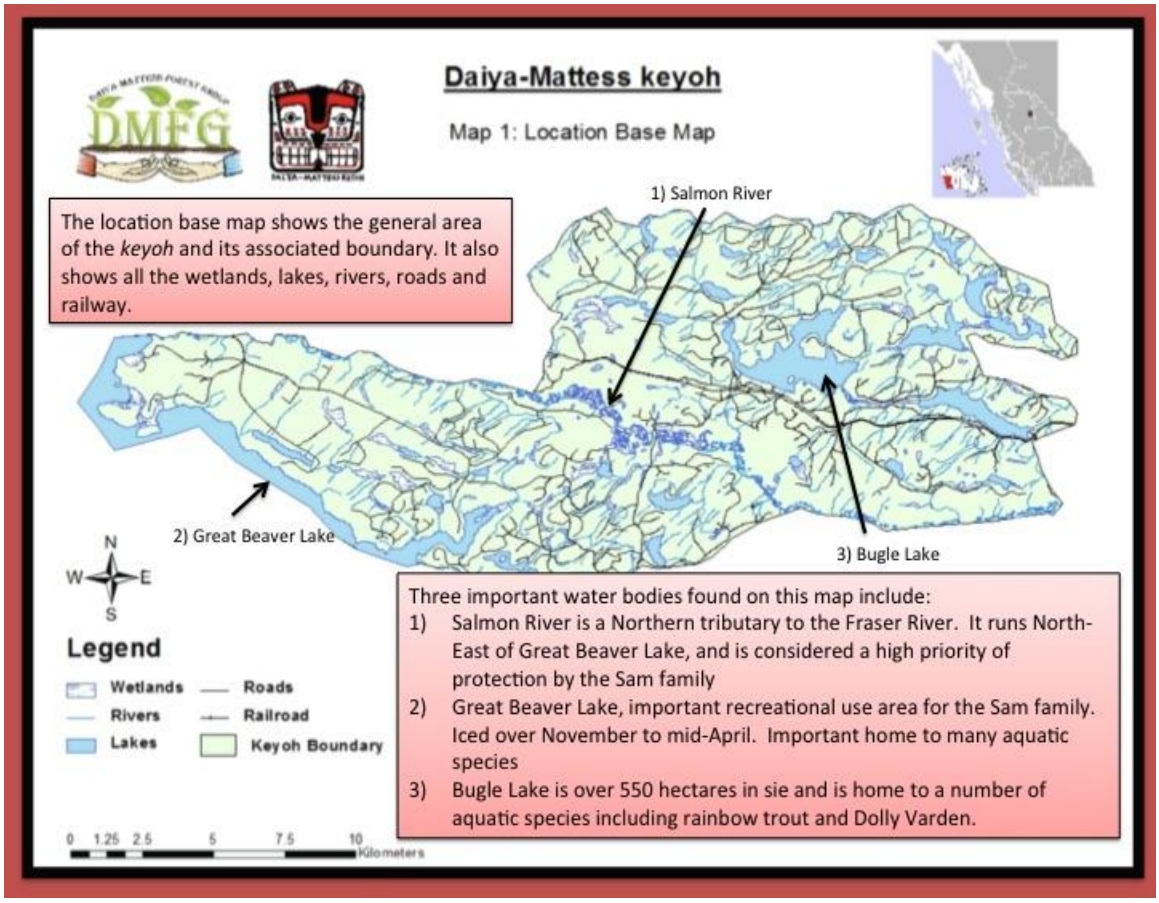


Figure 14: Streams and Lakes within the *Daiya-Mattess Keyoh*

Figure 15: Salish Sucker (http://www.gov.chilliwack.bc.ca/main/page.cfm?id=1579) and White Sturgeon (http://www.stockpix.com/stock/animals/fish/67011.htm)

Table 3: Aquatic Species within the *Daiya-Mattess Keyoh*

Species	Habitat Requirements	Threats	Current Status
Salish Sucker (*Catostomus sp. 4*)[19]	Found in headwaters of streams, or areas of deep pools	Agricultural activity, urbanization and low oxygen levels	COSEWIC: Endangered BC Status: Red Listed
White Sturgeon[20] **(*Acipenser transmontanus pop 3*)**	Large, deep mainstream pools. Estuaries and outreaches are preferred for juveniles	Over fishing and habitat fragmentation	COSEWIC: Endangered BC Status: Red Listed
Dolly Varden[21] **(*Salvelinus malma*)**	Lakes and estuary environments, as well as riparian zones	Forest harvesting, and water quality degradation	BC Status: Blue Listed
Bull Trout[22]	Limited to sensitive river estuaries and small streams	Angling and water quality degradation	BC Status: Blue Listed
Kokanee Salmon (*Oncorhynchus nerka*)[23]	Tributary streams, or shorelines along lakes	Industrial, agricultural and urban development	Not listed
Rainbow Trout (*Oncorhynchus mykiss*)[24]	Cold, clear water with a fast current. Shallow rivers and gravel bottoms	Peak flow timing	Not listed

[19] Pearson, Mike and Healey, M.C. (2011). *Species at Risk and Local Government: a Primer for BC*. Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 7, 2011.

[20] Environment Canada. (2011). *Species at Risk and Local Government: White Sturgeon (Nechako River Population).* Retrieved Feb 6, 2011, from District of Squamish: http://www.speciesatrisk.bc.ca/node/8279

[21] Pearson, Mike and Healey, M.C. (2009). *Species at Risk and Local Government: a Primer for BC.* Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 6, 2011 from: http://www.speciesatrisk.bc.ca/node/8078

[22] Pearson, Mike and Healey, M.C. (2009). *Species at Risk and Local Government: a Primer for BC.* Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 6, 2011 from: http://www.speciesatrisk.bc.ca/node/8163

[23] Ministry of Fisheries. (n.d.). *B.C. Fish Facts.* Retrieved February 7, 2011, from Kokanee : http://www.env.gov.bc.ca/wld/documents/fishfacts/kokanee.pdf

[24] Fisheries and Oceans Canada (2010). *Rainbow Trout.* Retrieved February 7, 2011 from: http://www.dfo-mpo.gc.ca/species-especes/aquatic-aquatique/rainbow-trout-eng.htm

1.34 Threats

CN Railway

The CN Railway currently runs through the centre of the *Daiya-Mattess Keyoh.* With Mount Milligan being built just North of Fort St. James, there is an increased concern by Ken Sam regarding transportation of minerals and chemicals along this line. These concerns can be seen in Figure 16.

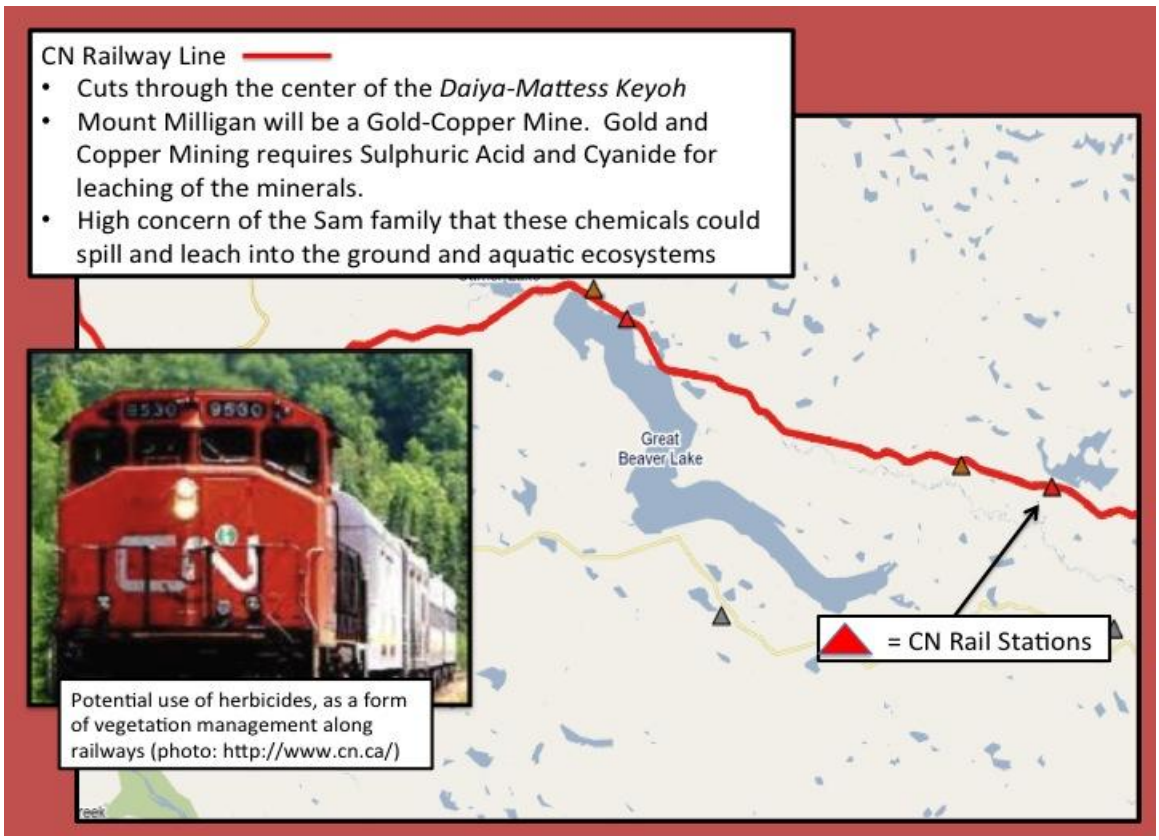


Figure 16: Threat of the CN Railway (http://cnebusiness.geomapguide.ca/?s_icid=home-feature-rght-stations-terminals-map)[25]

Enbridge Pipeline

The Enbridge pipeline will be built to transport petroleum and condensate products between Bruderheim, Alberta (AB) and Kitimat, BC. The proposed route of the pipeline can be seen in Figure 17, along with the concerns of Ken Sam and his family.

Herbicide

As part of Canfor's integrated pest management plan (IPMP), a broad-spectrum non0selective systemic herbicide known as Vision will be sprayed[26]. This herbicide has the

[25] Fisheries and Oceans Canada et. al. (2008). *Comprehensive Study Scoping Document Pursuant to Subsection 21(1) of the Canadian Environmental Assessment Act.* Retrieved on March 15, 2011, from http://www.ceaa.gc.ca/050/documents/29641/29641E.pdf

potential to kill beneficial insects and negatively impact birds or small insect-eating mammals[27]. Due to the negative effects of herbicide use on the landscape and towards wildlife species within the *keyoh,* Ken Sam does not want them used. Thus, they will not be a part of this management plan for regeneration techniques.

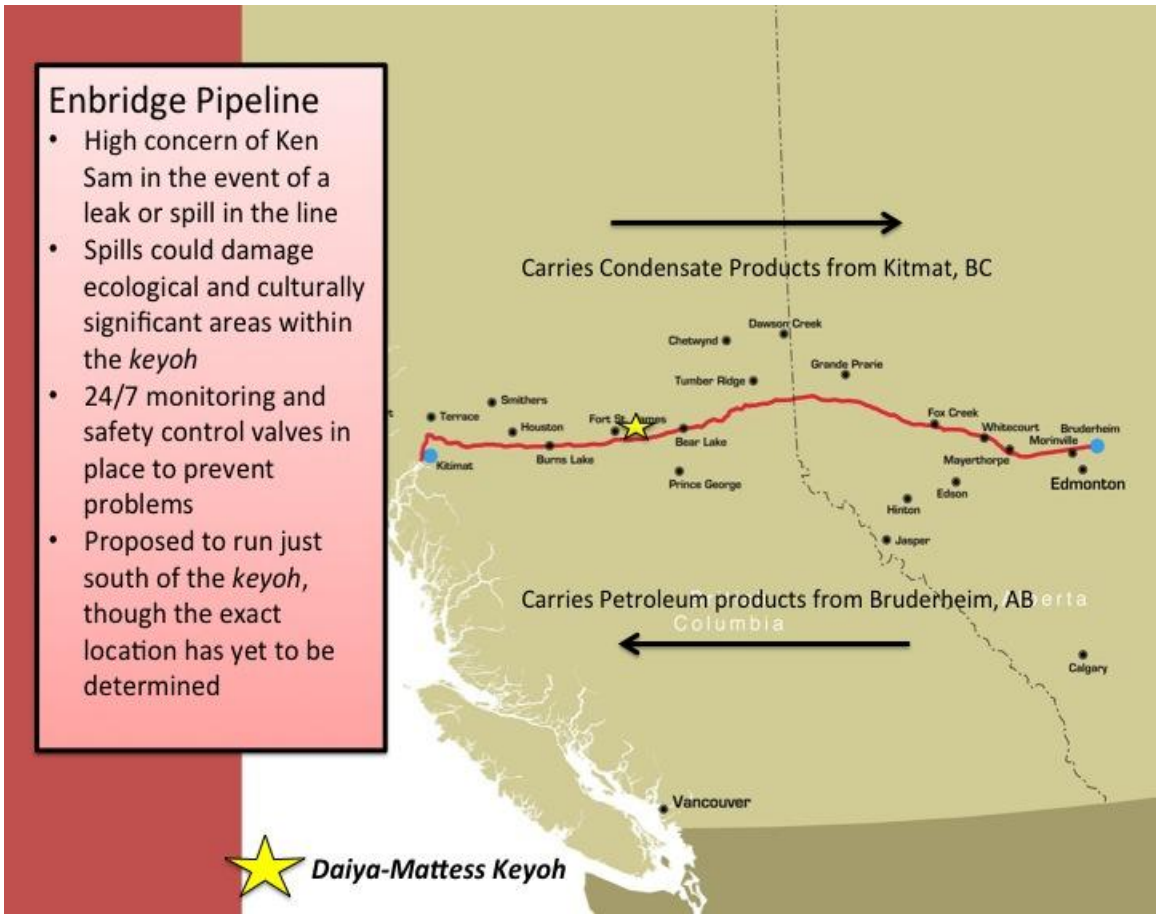


Figure 17: Enbridge Pipeline, location and concerns (http://www.northerngateway.ca/project-info/route-map)[28]

Fire Management

Fire has been considered a natural agent to replace stands for many centuries in BC. Wildfires help to produce healthy, diverse and produce forests and are generally fine left alone unless economical or endangered aspects are threatened or impacted[29]. Like many other places around the province, fire suppression has led to decades of fuel build-up. This has led to an increase in wildfire severity, especially in fire-prone forests, like those within

---

26 [26]Sierra Club Canada. (n.d.). *Pesticide Fact Sheet: Glyphosate.* Retrieved on March 15, 2011, from http://www.sierraclub.ca/national/programs/health-environment/pesticides/glyphosate-fact-sheet.shtml

27 ibid

28 [28] Northern Gateway Pipelines. (2011). *Project Info: Route Map.* Retrieved on March 12, 2011, from http://www.northerngateway.ca/project-info/route-map

[29] Environment Canada. (2010). *Wildland Fire Management Strategy.* Retrieved on March 16, 2011, from http://bcwildfire.ca/Prevention/PrescribedFire/docs/BCWFMS.pdf

the *keyoh*. Management strategies involving biological diversity and natural ecological process often involve maintaining coarse woody debris, wildlife trees and riparian management areas on the landscape. In order to emulate a natural stand replacing within an area of these management strategies, clearcuts of up to 60 hectares may be conducted as per the Ecosystem Based Management guidelines. As well, though expensive, fire reduction treatments such as thinning trees, reducing ladder fuels, and/or wood mastication could also be conducted in the future.

Methods for Fire Management

As part of the management scenarios, culturally significant areas will not be harvested. The risk of fire in this area for the future is considerably high, as no large-scale management practices, like harvesting will be emulated. The total area for the culturally significant zone is 12,546 ha, and includes approximately 171.5km of road. Partial deactivation of roads throughout this culturally significant area will limit access for fire crews in the event of a disturbance. Future fire management in the area could involve thinning roadsides to create artificial breaks in the event of a fire.

Though partial road deactivation is planned for the keyoh on non-essential routes, access for firefighters along mainline roads remains important in the event of a fire.

Ecological Risks

Ecological risks in the Fort St. James forest district can involve a number of things including pests, diseases, extreme weather conditions, and global warming effects. When considering potential pests and diseases within the keyoh, it is important to look at the different types of species that make up the forest. Lodgepole pine, sub-alpine fir, and hybrid spruce make up the majority of the species composition within the keyoh. Lodgepole pine, as seen by recent years, is very susceptible to the Mountain Pine Beetle in its mature form, when environmental conditions are favourable. Sub-alpine fir, which used to be the predominant tree species in the Fort St. James forest district, has succumb to many outbreaks of western balsam bark beetle and spruce budworm, as well as various heart rot diseases.

From a management perspective, creating multi seral stages throughout the keyoh will help to protect the trees from mass infestations to pests and diseases. As well, increasing the biodiversity of the species present within the forest will also help to reduce future risks to health concerns for the keyoh.

With a short growing season and changing conditions due to climate change, favourable summer conditions are key to a species success. Warming temperatures can lead to extended periods of drought, which can be harmful or damage the growth of a species. As well, with warming temperatures due to climate change and global warming, a shift in species throughout the Fort St. James forest district could be seen in the future. Douglas-fir (Fd), a tree species currently sitting on the boundary of its growing limit in the Fort St. James area, could have the ability to adapt and grow more frequently throughout the keyoh if the climate continues to warm.

Effects of Mountain Pine Beetle

The Mountain Pine Beetle (MPB) epidemic, and large scale salvage logging operations have led to potential effects on water yield, peak flows, temperatures and flood timing among other things[30]. A visual example of the MPB and salvage logging practices can be seen in Figure 18. Increase in peak flows can have implications on the channel stability, decreasing potential areas of fish habitat[31]. Significant increases in temperature have been found in the upper Fraser River system of British Columbia throughout all freshwater habitats. In some cases, water temperature increases of 3-6^{0}C were found when compared to historic records, limiting salmon to larger water bodies[32]. For pacific salmon, a temperature increase of 2-3^{0}C is enough to cause mortality to certain species.

Methods for Reducing Site Access

Reducing site access is one of Ken Sam's main objectives for this management plan. As seen by Figure 19, an extensive layout of roads covers the landscape within the *Daiya-Mattess Keyoh.* A forest service road that cuts across the *keyoh* will be left in as a main access route. Four recreational sites within the keyoh boundary are located just off of this forest service road: Tureen Lake recreational reserve, Bugle Lake recreational reserve, Tear Drop Lake recreational reserve, and Mossvale Lake recreational reserve. Recreational areas are generally classified as areas with a temporary status that allows mining and logging, with the intent of returning the land to an ecological reserve or park[33]. As prevention of access to these recreational sites cannot be limited, a chance to promote awareness about the *keyoh* may be available.

Figure 18: Left: A Mountain Pine Beetle attacked stand (http://www.enewsletters.gov.bc.ca/Energy_Mines_and_Petroleum_Resources/EMPR_Ministry_Report/April_2009/edition), Right: Post salvage logging (http://www.ecologyaction.ca/content/responding-coastal-development-issues)

[30] Forst Practices Board (2007). *The Effect of Montain Pine Beetle Attack and Salvage Harvesting on Streamflows.* Retrieved February 11, 2011 from: http://www.for.gov.bc.ca/hfd/library/documents/bib106689.pdf

[31] Forst Practices Board (2007). *The Effect of Montain Pine Beetle Attack and Salvage Harvesting on Streamflows.* Retrieved February 11, 2011 from: http://www.for.gov.bc.ca/hfd/library/documents/bib106689.pdf

[32] McDaniels, T., Wilmot, S., Healey, M., & Hinch, S. (2010). Vulnerability of Fraser River sockeye salmon to climate change: A lifecycle perspective using expert judgements. *Journal of Environmental Management , 91*, 2771-2780.

[33]Western Canada Wilderness Committee. (1987). *B.C. Parks and Ecological Reserves.* Retrieved on March 17, 2011, from http://store.wildernesscommittee.org/campaigns/historic/otherpub/reports/Vol06No04/BCparks

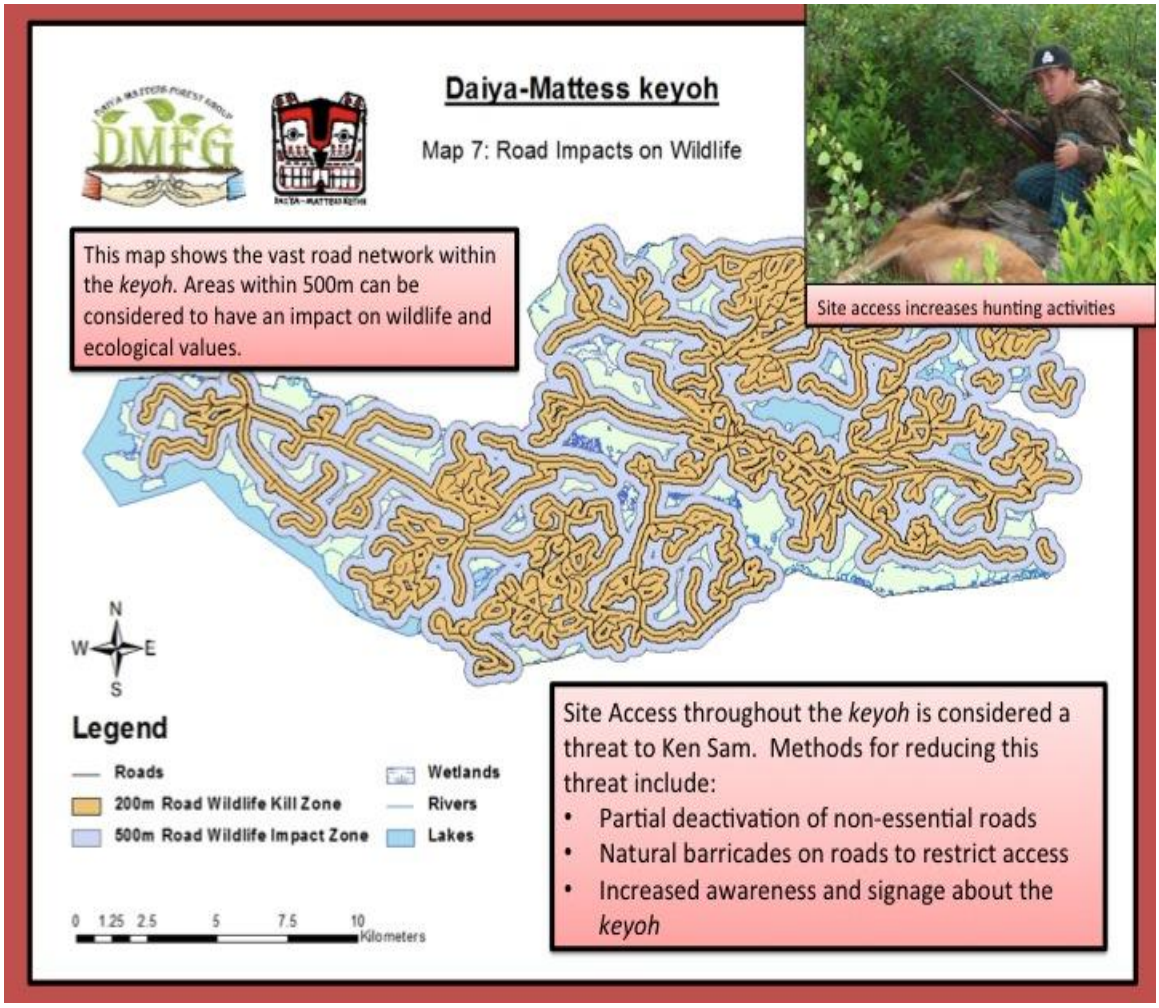


Figure 19: Site Access and Wildlife Impacts

2.0 Modelling

2.1 Introduction

The following section outlines the steps taken to create, analyze and rank modelled scenarios. Modelled scenarios are the main decision making tool in determining recommended strategies for the *Daiya-Mattess Keyoh.* Consequently, the level of detail in this section is such that it could be replicated. Assumptions are outlined and rationale is provided for each decision affecting the modelling.

Before making any decisions, it was decided that the best method of managing the *Daiya-Mattess Keyoh* was an ecosystem-based approach in the form of emulating natural disturbances (END). A brief overview of what emulating natural disturbances means and why it is an appropriate management approach for the *Daiya-Mattess Keyoh is given below.*

Emulating Natural Disturbances (END)

Emulating natural disturbances is a forest management approach, which uses management treatments, such as harvesting, to mimic historic disturbances and natural disturbance regimes[34]. Disturbance trends can be mimicked through disturbance return intervals (temporal scales) or area disturbed (spatial scales)[35].

END is a useful management approach. When implemented properly, it mitigates the risk of "...uncharacteristic and catastrophic disturbances..." in forests[36]. The *Daiya-Mattess Keyoh* is in an area in which fire is the main, stand-replacing disturbance every 125-200 years[37]. By END, fire risk is reduced on the *Daiya-Mattess Keyoh* while values such as wildlife habitat, ecosystem health and biodiversity are maintained.

END is a feasible management approach in this area as fire can be emulated through harvest. There is also recent scientific literature available on END specific to the Fort St. James area, which lends itself well to END on the *Daiya-Mattess Keyoh* (Figure 20).

---

[34] Natural Resources Canada. (2009, October 15). *Nature's guide to sustainable forest management*. Retrieved March 31, 2011, from Natural Resources Canada: http://canadaforests.nrcan.gc.ca/article/emulatingnaturaldisturbances

[35] Long, J. N. (2009, April 16). *Emulating natural disturbance regimes as a basis for forest management: A North American view.* Retrieved March 31, 2011, from Forest Ecology and Management: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6X-4VF0XVR-4&_user=1022551&_coverDate=04%2F16%2F2009&_rdoc=1&_fmt=high&_orig=gateway&_origin=gateway&_sort=d&_docanchor=&view=c&_searchStrId=1701511868&_rerunOrigin=google&_acct=C000050484&_versi

[36] Long, J. N. (2009, April 16). *Emulating natural disturbance regimes as a basis for forest management: A North American view.* Retrieved March 31, 2011, from Forest Ecology and Management: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6X-4VF0XVR-4&_user=1022551&_coverDate=04%2F16%2F2009&_rdoc=1&_fmt=high&_orig=gateway&_origin=gateway&_sort=d&_docanchor=&view=c&_searchStrId=1701511868&_rerunOrigin=google&_acct=C000050484&_versi

[37] DeLong, S. (2010). *BC Ministry of Forests and Range.* Retrieved March 29, 2011, from Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia: www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059

Figure 20: Emulating fire on the Daiya-Mattess Keyoh. The image to the left shows an intense, stand replacing fire[38]. The middle image shows a burned area[39]. The image to the right shows an area that has been harvested and been through a prescribed burn[40]. In the right image, note the variable sizes and the irregular edges of the harvested areas. These are the spatial aspects of fire that harvesting could emulate.

Having determined the management approach for the *Daiya-Mattess Keyoh,* the first step of the modelling process was to determine what management strategies would be employed on the *Daiya-Mattess Keyoh* in order to meet Ken Sam's objectives.

Management Strategies

In order to meet *Daiya-Mattess Keyoh* holder Ken Sam's objectives, five management strategies were proposed:

1) Do nothing (Base case)
2) Plant
3) De-build and re-vegetate roads
4) Apply Buffers
5) Harvest

Prescribed burning was another strategy that was considered. However, prescribed burning is a costly and risky strategy. Due to the size of the *Daiya-Mattess Keyoh*, harvesting can be used to emulate fire so prescribed burning was eliminated as a management strategy.

Management strategies can be further broken down into proposed treatments, which is the next step of the modelling process.

[38] Fraumeni, P. (2010, July 15). *It's forest fire season*. Retrieved March 31, 2011, from University of Toronto: Research & Innovation: http://www.research.utoronto.ca/behind_the_headlines/its-forest-fire-season/

[39] U.S. Geological Survey. (2010, October 15). *Landscape Effects of Frequency and Severity of Fire Effects on Boreal Alaskan Landscapes*. Retrieved March 31, 2011, from U.S. Geological Survey: http://alaska.usgs.gov/science/geography/fire.html

[40] Shorthouse, D. P. (2002, May 23). *Browse*. Retrieved March 31, 2011, from Forestry Images: http://www.forestryimages.org/browse/detail.cfm?imgnum=1450031

Proposed Treatments

In developing treatments for the *Daiya-Mattess Keyoh,* there were some key aspects to consider. First, each treatment should be in harmony with *Daiya-Mattess Keyoh* holder Ken Sam's objectives. Second, each treatment should be an attempt to emulate a natural stand. As fire is the primary natural disturbance in the area, treatments were aimed at re-creating stands influenced by fire[41]. At this stage, cost was not yet considered.

1. Do nothing (Base case)

There are no proposed treatments for the base case or baseline. Two baselines were used for every modelling scenario due to the *keyoh*'s complex history (Figure 21). To represent the logging history by Canfor, a baseline was created for "business-as-usual". This harvest baseline was used to compare changes between Canfor's harvesting regime and the proposed treatments. A second baseline was created to model a "do-nothing" approach and assess how the proposed treatments fared compared to no human influence.

Figure 21: The image to the left represents the "do-nothing" baseline. The image to the right represents the "business-as-usual", harvest baseline[42].

2. Plant

There are a total of four planting treatments that could be implemented in any combination.

The first planting treatment is re-stocking the "Not Satisfactorily Restocked" (NSR) polygons. These are areas that have been assessed by the Ministry of Forests, Lands and Natural Resources Operations and deemed not yet 'free to grow'. In other words, the stand is not adequately stocked with healthy, free growing trees of a minimum height of 2.00 m

[41] DeLong, S. (2010). *BC Ministry of Forests and Range.* Retrieved March 29, 2011, from Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia: www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059

[42] Natural Resources Canada. (2009, October 15). *Nature's guide to sustainable forest management*. Retrieved March 31, 2011, from Natural Resources Canada: http://canadaforests.nrcan.gc.ca/article/emulatingnaturaldisturbances

for lodgepole pine and 1.00 m for white spruce[43]. The most likely reason for being classified as NSR is inhibited seedling growth due to aspen (*Populus tremuloides)* competition. However, this is speculation, as it cannot be confirmed with the data provided. It is assumed that planting in these areas will only be successful after brushing has occurred, and potentially thinning where needed. Planting will target two NSR areas. The first targeted area is NSR areas with lodgepole pine (*Pinus contorta)* as the leading species. The second targeted NSR areas are those with white spruce, hybrid spruce or Engelmann spruce (*Picea glauca, P. glauca x P. engelmannii, Picea engelmannii* respectively) leading species.

In selecting planting species, BC Stocking standards were consulted, as well as natural stand compositions. Shade tolerance was of particular importance in predicting the survival success of planting species.

In NSR areas with leading lodgepole pine species, white spruce is the proposed planting species. White spruce grows naturally with lodgepole pine, and this is supported by the species composition data found in the vegetative resource inventory data (VRI data) provided. It was challenging to determine the composition of the target stand. Given that most of the *Daiya-Mattess Keyoh* area is naturally pine dominated, a stand of 80% pine and 20% spruce is more biodiversity than a 90 % pine- 10% spruce composition? Bearing in mind that one of Ken Sam's objectives is to replace logged areas with healthy forests as quickly as possible, planting in NSR polygons is only one solution. Increasing white spruce composition introduces more variability throughout the stand, creating a more diverse and resilient stand. Ideally one would also plant one other species, such as Balsam fir (*Abis lasiocarpa*) or Douglas-fir *(Pseutotsuga menziesii)*. However, it is difficult to generalise an area and declare that planting two species is better than one, as it may in fact not be better as you are creating an unnatural species composition in the stand. This should be considered if NSR planting is implemented.

In NSR areas with leading spruce species, balsam fir is the proposed planting species. VRI data also indicated that balsam fir grows naturally with white spruce, and this is further supported by the natural ecology of the site (see section on Ecological Background).

In all NSR areas, the target stand was 80% leading species- 20% planted species.

The two remaining planting treatments aim to increase biodiversity. These planting scenarios are very similar to those proposed in the NSR blocks in that they both occur in areas with pine or spruce leading species. As above, white spruce will be planted in blocks where lodgepole pine is leading and balsam fir will be planted in blocks where white spruce is leading. These low biodiversity areas were identified based on leading species, composition of leading species (had to be >89 %) and stand age (had to be 15 years or younger). This identified polygons that were young enough that planting would be successful yet still create an even-aged stand. Even aged stands are an important

[43] BC Ministry of Forests. (1995). *Riparian Management Area Guidebook*. Retrieved March 31, 2011, from Forest Practices Code: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/riparian/Ripar4.htm#link70

component of emulating natural disturbances in this area[44]. 15 years is also the last year for replanted blocks cut blocks to be assessed for free-to-grow by the Ministry of Forests, Lands and Natural Resource Operations. This co-ordinates biodiversity planting with NSR planting, creating more even-aged stands throughout the *keyoh*. Brushing and thinning will likely be necessary to ensure survival of seedlings.

3. De-build and re-vegetate roads

De-building roads is an intensive and expensive process. However, it meets Ken Sam's objective of limiting access to the *Daiya-Mattess Keyoh* and helps reduce fragmentation. Due to the number of roads, there are concerns for water quality, fragmentation of the landscape and increased wildlife kills due to roadside hunting.

De-building the roads entails removing stream crossings and culverts, pulling backside casts as necessary and re-contouring the land. We also propose planting aspen on the de-built roads for the purpose of claiming carbon credits and generating additional revenue, and speeding the process of ecosystem rehabilitation.

Aspen was selected as the re-vegetation species for three main reasons. Firstly, it is a pioneer species that means it does well in disturbed areas, such as de-built roads[45]. Secondly, it grows naturally in the area and is an important habitat component for many naturally occurring wildlife species. Third, aspen helps mitigate fire risk, as deciduous species do not burn as well as other tree species[46].

4. Buffer

Buffer treatments are a simple, cost effective and will protect areas of importance during harvest. Ken Sam expressed grave concern regarding water quality and the protection of aquatic ecosystems. Fish are an important resource on the *Daiya-Mattess Keyoh* and must be protected adequately. It was also important to protect land use sites for cultural purposes. In order to accommodate these concerns, buffers were applied to all water bodies (streams, the Salmon River and lakes) and land use sites and evaluated for protection and revenue generated through carbon credits. Buffer treatments can be seen in Figure 22.

[44] DeLong, S. (2010). *BC Ministry of Forests and Range.* Retrieved March 29, 2011, from Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia: www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059

[45] BC Ministry of Forests. (2002, June). *Forest Road Engingeering Guidebook.* Retrieved March 31, 2011, from BC Ministry of Forests, Lands and Natural Resource Operations: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/Road/FRE.pdf

[46] Province of British Columbia. (n.d.). *FireSmart Manual: Protect your home from wildfire*. Retrieved March 31, 2011, from Provincial Emergency Program: http://www.pep.bc.ca/hazard_preparedness/FireSmart-BC4.pdf

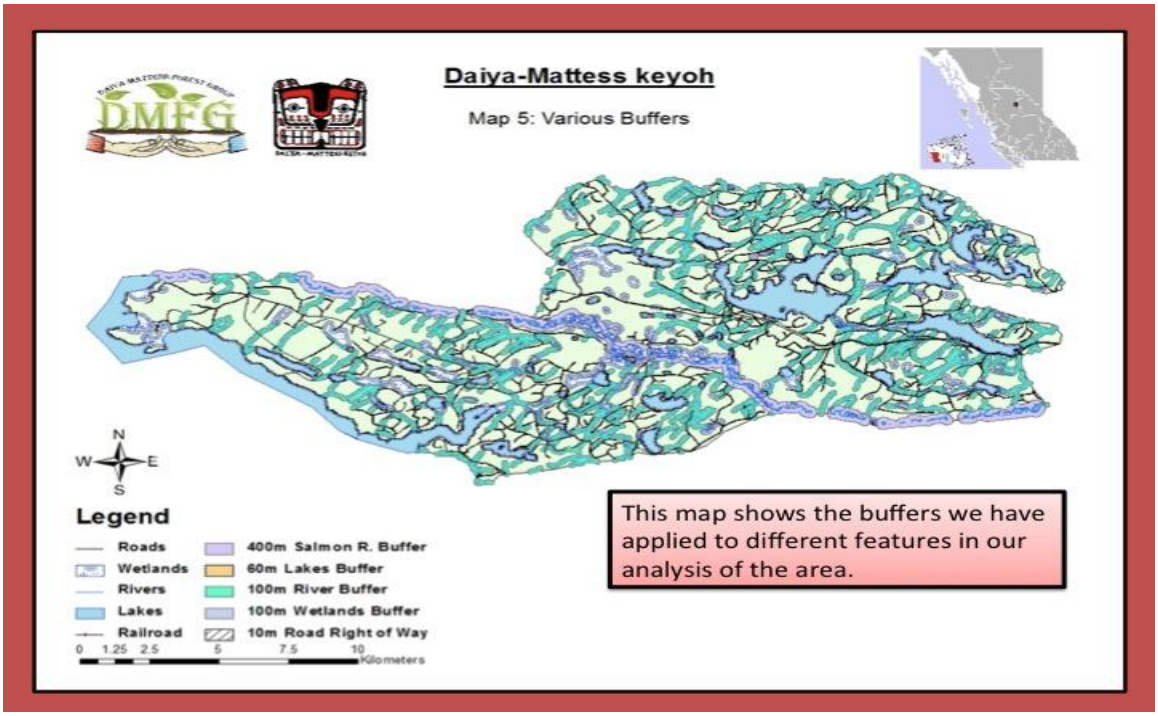


Figure 22: Buffer Treatments

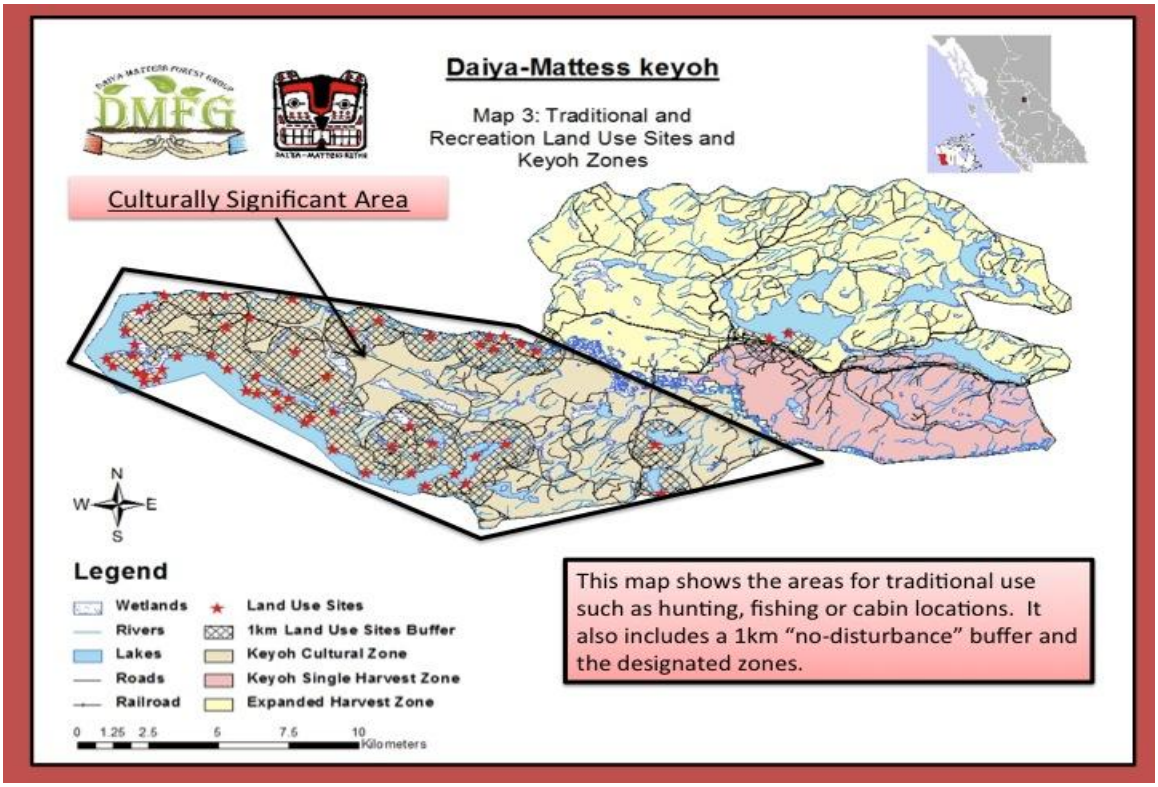


Figure 23: Culturally Significant Areas and Zones

The Salmon River is a crucial water body. It is well known that kokanee salmon spawn in this river, so water quality must be maintained. In order to ensure protection, large buffers of 200 m are used in modelling.

As many streams feed in to the Salmon River, it is important to protect these as well. Streams are modelled with 100 m buffers. Buffers and protected areas will also help to protect species that rely on these riparian areas (Figure 24).

Lakes typically do not require buffers if they are larger than 1000 ha[47]. This is because the larger the lake, the less it is affected by terrestrial ecosystems. On the *Daiya-Mattess Keyoh* a generic 60 m buffer was applied to all lakes, regardless of the size. This is in part due to the location of recreational sites within the *Daiya-Mattess Keyoh,* which are subject to visual quality objective as outlined by the Ministry of Forests, Lands and Natural Resource Operations, and in part to protect the lakes.

The Forest Practices Code was used as a reference for determining buffer size to apply to water bodies. A literature review was conducted and found that the Forest Practices Code's buffer sizes were in line with scientific findings. These buffer sizes were then double to ensure that water was fully protected. The large buffers also help protect culturally significant areas as many of these areas, or land use sites, are located near water. In addition, the large buffers protect most of the wetlands in the area. A separate wetland buffer was not applied as stream buffers protect most of the wetlands.

5. Harvest

Harvesting is used to maintain wildlife habitat characteristics and emulate natural disturbances. It meets Ken Sam's objective of maintaining wildlife habitat, although he expressed serious concern regarding the scale of Canfor's harvesting on the *Daiya-Mattess Keyoh.*

In order to meet Ken Sam's wildlife habitat objective and mitigate his concern regarding negative harvesting impacts, a cultural heritage zone was set-aside as a no harvest area. This cultural heritage zone is approximately half of the *Daiya-Mattess Keyoh* (Figure 23).

To determine the optimal harvesting arrangement, numerous harvesting scenarios were examined. These can be summarised in four general scenarios, and further broken down into four minimum harvest ages (Figure 25). When determining the scenarios, the minimum harvest ages were manipulated through FPS-Atlas. The minimum harvest age refers to the average age at which a species is ready for harvest[48].

[47] BC Ministry of Forests. (1995). *Riparian Management Area Guidebook*. Retrieved March 31, 2011, from Forest Practices Code: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/riparian/Ripar4.htm#link70
[48] Pedersen, L. (1996). *Tree Farm Licence (TFL) 39 AAC Rationale*. Retrieved March 31, 2011, from BC Ministry of Forests: http://www.for.gov.bc.ca/hts/tsr1/ration/tfl/t39/httoc.htm#RTppKC26

Figure 24: Wildlife within the *keyoh* that may benefit from protected culturally significant areas, as well as buffers

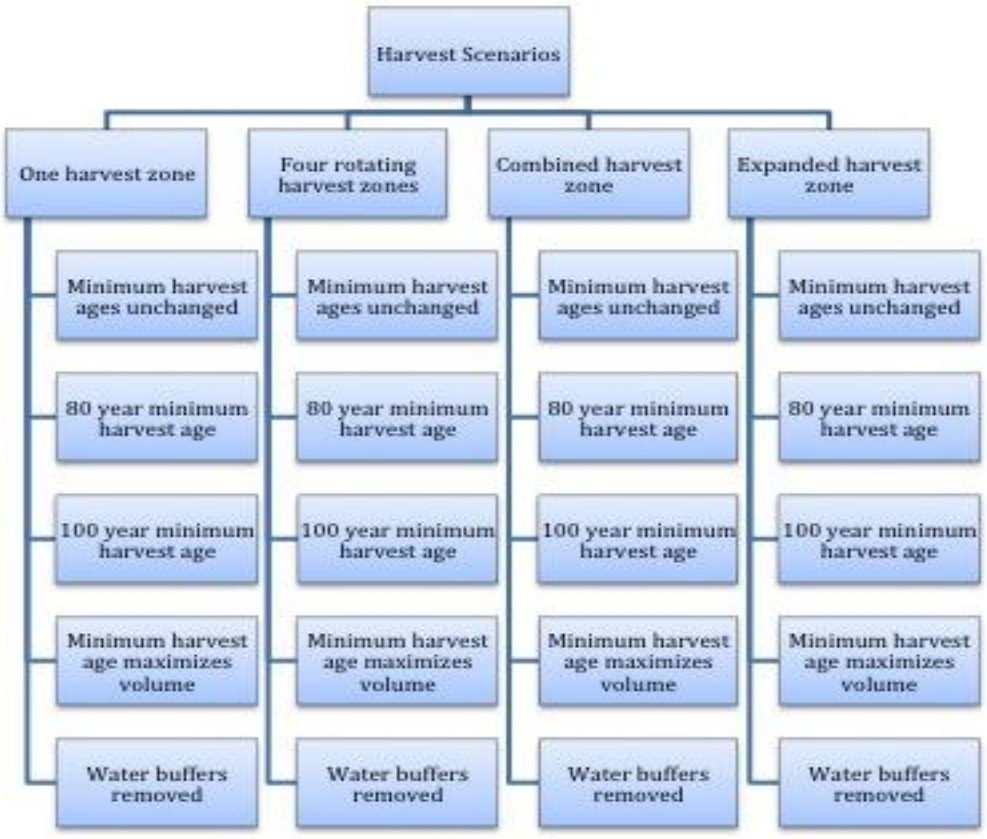


Figure 25: Harvesting Scenarios

The objective of modelling a wide selection of harvesting scenarios was to examine many options and manipulate the harvest zone. Modelling variables examined the area of land

allocated to harvest, the potential revenue to be generated by expanding and shrinking harvestable areas, the effects on wildlife habitat of expanding and shrinking harvestable areas, and annual allowable cut (AAC) effects of changing the minimum harvest age.

2.2 Methodology

Having identified END as the management approach to the *Daiya-Mattess Keyoh* and determined management strategies and treatments, the next step was to determine how to model the management treatments.

Two growth and yield models, one aspatial model and two spatial models were used to analyze the treatments' effects upon the *Daiya-Mattess Keyoh.* These different models can be found in a summary table below in Figure 26 and 27, and in more detail in Appendix 4

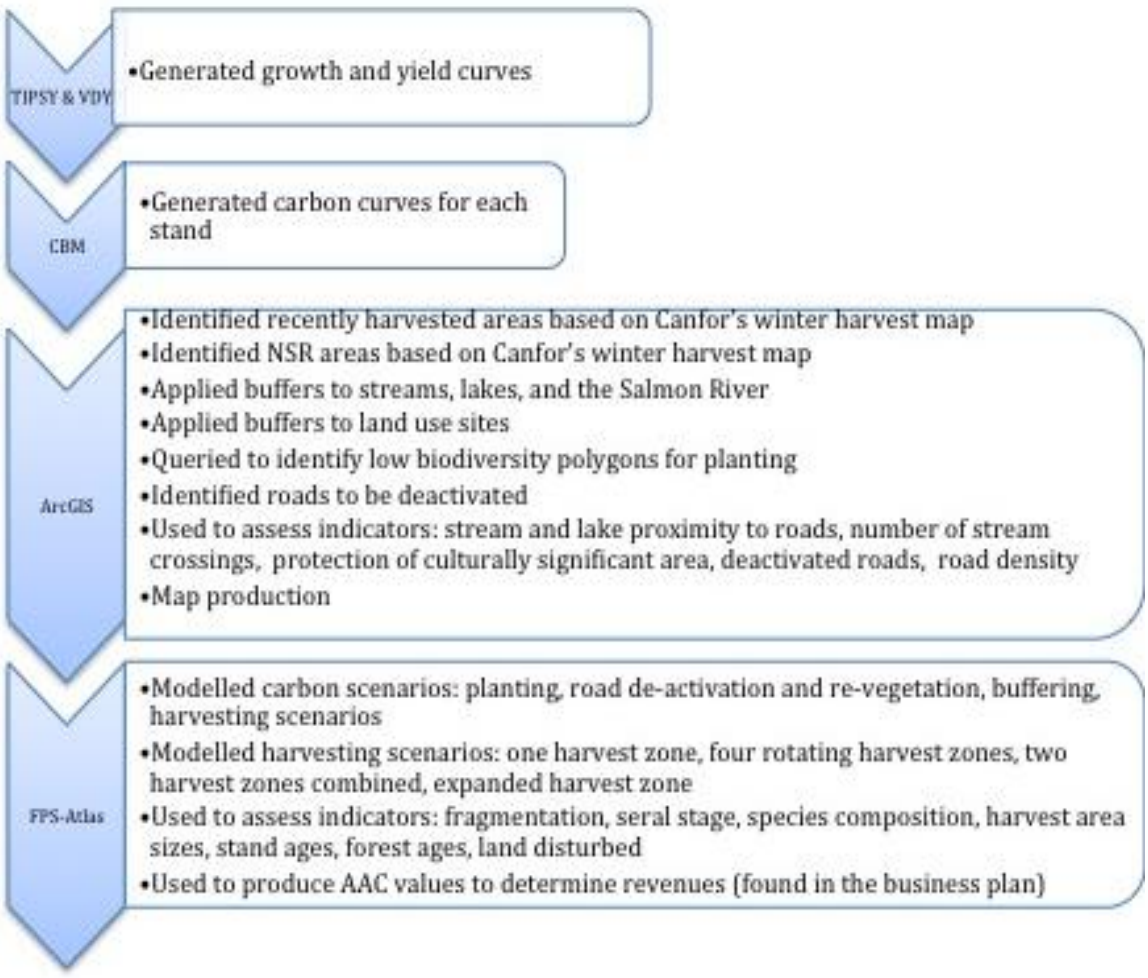


Figure 26: A summary table describing the models used and how they were applied

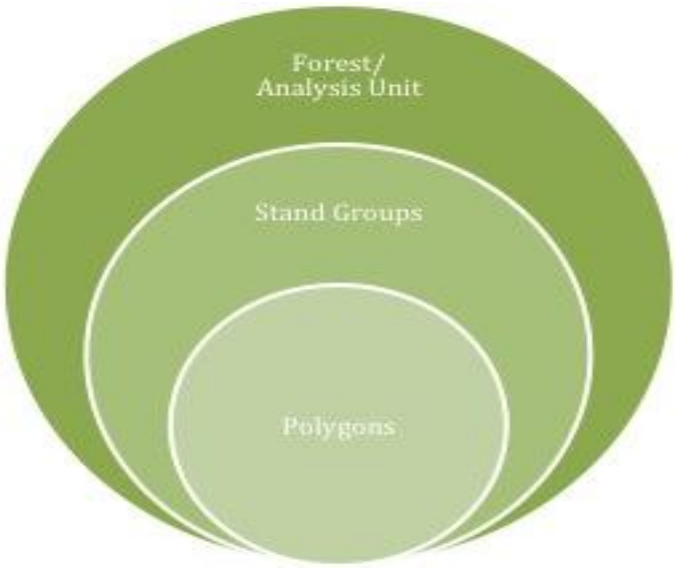


Figure 27: There were three spatial scales used in modeling.

For the purpose of accurately explaining the modeling process, it is important to understand the spatial scales of the models. ArcGIS and FPS-Atlas were the two spatial models used. The spatial scales explained here are meant to provide understanding of the terms that will be used to explain the modeling methods. Three spatial scales were used in ArcGIS and FPS-Atlas.

The first spatial scale is the largest: the forest. For the purposes of this management plan, a forest refers to the entire *Daiya-Mattess Keyoh*. A forest is equivalent to the 'analysis unit' (AU) in FPS-Atlas.

The second spatial scale is the stand, or stand group. The forest comprises of 43 stand groups. A stand is determined based on leading species, site index and whether it is managed or unmanaged.

The third and finest spatial scale is the polygon. There are 13,668 polygons, which make up the *Daiya-Mattess Keyoh.*

2.3 The Modeling Process

This section outlines the general steps taken to produce the scenarios that were evaluated based on indicators.

Generated growth and yield curves for the carbon planting scenarios:

Three new growth and yield curves were needed. One for the aspen road re-vegetation, one for the lodgepole pine and white spruce planted blocks and one for the white spruce and balsam fir planted blocks.

In order to model these stands in Atlas, it is necessary to have growth and yield model so Atlas can 'grow' the stands and harvest them. The assumptions used to model the growth and yield curves for the carbon planting scenarios can be seen in Figure 28.

The growth and yield curves were generated in TIPSY and exported into Atlas by creating new stand groups.

VDYP was used to generate an unmanaged balsam fir growth and yield curve, as the one provided was incorrect.

Created five new stand groups, although the SG5100's use the same growth and yield curves as the SG5200's. In order to obtain accurate carbon data, the stand groups had to be applied to different areas, thus five new stand groups were needed.

Scenario	Assumptions
Generated growth and yield curves for the carbon planting scenarios	Average site index (SI) of 18. 18 was derived from a query in GIS of all the site indices of areas to be planted
	Slope of 7 % based on field observations of the *Daiya-Mattess Keyoh*
	Planting densities of 1600 stems per hectare
	Stand group 3257's growth curve is incorrect. Did not correct stand group curve 3257 due to negligible area
	Assume Operational Adjustment Factors and utilization is accounted for in Ministry of Forests, Lands and Natural Resource Operations growth and yield curves. This assumption is based on the Timber Supply Review (TSR) data package.
	Aspen growth and yield curve generated without utilization since there will be no deciduous harvesting on the *Daiya-Mattess Keyoh* for fire protection purposes
	Pine-spruce and spruce-fir curves were generated using utilization of 17.5 cm for non-pine species and 12.5 cm for pine, and decay/waste/breakage as this ensured consistency with the growth and yield curves that were provided based on the TSR data package

Figure 28: Assumptions for the carbon planting scenarios

Generated carbon curves:

Carbon curves needed to be generated for the baseline scenario and for the new stand groups. Curves were generated based on the growth and yield curve data provided by the Ministry of Forests, Lands and Natural Resource Operations. Each stand group needed a carbon curve. There were 43 stand groups, which required carbon curves. One stand group (SG888) is a non-productive stand group and was used to identify roads and water bodies- no carbon curve was generated for this stand group. Assumptions used to generate the carbon curves can be seen in Figure 29.

Once the carbon curves were created, they were imported into Atlas. Using the Carbon Grid, Atlas was able to provide carbon outputs for every scenario. It was these carbon outputs that are included in this report and were used to calculate carbon credit revenue in the companion business plan document.

Scenario	Assumptions
Generated Carbon Curves	All unmanaged, mature baseline carbon curves were modeled without a disturbance
	All managed baseline carbon curves were modeled with a harvesting clearcut disturbance of 97% at 80 years. The carbon data from 80 years onward was used to create the carbon curve that was then imported into Atlas. This assumes that stands are harvested at 80 years.
	The new, road re-vegetation carbon curves were modeled with an afforestation disturbance at 0 years. The carbon curve was created from the carbon data and was then imported into Atlas.
	The new-planted carbon curves were modeled with a clearcut disturbance of 97% at 80 years and an afforestation disturbance at 95 years (15 years later). The carbon curve was created from the carbon data from 95 years and onward, and was then imported into Atlas. This assumes stands are harvested at 80 years and accounts for the planted blocks having an age range of 0-15 years. It assumes that all blocks are re-forested 15 years later.
	Deciduous stand groups had modified carbon curves. It was assumed that deciduous stands were deciduous in perpetuity. In other words, deciduous species (likely trembling aspen) was the climax species. However, the carbon curves did not reflect this. The carbon curves grew, peaked, and then dropped down to 0 tones of carbon. To remedy this, the carbon at which aspen reached its pathological rotation age (120 years (BC Ministry of Forests and Range, 2008)) was the value assumed for the remainder of the stands' existence. The carbon curves were allowed to peak, but upon their descent were not allowed to fall below the carbon generated in year 120. This value was then repeated.

Figure 29: Assumptions for the generated carbon curves

Queried data in ArcMap, updated polygons in Atlas:

In order to identify polygons to be planted, areas to be buffered, and roads to be de-activated, queries were used in ArcMap. Once these polygons were identified, the tabular information was imported into Atlas. Having the data in Atlas allowed the model to grow

the areas to be planted and to avoid harvesting in buffered areas. Assumptions used to query the data in ArcMap to update the polygons in Atlas can be seen in Figure 30.

To identify low-biodiversity areas to be planted, a query was used to first select pine and spruce leading species. Then % species composition was used to ensure these polygons were 90% or more leading species. Finally, age was used to select polygons aged 15 years or younger.

In addition to querying data, ArcMap was also used to identify recently harvested polygons that were not up to date in the provided data. Selecting the polygons based on Canfor's Winter Harvest map did this. The same process was applied to identifying NSR polygons. Once the NSR polygons were selected, they were queried to identify Pine NSR areas and Spruce NSR areas. The new stand groups were then applied to these areas accordingly, so spruce was only planted in pine NSR areas and balsam fir was only planted in spruce NSR areas. Once these were updated, the data was imported into Atlas to ensure the information was as accurate as possible.

Scenario	Assumptions
Queried data in ArcMap, updated polygons in Atlas	Some NSR polygons were neither spruce nor pine. These areas were open, upland, and non-treed. These polygons were not updated with new stand groups, and instead are reserved for habitat purposes.

Figure 30: Assumptions for the queried data in ArcMap

Created Maps in ArcMap:

ArcMap was also the software used to create the various maps seen in this document.

Placed constraints in Atlas, modeled harvesting scenarios:

When modeling in Atlas, constraints, cliques and zones were used. Constraints were used to create the rotating harvest zones. Do not harvest constraints were also applied to the buffered areas.

When developing the harvest scenarios, minimum harvest rotation ages were modified in Atlas. In order to do this, multiple copies of the Atlas database were made for each harvest scenario. The assumptions used to model these harvesting scenarios can be seen below in Figure 31.

Cliques were used for buffered areas. Buffered areas consisted of the Salmon River, land use sites, streams and lakes. No harvest constraints were then applied to the buffered areas.

Zones were used to create the cultural heritage zone and the various harvest zones. A no harvesting constraint was always placed on the cultural heritage zone.

In order to generate carbon outputs for the re-vegetated roads, a query in GIS was used to identify road polygons. These polygons were used to create stand group 5000 (SG5000) and an aspen growth and yield curve and carbon curve were linked to the stand group in the Atlas database. The polygons in this stand group had to have their productivity modified so

they were able to grow trees. Having done this, Atlas was now able to model carbon for the road re-vegetation scenario.

Scenario	Assumptions
Placed constraints in Atlas, modeled harvesting scenarios	Once the carbon scenarios were altered in the databases, they were modeled in every harvesting scenario. This means some of the stand groups are slightly different than the original stand groups, and that every harvesting scenario in fact models the planting scenarios. However the road re-vegetation scenario was not.
	Buffers were placed on all harvest scenarios except the "no buffer" scenarios.
	No deciduous stands were harvested as a fire management strategy.
	The minimum harvestable ages were modified. The rotations associated with each of these minimum harvest ages were modified to match the ages in the four rotating harvest zones scenario. Minimum harvest ages of 80 years were on an 80 year rotation, minimum harvest ages of 100 years were on a 100 year rotation, and minimum harvest ages which maximized volume were on 120 year rotations as that was the age at which most of the stands' volume peaked.

Figure 31: Assumptions for the placed constraints in atlas for the harvesting scenarios

3.0 Values, Objectives, Indicators, Targets: Rationale and Evaluation

3.1 Value, Objective, Indicator, Target Rationale

A value, objective, indicator, target framework has been used to evaluate the modelled scenarios. This framework is ideal as it ensures that the objectives of the client are met with the support of quantifiable results.

In creating the values, objectives, indicators and targets for the *keyoh* (Table 4), the following definitions were applied:

Value

A characteristic, quality or key aspect of the *keyoh* which is important to the *Daiya-Mattess keyoh* holder or impacts the feasibility of the management strategy (ex- socio-economic value and revenue indicator).

Objective

A specific management approach for the associated value. An objective should ensure the value is addressed through protection or maintenance.

Indicator

A quantifiable characteristic which meets the objective. A good indicator should ensure the objective is met and the value is managed for.

Target

A quantitative assessment of the indicator. Targets should be scientifically supported.

Each indicator and target is explained in detail based on the values they are meant to protect and the objectives they are meant to meet. For further detail, please see Appendix 5: Values, Objectives, Indicators, Targets: Evaluation Results and Discussion.

Table 4: Summary of the values, objectives, indicators and targets used to evaluate modelled scenarios for the *Daiya-Mattess Keyoh*.

Values	Objectives	Indicators	Targets
Wildlife	Protect & Restore Habitat	Fragmentation[49]	**Good**: Harvested polygons are aggregated **Medium**: Most harvested polygons are aggregated, some are dispersed, small polygons **Poor:** Most harvested polygons are small and dispersed
Water	Protect Aquatic Ecosystems & Water Quality	Road proximity to rivers, streams and lakes: Road density within 100 m of streams and lakes[50]	**Good**: 0 % of roads **Medium**: 1-25% of roads **Poor**: >26% of roads
		Number of stream crossings[51]	Good: 0-47 crossings Medium: 48-98 crossings Poor: ≥99 crossings
Heritage	Protect Culturally Significant Areas	Protect culturally significant area	**Good**: All cultural area protected **Medium**: Most cultural area protected **Poor**: <70% cultural area protected
		Deactivate roads	% or km for roads deactivated in cultural zone plus harvest zone

[49] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

[50] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

[51] William Haskins and David Mayhood. 1997. *Stream Crossing Density as a Predictor of Watershed Impacts*. Proceedings of the Seventeenth Annual ESRI User Conference, Paper 457. http://proceedings.esri.com/library/userconf/proc97/proc97/to500/pap457/p457.htm

Forest	Maintain Ecosystem Health and Vitality	Seral stage	>17% Late Seral
		Species Composition[52]	Douglas fir: 1% Fir: 9% Spruce: 30% Pine: 45% Aspen/Birch: 15%[53]
		Road Density[54]	**Good**: <=0.40% of land base **Medium**: 0.41- 3.89% of land base **Poor**: >=3.90% of land base
	Emulate natural disturbances	Harvest area sizes	- Large cuts ranging from 40-60 ha[55]
			-0.75-1.25% of land base disturbed[56]
		Stand ages	Even aged stands[57]
		Forest Ages	>200 y Rare[58]
		Land disturbed	0.75-1.25% of land base disturbed[59]
Socio-Economic	Maintain and enhance long-term benefits to the *Daiya-Mattess Keyoh*	Revenue generated	Break-even
		Jobs created	>0

[52] Public Advisory Group, BC Timber Sales, Carrier Lumber Ltd., Takla Track and Timber Ltd., Canfor, Ltd., Apollo Forest Products, Stuart Lake Lumber Co. Ltd., (2007, March). *Fort Saint James Sustainable Forest Management Plan.* Retrieved March 26, 2011, from Canfor: http://www.canfor.com/_resources/sustainability/Fort_St_James_SFM_Plan_May-18-2007.pdf

[53] Ministry of Forests and Range. (2008, November). *Prince George Timber Supply Area: Timber Supply Review Data Package.* Retrieved March 25, 2011, from Ministry of Forests and Range: http://www.for.gov.bc.ca/hts/tsa/tsa24/tsr4/24ts08dp.pdf

[54] William Haskins and David Mayhood. 1997. *Stream Crossing Density as a Predictor of Watershed Impacts*. Proceedings of the Seventeenth Annual ESRI User Conference, Paper 457. http://proceedings.esri.com/library/userconf/proc97/proc97/to500/pap457/p457.htm

[55] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

[56] ibid DeLong

[57] ibid DeLong

[58] ibid DeLong

[59] ibid DeLong

Wildlife

Protect and Restore Habitat

This objective addresses the importance of wildlife by ensuring there is habitat. To comprehensively assess wildlife habitat, a separate wildlife habitat criteria and indicator is applied to the top six scenarios evaluated by these targets (Appendix 5, Table 36).

Fragmentation

Indicator & Target Rationale

Fragmentation is a useful indicator for wildlife habitat as it ensures that animals have sufficient area (Appendix 5, Figure 36). Fragmentation also doubly serves to ensure that the emulation of natural disturbances (END) is employed successfully.

Fragmentation Results

Fragmentation ranges from poor to moderate. 'No harvest' scenarios have no fragmentation. The harvest baseline ranks 'good' because all of the harvested areas are large openings and do not isolate the remaining stands of forest. All other scenarios have moderate fragmentation (Appendix 8).

Discussion

The larger the harvest zone the less fragmented the landscape. This is a result of increased flexibility when harvesting, allowing the aggregation of harvest polygons.

Water

Protect aquatic ecosystems and water quality

Maintaining water quality on the *Daiya-Mattess Keyoh* not only protects its aquatic organisms, but also contributes to the protection of aquatic organisms in the Fraser River and maintains healthy, resilient ecosystems.

Road Proximity to Rivers, Streams and Lakes

Indicator & Target Rationale

The purpose of measuring the proximity of roads is to assess the potential impact they may have on water. The increased amount of sediment to streams from runoff (known as sedimentation) is a major environmental impact of roads and may damage fish food supplies and habitats, injure fish directly, cause bank erosion, fill the channel, widen the channel, or flood it.[60]

[60] William Haskins and David Mayhood. 1997. *Stream Crossing Density as a Predictor of Watershed Impacts*. Proceedings of the Seventeenth Annual ESRI User Conference, Paper 457. http://proceedings.esri.com/library/userconf/proc97/proc97/to500/pap457/p457.htm

Road Proximity to Rivers, Streams and Lakes Results

To assess this target, buffers of 20m, 40m, 60m, 80m and 100 m were used to gauge the road lengths in each width (Appendix 5, Figure 40). That information was used to evaluate the target in each scenario. There were 100% more roads within the 100m buffer than the 20m buffer.

Discussion

The highest number of roads falls within the 100m buffer. There is a significant difference in the number of roads in the 80 m buffer and the 100 m buffer, so it is possible that 80m would suffice in most situations.

Number of Stream Crossings

Indicator & Target Rationale

The high density of roads and streams throughout the *keyoh* results in many stream crossings. Increasing number of stream crossings creates sedimentation risk or may result in contamination from pollutants entering the water from cars, trucks, and/or trains.

Number of Stream Crossings Results

The Cultural Heritage Preservation Zone has 50 water channels crossings and the remaining area has 65 crossings (Appendix 5, Figure 43). Crossings in each scenario vary with de-activated roads.

Discussion

Trends here mimic those in the road proximity to water target. The only scenario classified as `good` is the road de-activation and re-vegetation scenario. The one harvest zone and combo zone harvest scenarios are ranked moderate, and all other scenarios are ranked poor.

Heritage

Protect Culturally Significant Areas

This objective seeks to maintain the heritage values of the *Daiya-Mattess Keyoh* by protecting high use areas important to the *keyoh* holder and his family for trapping, fishing and recreation.

Protect Culturally Significant Area

Indicator & Indicator Rationale

All cultural land use sites are special to the *keyoh* and tell a story of the *Daiya-Mattess Keyoh* people's history. The majority of these locations can be found at the west end of the *keyoh*, which is the primary reason a Cultural Heritage Zone was created (Appendix 5, Figure 44). 1 km radius buffers were placed on the cultural land use sites (Appendix 5, Figure 46). An

awareness survey has been created to promote awareness for the *Daiya-Mattess Keyoh*, and can be found in Appendix 7.

Protect Culturally Significant Area Results

Most of the cultural land use sites are located in the Cultural Heritage Zone in the southwest portion of the *keyoh*.

Discussion

The smaller the area available for harvest, the better the cultural areas are protected. The less area available for harvesting, the more roads can be de-activated and the more access is limited. The Cultural Heritage Zone and water buffers protect the majority of the cultural land use sites.

De-activated Roads

Indicator & Target Rationale

This indicator focuses on reducing the number of roads throughout the *keyoh* to decrease access and allow de-activated road areas to naturally regenerate (Appendix 5, Figure 47).

De-activated Roads Results

The 191.8 km of roads are found in the portion of the *keyoh* outside of the Cultural Heritage Zone. The Cultural Heritage Zone has 171.5 km of road.

Discussion

Road de-activation trends are similar to those seen in the cultural area protected target. The smaller the area available for harvest, the better the road-deactivation targets are met.

Forest

This ecological value seeks to protect one of the *Daiya-Mattess Keyoh's* most valuable resources. The forest provides habitat, protects water quality and has the potential to generate revenue.

Maintain ecosystem health and vitality

This objective ensures the forest is productive, resilient and healthy for use in future generations. The target seeks to create a forest within its natural range of variation.

Seral stage

Indicator & Target Rationale

This indicator provides insight into stand turnover due to disturbances. It also ensures there is a range of seral stages to meet the varied requirements of wildlife.

Target Rationale

To meet this target, stands must comprise of more than 17% late seral stage.

Seral Stage Results

In all scenarios except the baseline harvest scenario, seral stage increases from year 0 to 100. Increases of up to 63% occur in the no harvest baseline and the planting, buffer and road treatments.

Discussion

These results are as expected. Nearly half the *Daiya-Mattess Keyoh* is reserved in a cultural heritage zone (Appendix 5, Figure 44). It is expected that late seral stage compositions will become quite high as harvesting is restricted and can no longer be used as a tool to maintain seral stage compositions.

Species composition

Indicator & Target Rationale

In maintaining a natural, healthy stand, it is important to ensure species composition is within natural ranges. This helps maintain biodiversity, stand structure and regulates stand development through competition (Appendix 5, Figure 49).

Species Composition Results

None of the scenarios meet the species composition target. In all scenarios, pine is a very large component of the stand, much larger than the target composition of 45%. Species compositions do not vary much throughout the scenarios, and all scenarios show an increase in pine composition.

Discussion

While this target is specific for the SBS mk1, it would be surprising if the *Daiya-Mattess Keyoh* met the species composition target. However, the results do indicate that there is a problem that should be investigated further. Pine composition is too high. If this is a result of harvesting and conversion to pine stands, then pine stands should be targeted for harvest when possible and converted to their natural species compositions.

Road Density

Indicator & Target Rationale

To return the forest to a natural, continuous stand there should be less fragmentation and openings due to roads (Appendix 5, Figure 50).

Road Density Results

In the *Daiya-Mattess* Keyoh there are 488km of road and just under 976 ha of right of way (assume 20 m wide) area. This works out to 19.32m of road per hectare of land or 3.87% of the *keyoh* land. If the cultural area was to be deactivated the road density would decrease to 2.51%.

Discussion

The only scenario classified as 'good' is the road-deactivation scenario. As with the previous targets, the smaller the area designated for harvest, the better the target is met.

Emulate natural disturbances (END)

This objective ensures a healthy, resilient forest by emulating fire. Disturbances are nature's way of re-setting a forest and eliminating old, decadent stands that are diseased or unproductive. END ensures that forests aren't loading fuel and creating an immense fire hazard.

Harvest area sizes

Indicator & Target Rationale

This indicator is useful for emulating the spatial aspect of a fire disturbance. Harvest sizes should range from 40-100 ha, but due to clear-cut size constraints in the interior, will range from 40-60 ha[61].

Harvest Area Size Results

The no harvest baseline and road, buffer and planting treatments have no harvesting and do not apply to this target. The more area available for harvesting, the better the harvested area size results. Consequently, most of the no buffer scenarios do well- specifically the four rotating no buffer harvest scenario and the one zone no buffer scenario.

Discussion

Many of the openings are less than 40 ha. This is simple to change during planning. When determining long-term harvest plans and laying out harvest blocks on the ground, consider harvest area size. The harvest area trends are a result of Atlas choosing which stands to harvest. It is important to note that in the one harvest zone and the four rotating zones, it may be more challenging to meet these increased opening sizes, as there is limited area available for harvest.

Stand ages

Indicator & Target Rationale

This indicator ensures that stands are even-aged which also helps to emulate fire as fire disturbance creates even-aged stands.

Target Evaluation

This target was evaluated based on four age classes: 0-20 years, 21-40 years, 41-60 years and 61-80 years. The emphasis is on younger age classes as these are the stands that will contribute to the forest over time.

Stand Ages Results

The trends for this target do not emulate fire well. Within 20 years of no harvesting in the no harvest baseline, road, buffer and planting treatments, there is no 0-20 age class. It follows that by period 100, there are no 0-80 year stands.

---

[61] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

Discussion

It is important to note that while the starting point can be used as a reference point for where targets ought to be, the *Daiya-Mattess Keyoh* has been heavily salvaged. The values at time 0 are not necessarily representative of what the *keyoh* should be at. Careful planning and valid information should be applied to seek balance within the targets.

This is a doubly useful indicator as it also assess fire risk. The more area in the earlier age classes, the lower the risk of fire. The most harvest area available, the easier it is to regulate and balance the age classes, as the no buffer scenarios indicate.

Forest ages

Indicator & Target Rationale

This target seeks to identify stands that are greater than 200 years old based on their percentage of the forest[62].

Forest Ages Results

Trends indicate that without harvest, the percent of old forest increases to as much as 37 % in no harvest scenarios. Even with harvest, old forests are approximately 30 %. The baseline harvest scenario eliminates old forest by period 100. In either case, the target is not being met as there is either too much old forest or not enough.

Discussion

This target can be used to assess fire risk on the *keyoh*. Without harvest, fire risk increases and it may be necessary to pursue fire management strategies (Page 28). In scenarios with no harvest or in the one harvest zone scenario, it is important to monitor these areas, as they may be prone to disease outbreaks in addition to fire.

Land disturbed

Indicator & Target Rationale

This target indicates that 0.75-1.25 % of the land base should be disturbed per year [63].

Land Disturbed Results

All scenarios have some level of disturbance except for the no harvest scenarios. However, many scenarios do not meet the 0.75-1.25% target. The only scenario that meets the target in every time period is the expanded harvest zone that maximizes volume.

[62] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

[63] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

Discussion

This target was applied to the entire *Daiya-Mattess Keyoh* even though half of the *keyoh* is in the Cultural Heritage Zone. If it were evaluated based on the disturbance in the harvestable area, the results would be quite different. It is also important to remember that disturbance is constantly taking place in the same areas- areas being harvested. This is not ideal unless the rotations are longer which allows stands to recover and provide habitat.

Socio-Economic

Maintain and enhance long-term benefits to the *Daiya-Mattess Keyoh*

This objective addresses concern for the well being of Ken Sam's family, and seeks to identify scenarios which practical to implement and have the potential to fund other treatments.

Revenue Generated

Indicator & Target Rationale

Analysing the revenue generated in each scenario seeks to identify the most practical scenarios for implementation. If a scenario does not generate much revenue, then it will likely not be able to cover the costs of implementation.

Revenue generated Results

The results for this target are predictable. The scenarios that allowed the most timber harvesting yielded the best revenues. Scenarios that generated carbon yielded high revenues, but also have high implementation and start-up costs.

Discussion

Revenue is a consideration to fund other treatments such as planting and road deactivation. While it isn't a high priority for *Daiya-Mattess Keyoh* holder Ken Sam, it was examined to ensure treatments were feasible, and to determine which treatments were possible and practical.

Job Creation

Indicator& Target Rationale

Job creation examines how much benefit the Sam family sees either by providing jobs within the family or within the Fort St. James Community. This may be a more important consideration in the future. For now, it helps to provide a sense of the labour involved for each treatment in that the more jobs, the more work a treatment requires, and the more it will cost.

Job creation Results

The jobs created by harvesting scenarios are the most consistent through time. Jobs created through planting and road de-activation treatments are 12 and 5 respectively, but only occur in period 0.

Discussion

While jobs created by road de-activation occur only in period 0, in reality they may be spread through time, as it may not be realistic to pay for the road-deactivation treatments in one lump sum. It is also important to note that while jobs related to harvesting only occur for each 20-year.

4.0 Conclusion: Recommended Strategies

This section is meant to provide guidance for *Daiya-Mattess Keyoh* holder Ken Sam in his pursuit of management options for the *Daiya-Mattess Keyoh.* This section is based on the evaluated scenarios findings (Table 5).

To determine recommended strategies, the top scenarios from the Ecological and Cultural Evaluation Table (Appendix 8) were compared in addition to the road-deactivation, planting and buffer treatments. These scenarios were then ranked against one another to determine the scenario which best met all of the values.

Table 5: Top scenarios based on the Ecological and Cultural Evaluation Table (see Appendix#: ecological and cultural evaluation table). The scenarios were ranked against one another to determine the top scenarios overall (see bottom row). In some cases, scenarios were tied. The "Ranked out of..." column shows in which values scenarios had equal results. Colours are associated with the rankings (dark green = 1, medium green = 2, light green = 3, white = 4, >5 = yellow).

		Scenarios						
Value	Ranked out of...	4_Z_G	B_Z_G	B_Z_G_80	Combo_Z_G_35	Road De-activation	Planting	Buffers
Wildlife	Out of 5	4	2	5	3	1	1	1
Water	Out of 4	3	3	3	2	1	4	4
Heritage	Out of 4	3	3	3	2	1	4	4
Forest	Out of 5	4	3	1	2	5	5	5
Socio-Economic	Out of 7	7	5	2	4	3	6	1
Overall	Out of 3			1	2	3		

The expanded harvest zone is the best option to pursue. Having a larger area available to harvest not only generates more revenue, it allows habitat maintenance for species requiring early seral stages and allows the emulation of natural disturbances. This option also maintains protection of culturally significant areas and water quality through the application of buffers. Culturally significant areas were applied with 1 km radius buffers, the Salmon River has 200 m buffers, streams have 100 m buffers and lakes have 60 m buffers. While harvesting in an expanded area requires access remain open, roads can still be deactivated in the cultural heritage zone.

The suggested minimum harvest age (MHA) is 80 years as it creates more natural age distributions. While seral stage distributions are still favoring late seral (Figure 32) and old forest ages (>200 years), there is a better representation of the younger age distributions (Figure 33). The land disturbed in the 80-year minimum harvest age case is more regular and within the range than the base case expanded harvest zone (Figure 34). In addition, the 80-year MHA generates more revenue than the base case (Figure 35).

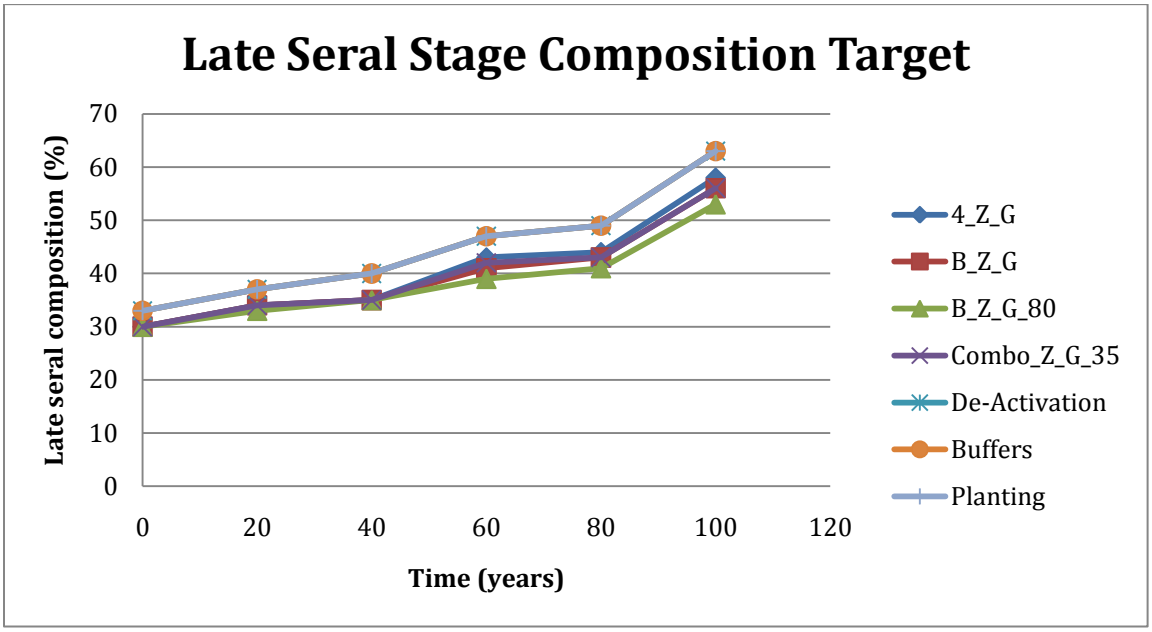


Figure 32: A comparison of the top management treatment scenarios and their late seral stage composition target results. The target was to have a minimum of 17% late seral. The concern is that too much late seral will create a fire hazard. B_Z_G_80 does the best job of meeting the target while posing less of a fire hazard than the other scenarios. Note the increases in all scenarios around period 40. Fire hazard assessment should begin around period 40.

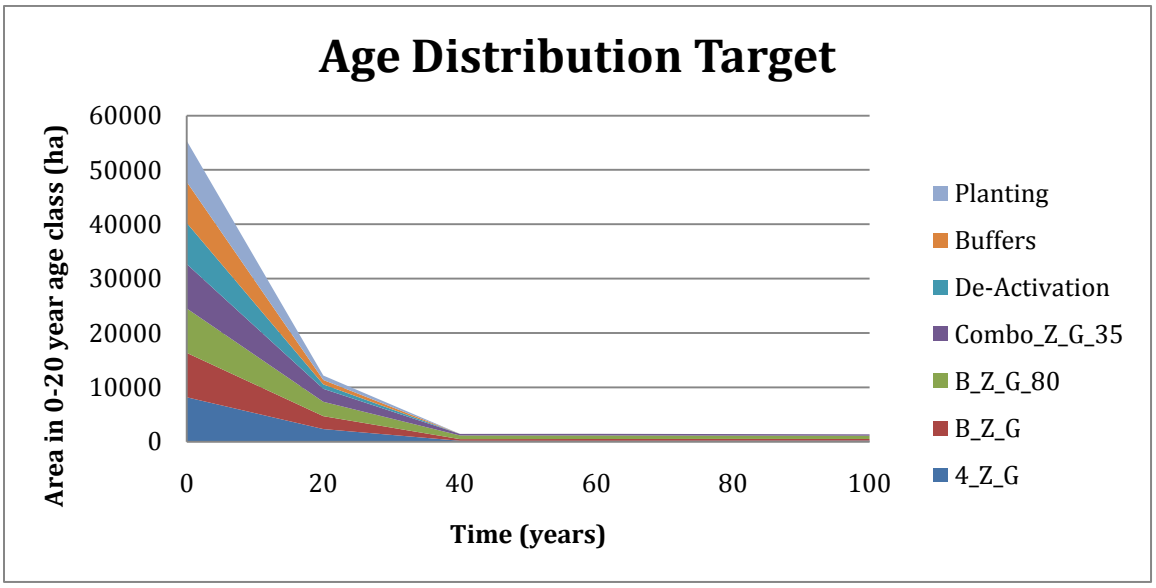


Figure 33: A comparison of the change in early age class (0-20 years) through time. The target is to maintain early age distribution classes. None of the scenarios do a very good job of this, though some fare slightly better than others. The trend in Figure 1 is echoed here in that by period 40, there is very little 0-20 age class remaining.

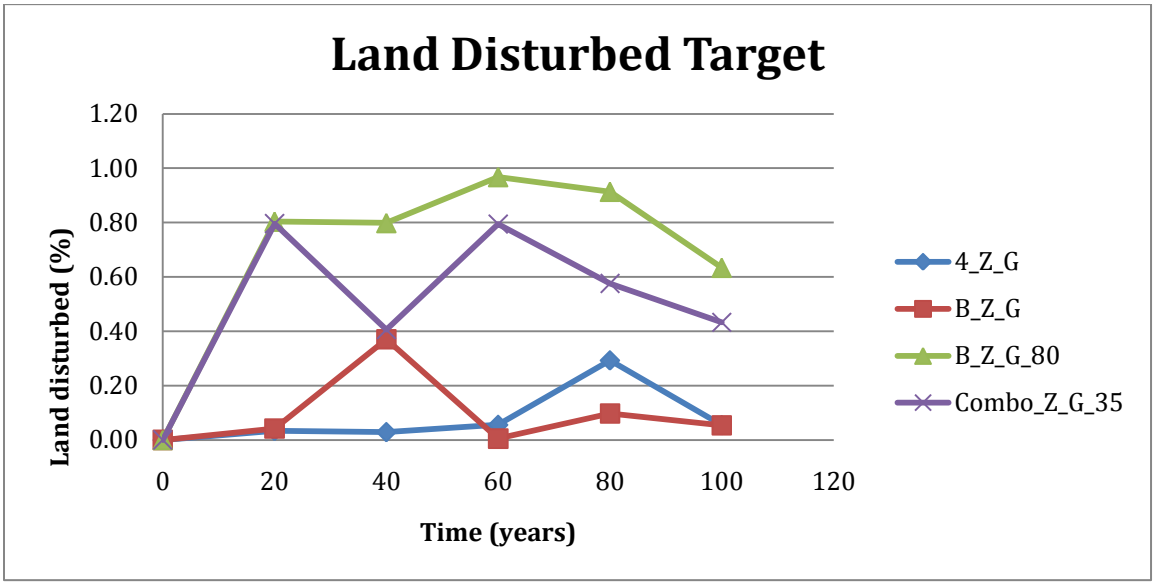


Figure 34: Compares disturbed areas between top four harvesting scenarios. The de-activation, buffer and planting treatments are excluded from this graph as they experience no disturbance since they are no harvest scenarios. The target is 0.75-1.25% of the landbase disturbed per year.

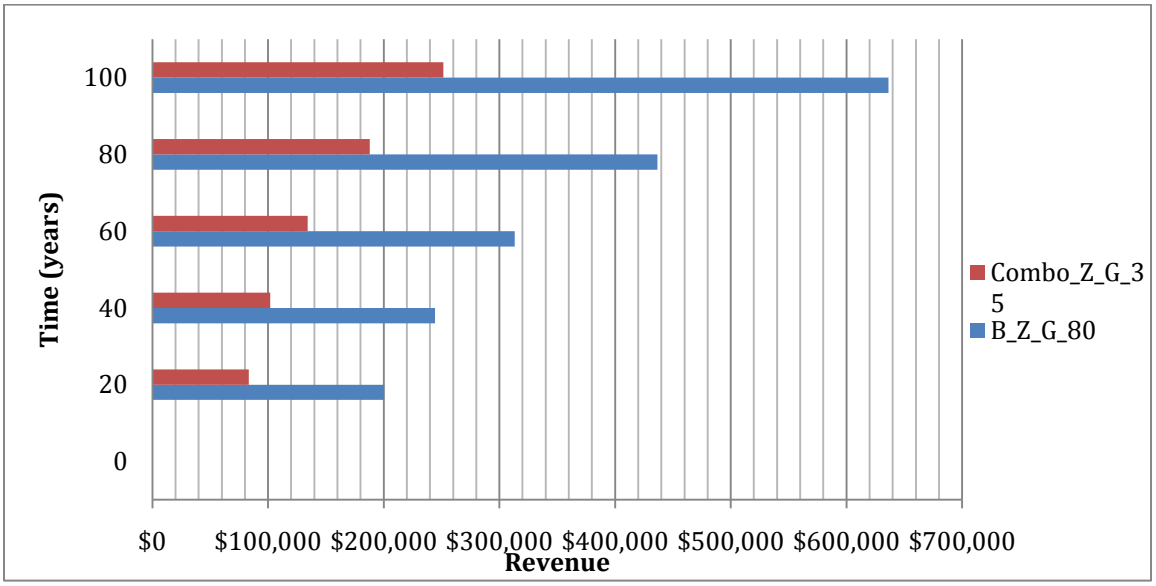


Figure 35: A comparison of the revenue generated in the top two harvesting scenarios.

In order to counter the accumulation of older forests, it is important to emulate natural disturbances. Disturbances often target older forests and in this case, it is important to prioritize harvests based on stand age. Fire often does this in nature due to the accumulation of fuels in old forests. Emulating natural disturbances is the recommended management approach, as this will help guide management decisions and will produce

stands with increased biodiversity and more natural species compositions that do not necessarily favour the most valuable tree species.

Thoughtful planning is also important to successfully managing the *Daiya-Mattess Keyoh*. There are many signs that monitoring will be required on the landbase, in part to ensure that treatments and strategies are appropriately implemented, but also to track the accumulation of old forest. The species compositions are showing signs that humans may have altered the natural composition to favour lodgepole pine. Based on historical knowledge of the *keyoh*, Ken Sam should consider whether this should be continued, or whether focus should be shifted to efforts to increase planting spruce and subalpine fir. In planning harvested areas, it is important to create harvest openings of variable sizes and with variable edges to emulate fire. Harvest blocks should be laid out to avoid fragmentation and creating small openings rather than large openings. Before any decisions are made, the land should be fully assessed so management decisions are informed and in the best interest of the *Daiya-Mattess Keyoh*.

The conclusions of this management plan are meant to help guide management on the *Daiya-Mattess Keyoh*, but there is no perfect answer in managing forests.

5.0 Business Plan

5.1 Carbon

Methods

In our project for *Daiya-Mattess Keyoh*, scenarios were established for managing the forests and improving the biodiversity. These scenarios include planting and harvesting, and were applied to various managed areas. The idea of a carbon project was considered, though not all requirements may be physically met, to help fund proposed actions in the management plan. The carbon analysis complies with the standards and procedures of creating a carbon project, but cannot necessarily be properly implemented without further action. Thus, the objectives of the carbon analysis research the possible impacts of our scenarios on the ecosystem by estimating the potential carbon credits the forest can generate under the scenarios.

In order to overcome problems related to carbon credit calculations, and to just generate a brief analysis on the potential of carbon within our scenarios, four assumptions were made.

First of all, it was assumed that each discrete area of managed land to be included in the boundary is eligible for a carbon project. Therefore, it was consider that all areas within the *Daiya-Mattess Keyoh* can be part of the carbon analysis. Approved afforestation and reforestation baseline methodology, AR-AM0005, was used[64].

Secondly, it was assumed that carbon pools included within the project boundary were found respectively aboveground, belowground, dead wood, litter, and soil organic carbon. Total ecosystem carbon stocks were used as the indicator for Greenhouse Gas (GHG) emission reduction and removal by our managed forest. As well, the issue of gases considered from emissions by sources other than stocks in carbon pools is neglected in this carbon analysis.

Thirdly, the project activity area is supposed to be homogeneous, meaning stratification was not applied to improve the accuracy and the precision of biomass estimates.

[64] Carbon. (2009). *Approved afforestation and reforestation baseline methodology AR-AM0005: Afforestation and reforestation project activities implemented for industrial and/or commercial uses.*

Fourthly, the crediting period is assumed to be 100 years.

Based on the aforementioned hypotheses, Total Ecosystem Carbon (TEC) stocks changes were considered the basis for the management scenarios and baseline scenarios. This is the indicator of the additionality for GHG emission reduction and removal by our management scenarios.

The Equation used for each period was:

Equation 1: Net TEC Change

Net TEC Change = TEC of Management Scenario – TEC of Baseline

Equation 2: Total TEC Change

Total TEC Change = Σ Net TEC Change for Period n (n=0, 1, 2 ……10) = The Sum of Net TEC Change from Period 0 to Period 10 (From Year 0 to Year 100)

Throughout the *Daiya-Mattess Keyoh*, planting and harvesting scenarios were completed. For each scenario, clique combinations were derived, and two different baselines were set. These were respectively set according to Ken Sam's baseline and Canfor's baseline.

Planting Scenarios

Each planting scenarios was classified into 10 different cliques, according to the management plan. Here's a description for these cliques:

Clique 2: Deactivated roads- Cultural Area
Clique 3: Salmon River buffer
Clique 4: Streams buffer
Clique 5: Lakes buffer
Clique 6: Pine NSR
Clique 7: Land use sites buffer
Clique 8: Pine Biodiversity Plant
Clique 9: Spruce Biodiversity Plant
Clique 10: Spruce NSR
Clique 11: Deactivated Roads- Harvest

Several planning options were created for each clique combination. These can be seen below in Table 6.

Table 6: Planting options created for each clique combination

Option No.	Clique Combinations	Description
1	8	Pine Biodiversity Plant
2	9	Spruce Biodiversity Plant
3	8&9	Biodiversity Plant(Pine & Spruce)
4	6	Pine NSR
5	10	Spruce NSR
6	6&10	NSR Plant(Pine & Spruce)
7	2	Road Re-vegetation------Cultural Area
8	2&11	Road Re-vegetation----Cultural & Harvest Area
9	3,4,5&7	Salmon River buffer, Stream buffer, Lakes buffer & Land use sites buffer

Harvesting Scenarios

Six harvesting zones were created for each harvesting scenarios according to the zones. Below is a description of the harvesting scenarios for each zone (Table 7).

Table 7: Harvesting Scenarios for each zone

Zone	Total Area (ha)	Unproductive Area (ha)	Productivity (%)	Net Area (ha)
Total Area	28583	3848		24734
Cultural Heritage Zone	12483	1917	58	10566
Expanded Harvest Zone	12705	1418	57	11286
Harvest Zone 1	3059	206	53	2853
Harvest Zone 2	3022	136	58	2885
Harvest Zone 3	3643	891	59	2752
Harvest Zone 4	2981	185	58	2796
No Harvest area	3395	513	54	2882

Several harvesting options were created for each zone combinations as seen in Table 8.

Table 8: Harvesting options created for zone combinations

Option No.	Zone Combinations	Description
1	2	Cultural Area
2	3 / 4 / 5 / 6	Rotating Zones

		Gradual harvests, 100 years rotation
3	3 & 5	**Combined two harvest zones** **Gradual harvests, 80 years rotation**
4	3 & 5	**Combined two harvest zones** **Gradual harvests, maximize volume**
5	3,4,5 & 6	**Expanded harvest zone** **Gradual harvests, 80 years rotation**
6	**3,4,5 & 6**	**Expanded harvest zone,** **Gradual harvests, maximizing volume**

By using Equation 1 and Equation 2, we're able to compute the net carbon change between management scenario and baseline in each period for each option, and then calculate the total carbon mass change in 100-years period for each option. And graphs are plotted to illustrate the trend of baselines and management scenarios.

For example:

For Period 1 in "Biodiversity Pine Plant" Option,
TEC (Management Scenario) = 190628 tonnes
TEC (Canfor's baseline) = 154690 tonnes
Net Carbon Change= 190628-154690=35938 tonnes

By using this equation, Net Carbon Change for each of other periods can be calculated. Finally, summing up Net Carbon Changes of all of these periods, we can find that Total Carbon Mass Change=288127 tonnes.

Results

By using the database processed by CBM and ATLAS, Total Carbon Mass Change for each scenario was obtained and compared in the following tables to including planting options and harvesting options (Table 9 and 10).

Table 9: A table showing TEC changes among different planting scenarios

Description	TEC Change for Ken Sam's baseline	TEC Change for Canfor's baseline
1. BioDi Pine Plant	252345	288127
2. BioDi Spruce Plant	36530	58002
3. BioDi Plant	288875	346129
4. NSR Pine Plant	-4966	199559

5. NSR Spruce Plant	8581	19144
6. NSR Plant	3615	218703
7. Road Re-vegetation- Cultural	621692	621692
8. Road Re-vegetation- C & Har	1228833	1228833
9. Buffers	0	7575862

Table 10: A table illustrating TEC changes among different harvesting scenarios

Description	Scenario 1 for Ken Sam's baseline	Scenario 1 for Canfor's baseline	Scenario 2 for Ken Sam's baseline	Scenario 2 for Canfor's baseline
Cultural Area	0	1885893	None	None
Rotating Zone 3	-30087	463610	None	None
Rotating Zone 4	-52819	479312	None	None
Rotating Zone 5	-31888	60738	None	None
Rotating Zone 6	-39545	-89090	None	None
Combo Zones 3-5	-270014	316309	-78563	507760
Big Harvest Zone	-393714	675195	-163766	905143

Planting Scenarios

In plotted graphs, Baseline (No Harvest) stands for the baseline set under the requirements by Ken Sam, and Baseline (Harvest) represents the baseline that we assume Canfor would apply in the future.

Referring to Table 9, under Ken Sam's baseline, it can be found that the scenario of Road Re-vegetation- Cultural & Harvest is able to lead to the most GHG emission reduction & removal, followed by Road Re-vegetation- Cultural. Under Canfor's baseline, the scenario of buffers is capable of reducing much more GHG emission than Road Re-vegetation-Cultural & Harvest.

From Graph 1, 2 and 3, (Appendix 6, Figure 52, 53, 54 respectfully) it can be found that Baseline (No Harvest) Curves and Scenario increase gradually, but Baseline (Harvest) Curves drop sharply in approximately Period 7.

As can be found in Graph 4, 5 & 6 scenarios (Appendix 6, Figure 55, 56, 57 respectfully). Curves decrease significantly in the beginning periods. This is caused by our calibration on the starting points of the curves. TEC values of Baseline

(Harvest) in Period 0 should have been the same to the values of Baseline (No Harvest), based on the fact that none of planting strategies is applied to the forest in our management scenario in the Period 0. In order to reduce the bias, we calibrate the TEC values of Baseline (Harvesting) to be the same to that of Baseline (No Harvest).

For Graph 7 & 8 (Appendix 6, Figure 58 and 59), the curves for Baseline (No Harvest) and Baseline (Harvest) keep at the value of 0 due to no deactivation to existing roads.

For Graph 9 (Appendix 6, Figure 60), as no strategies are applied in management scenario, the curve of management scenario and the curve of Baseline (No Harvest) coincide.

Harvesting Scenarios

Referring to Table 10, for Combo Zones 3-5, Scenario 2 will be a better choice to manage the forest, which is gradual harvesting and maximizing volume. For Big Harvest Zone, Scenario 2 will be better than Scenario 1, which is gradual harvesting and maximizing volume. As can be seen from Table 2, the scenario for Cultural Area will be the most likely to maintain the capability to sequestrate GHG.

For Graph 10 (Appendix 6, Figure 61), the curve for management scenario and the curve for Baseline (No Harvest) coincide. This is because we don't apply any harvesting activities to cultural area in management scenario.

In Graph 11, 12, 13, 15 and 16 (Appendix 6, Figure 62, 63, 64, 66 & 67 respectively), harvesting activities in Baseline (Harvest) cause significant reduction in TEC. So it can be found that there is greater additionality between management scenarios and Baseline (Harvest).

As can be seen from Graph 14 (Appendix 6, Figure 65), Baseline (No Harvest) is similar to Baseline (Harvest). So TEC Changes for two baselines are close.

5.2 External Funding

There are many avenues for funding the management options being pursued on the Daiya-Mattess Keyoh. However, some of these avenues are less achievable and realistic than others. Some of the most generous philanthropists in the United States and their foundations are possible options. These foundations include: Gordon and Betty Moore Foundation, Donald Bren Foundation, Ted Turner Foundation. They fund environmental and conservation related projects but are strictly by invitation only and generally deal with larger scale projects.

Another option is from funding through the Canadian Federal Government. The Natural Resources of Canada has a First Nations Forestry Program that fund first nations groups to improve economic conditions and promote sustainable forest management. Moreover, the funding is used to improve the capacity of first nations and help them develop and sustainably manage their resources. This appears to be one of the more feasible and obtainable options compared to the other foundations and organizations.

A third option is funding from foundations such as the Koerner Foundation, Tides Canada and Ducks Unlimited. An issue with this funding option is that some of these Non-Governmental Organizations (NGO's) offer protection through acquiring or joint acquiring of the land and the chance of funding is very low.

5.3 Research Forest Proposal

Research forests are often established through special use permits, or crown grants given to a specific party with the intention of providing a research, demonstration and education facility in an outdoor environment. Generally, research forests need to be partnered with a certified university, and need to be created with the intent of creating jobs that will benefit local economies. Although zoning can occur to preserve areas of cultural significance, funding to support these forests are generally created through large scale harvesting on the landbase.

Obtaining the rights to create a research forest can be a complex and lengthy process. Areas of land in question need to have certain characteristics in order to be considered for academic use by both a university and the government. The ability to be used for multiple uses and co-management research is key making characteristics like big lakes, mines, geological fault lines, and old growth very important.

5.4 Non-Timber Forest Products

Most Non-timber forest products (NTFP)[65] are collected and sold at farmer's markets. Aside from the seed cone industry and the nursery business, NTFP's generate less than a gross annual income of $30,000.

The seed cone industry provides the greatest contribution to the regional economy and generates $700,000 annually. Mushrooms are another common NTFP but it is hard to determine exact numbers for this industry because pickers are very secretive about their harvest areas and typically reluctant to share harvest information.

Various species of wild berries are picked and turned into jam, jellies, fruit spreads, etc. The production of these goods occurs on small scale and none of it can be considered a

[65] Carla Burton. (2006). *A Regional Profile of Commercial Harvesting of Non-Timber Forest Products in the Prince George, British Columbia Area.* Prepared for The Centre for Non-Timber Resources, Royal Roads University. Victoria, British Columbia.

commercial business since annual sales are less than $1000-2000. Other types of edible non-timber forest products include honey and fiddleheads.

Non-timber forest products are also used to produce herbal cosmetics. Natural soaps, bath products and other skin lotions are a few of the products being made in the Prince George area. This is a small industry, generating less than $30,000 annually.

Arts and crafts such as boxes, picture frames, tool handles are made from waste wood and waste sources usually commonly found in recent forest cutblocks. This business again generates less than $30,000 in sales annually.

A potential business venture in the Prince George and surrounding area is utilizing non-timber forest products are floral greens. However, the work involved is seasonal and considered part-time work. Moreover, a few contacts that were surveyed complained that the greens native to the area were “not green enough.”

Appendix 1: Wildlife

Moose[66]

Moose are a common source of food, clothing and implements in the *Daiya-Mattess Keyoh*. They are widely distributed across British Columbia and are most commonly found in the central and sub-boreal interior, the northern boreal mountains, and the boreal plains of north-eastern British Columbia. Snow depth and sufficient supply of winter browse dictate population densities. Typical winter population densities vary from 0.3 moose per square km to 1.5 per square km. They roam between their summer and home ranges that are roughly 5 to 10 square km. Moose are well adapted to travelling through deep snow and studies have shown that they are adept at moving through snow up to 40cm deep and only slight difficulties in snow depths of 40 to 70cm deep. The seasonal movements of the moose can be attributed to the depth and duration of snow cover. They are commonly found near lakeshores, swamps and Beaver ponds. In the winter, they are attracted to river valleys that cut through the plateaus and in burns, logged areas, and wetland complexes. Logging is mostly detrimental to the moose. Although, it may provide abundant browse in cutblocks but a lack of forest cover reduces hiding cover, shade in hot weather and for shelter during severe winter storms.

Beaver

The ideal habitat for a beaver is along slow-moving sections of rivers and streams and on ponds and lakeshores. They are attracted to muddy shores and stable streams and avoid areas with rock and gravel, which make burrowing, channelling and damming difficult. In northern areas with waters that freeze in the winter, an accessible supply of woody vegetation is vital for a sufficient supply of winter food. The best beaver colonies are found in newly established stands of poplar that regenerated from disturbances. Poplar stands can support beaver populations 8-10 years after a burn, but it usually takes 20-30 years to produce poplar stands large enough to provide a steady supply of food[67]. Fire suppression has reduced the amount of aspen stands and consequently renewed beaver habitat. Logging may also change drainage patterns and alter velocities of streams that were once stable. Beavers are primarily nocturnal animals and stay in well-defined area within range of their home.

Wolverine[68]

---

[66] Blood, D. (2000). *Moose in British Columbia*. Retrieved on February 5, 2011 from http://www.env.gov.bc.ca/wld/documents/moose.pdf

[67] Hatler, D., Beal, A. (July 2003). *Furbearer Management Guidelines*. Retrieved on February 5, 2011 from http://datafind.gov.bc.ca/cs.html?url=http%3A//www.elp.gov.bc.ca/fw/wildlife/trapping/docs/beaver.pdf&charset=utf8&qt=url%3Awww.elp.gov.bc.ca/fw+%7C%7C+beaver+trapping&col=bcgovt+blogs+govdaily+qlinks&n=3&la=en

[68] R.D. Weir. (2004). *Accounts and Measures for Managing Identified Wildlife – Accounts V*. Retrieved on February 5, 11 from http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Mammals/m_wolverine.pdf

Wolverines are common in low elevations and across most of British Columbia. They range from valley bottoms to alpine meadows but are less common at higher elevations due to a lack of food. Male wolverines have home ranges of roughly 1000 square km while females occupy 300 square km. They spend large amounts of time in forests that are at the mature and old structural stage. However, because they are dependent upon many different food sources, they also need a wide range of stand structures. Human activities and transportation corridors are detrimental to wolverine movements around the landscape. Moreover, activities such as logging can cause habitat fragmentation, as wolverines will often avoid young cutblocks. Wolverines are especially susceptible to population threats because of their low densities, large home ranges and low reproduction rates. Management strategies include: limiting the amount of roads and access, maintaining a mosaic of structural stands and creating habitat corridors between cutblocks.

Caribou[69]

Caribou require a variety of habitats at different elevations. They occupy different ranges depending on the season so caribou depend on both old growth forests and open habitats. In the winter, caribou migrate from high elevation summer ranges to lower elevation sites. They feed predominantly on terrestrial lichens and consequently they are attracted to drier sites or sites with low productivity such as old growth forests, which are rich in lichens. Old growth forests also have many vital attributes and features that make it an important habitat. Firstly, old growth forests have large crowns that provide good snow interception, which improves winter movement. Secondly, there is more visibility in old growth forests due to open stand structures and less under brush, which leads to an improved ability to detect predators. Thirdly, arboreal lichen such as Bryoria is only abundant in old growth forests.

Sandhill Crane[70]

The sandhill crane is a species at risk in British Columbia due to its small population and threats to its nesting habitat. Due to the size and vastness of crane nesting sites in British Columbia, some information such as population data is not listed with confidence. Sandhill cranes are widely distributed throughout North America. In the Cariboo-Chilcotin area in British Columbia, where most of the nesting cranes are found, common habitat is sedge dominated wetlands surrounded by coniferous forest. Moreover, these wetlands have convoluted shorelines with many bays. Dense bulrush marshes in rangelands are also a common nesting habitat and it appears that there is greater preference for an isolated habitat over amount of water and in size. During migration, they use swampy fields, the edge of

[69] Cichowski, D., Kinley, T., Churchill, B. (2004). *Accounts and Measures for Managing Identified Wildlife – Accounts V*. Retrieved on February 5, 11 from http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Mammals/m_caribou.pdf

[70] Ministry of Environment, Lands and Parks. (1999). *Sandhill Crane: small populations and threats to nesting habitat put this species at risk in British Columbia.* Retrieved on March 20, 2011 from *www.env.gov.bc.ca/wld/documents/sandhillcrane.pdf*

wetlands, dry rangelands, grain fields and estuarine meadows as stopover sites. Crane nesting sites are harmed by agricultural land development and logging. Logging projects that remove tree buffers around water bodies can expose nesting wetlands to disturbance.

Fisher[71]

The fisher is a provincially blue listed species. It has a home range of 32 square kilomoters for females and between 19-79 square kilometers for males. They forage within non-vegetated through to tall shrub structural stages but their most common habitats are associated with mature forests and old growth forests. Features such as coarse wood debris, wildlife trees and canopy cover are key to denning habitats. Moreover, fishers generally stay near forests with 30% canopy closure with a dominant understory. The main long-term threat to this species is human development on forested lands resulting in a loss of habitat. Fishers require a large spatial habitat and the loss of contiguous forests cause a major conservation challenge.

American White Pelican[72]

The American White Pelican has been legally designated as an Endangered Species in British Columbia and is red listed under sensitive species. This is due to the fact that British Columbia has only one nesting colony of this species. The colony is situated in Stum Lake, 70 kilometers west of Williams Lake. The species has been rebounding from roughly 100 nests in the early 1980's to over 400 in 1993. They are migratory birds and leave their southern winter homes in March to nest in British Columbia, specifically Stum Lake. The government of BC has provided protection to the nesting colonies by giving Provincial Park Status to Stum Lake and the surrounding lands. The preferred nesting sites are islands that are flat, have bare ground and are covered by minimal tree and shrub growth. Moreover, the habitat is situated close to the water but far enough to avoid waves.

Table 11: Culturally Significant Animals and Characteristics

Animal	Habitat and Ecological Relationships	Values and Uses	Conservation
White-tailed Deer[73]	Valley bottoms are the main habitat. Best summer ranges are in well-developed riparian habitats. Winter ranges are on south to	Heavily relied on for food and clothing. Antlers were made into tools and	Not at-risk in BC but human activity has put pressure on their habitat. Several areas are undertaking

[71] Ministry of Water Land and Air Protection. 2004). *Accounts and Measures for Managing Identified Wildlife: Northern Interior Forest Region.* Retrieved on March 21, 2011 from http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Accounts_and_Measures_North.pdf

[72] Ministry of Enironment, Lands and Parks (1993). *American White Pelican: British Columbia has only one nesting colony of the provincially endangered American White Pelican.* Retrieved on March 19, 2011 from *www.env.gov.bc.ca/wld/documents/pelican.pdf*

[73] Ministry of Environment, Lands and Parks. (2000). *White-tailed Deer: In British Columbia*. Retrieved on March 22, 2011, from *www.env.gov.bc.ca/wld/documents/whttail.pdf*

	southwest facing slopes where the understory has developed after a disturbance event In summer, migrates to floodplains and cultivated fields where they find forage	ornaments; sinews became bowstrings, fishing lines, and thread. Not as abundant in BC therefore less are hunted	habitat enhancement measures, such as prescribed burning and logging.
Mule Deer[74]	Old-growth forests are critical for survival. They provide shelter, snow interception, and food in the form of lichen. In summer, migrates to higher elevations. Cannot survive in alpine zones in winter due to difficult moving through snow deeper than 30cm	Traditionally, heavily relied on for food and other products. Recreational hunting has been popular since WWII and in BC it is worth millions of dollars	Has been fairly resilient to expanding civilization and are not species at risk. Habitat loss has occurred as a result of mining, highways, agricultural land development, forestry
Black Bear[75]	**Home ranges are of adult males are 25 to 150km^2 while adult females are 5 to 25$km2$. They are typically in wooded areas that provide cover. Black bears avoid open areas when travelling between foraging sites. Habitats include forests, wetlands, subalpine meadows, riparian habitats and beaches. Listed as an omnivore, but it functions primarily as a herbivore and secondly as a carnivore.**	**In the past, First Nations included the black bear in traditional ceremonies and mythology. The meat was used fresh or dried for the winter. Along with other large carnivores that symbolize wilderness, the black bear is a major tourist attraction.**	**Not at risk in BC but conflicts between people and bears are of concern. Up to 1000 black bears are killed every year due to serious conflicts with people. Improperly disposed garbage is the prime cause of human-bear conflict in BC.**
Muskrat[76]	Found in aquatic habitats	Has been one of the	Productive muskrat

[74] Ministry of Environment, Lands and Parks. (2000). *Mule and Black Tailed-Deer in British Columbia*. Retrieved on March 22, 2011, from www.env.gov.**bc**.ca/wld/documents/**muledeer**.pdf

[75] Ministry of Environment, Lands and Parks. (2001). *Black Bears in British Columbia.* Retrieved on March 22, 2011, from www.env.gov.bc.ca/wld/documents/blackbear.pdf

[76] Halter, David, et. al. (2003). *Muskrat.* Retrieved on March 23, 2011, from www.env.gov.bc.ca/fw/wildlife/trapping/docs/muskrat.pd

	that feature a body of fresh water, usually standing or slow moving. The most productive habitats are marshes and lake or ponds that can support growth of plants but won't freeze to the bottom in winter. Cattail is the main source of food, making up 80% of its diet. Home range is roughly 100m from their den. Limited distribution in BC due to mountainous terrain but abundant in wetlands.	most valuable furbearers in North America generating as much as $30 million in the 1980s. Also used as a source of food	habitat is in the lowland areas that are also commonly occupied by humans. Controlling water levels is the most important method of improving muskrat habitat.
Rusty Blackbird[77]	Common habitat includes slow moving streams, peat bogs, sedge meadows, marshes and swamps. In the winter it nests in primarily damp woodlands and cultivated fields. Over 70% of the breeding range is in the boreal forest.	Blackbirds and sometimes considered pests and may be killed if they cause damage human property.	Listed as special concern in COSEWIC given that 70% of the breeding range is in Canada. Agriculture and urban development is the main cause of habitat loss.
Common Nighthawk[78]	Habitat includes open areas where there is no vegetation such as sand dunces, beaches, logged areas and forest clearings.	One of the only species of insectivorous bird that is both crepuscular and widely distributed in Canada.	Listed as threatened by COSEWIC. 49% decline in some areas over the last 3 generations.

[77] COSEWIC. (2006). *COSEWIC Assessment and Status Report on the Rusty Blackbird in Canada. Retrieved on March 23, 2011, from dsp-psd.pwgsc.gc.ca/Collection/CW69-14-495-2006E.pdf*
[78] COSEWIC. (2007). *COSEWIC Assessment and Status Report on the Common Nighthawk in Canada.* Retrieved on March 23, 2011, from *dsp-psd.pwgsc.gc.ca/collection_2007/ec/CW69-14-515-2007E.pdf*

Appendix 2: Aquatic Species

Salish Sucker (Catostomus sp. 4)

A survivor of the ice age, the Salish Sucker is found only within a few small freshwater lakes and streams throughout wetland areas of British Columbia (BC) and the United States. More specifically, in BC it is only found within the Chilliwack, Fort St. James and Prince George Forest District[79]. Smaller than other suckers, the Salish sucker reaches a maximum size of approximately 25 centimeters in length. They are often found in the headwaters of small streams, or areas with relatively deep pools with plenty of well established aquatic vegetation[80].

Mainly agricultural activities, urbanization and low oxygen levels threaten the Salish Sucker[81]. Its current status entails[82]:

- COSEWIC: Endangered
- BC Status: Red listed
- SARA: Schedule 1

White Sturgeon (Acipenser transmontanus pop. 3)

The white sturgeon is one of the largest freshwater fish in Canada mainly restricting them to large rivers of the Pacific Northwest[83]. Six distinct populations of white sturgeon occur within BC, the Nechako River population being the one affected in the Fort St. James region. Among rivers, they are also found within estuary, inshore marine, and lake environments. In their adult stage, large, deep mainstream pools are preferred, where as juveniles prefer the outreaches of tributaries. Declines in numbers are attributed to over fishing and habitat degradation and fragmentation[84]. In the Nechako and Fraser River however, population numbers have declined due to failed reproduction due to dams and river regulations[85]. The white sturgeon is currently listed below, even though conservation measures are in place.

---

[79] Pearson, Mike and Healey, M.C. (2011). *Species at Risk and Local Government: a Primer for BC*. Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 7, 2011.

[80] Environment Canada. (2004). *Aquatc Species at Risk - Salish Sucker*. Retrieved Feb 6, 2011, from Fisheries and Oceans Canada: http://www.dfo-mpo.gc.ca/species-especes/species-especes/salishsucker-meuniersalish-eng.htm

[81] Environment Canada. (2004). *Aquatc Species at Risk - Salish Sucker*. Retrieved Feb 6, 2011, from Fisheries and Oceans Canada: http://www.dfo-mpo.gc.ca/species-especes/species-especes/salishsucker-meuniersalish-eng.htm

[82] Environment Canada. (2009). *Species at Risk and Local Government: Salish Sucker.* Retrieved Feb 6, 2011, from District of Squamish: http://www.speciesatrisk.bc.ca/node/7846

[83] Environment Canada. (2011). *Species at Risk and Local Government: White Sturgeon (Nechako River Population).* Retrieved Feb 6, 2011, from District of Squamish: http://www.speciesatrisk.bc.ca/node/8279

[84] Pearson, Mike and Healey, M.C. (2011). *Species at Risk and Local Government: a Primer for BC.* Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 6, 2011 from: http://www.speciesatrisk.bc.ca/node/8279

[85]

- COSEWIC: Endangered
- BC Status: Red Listed
- SARA: Schedule 1

Dolly Varden (Salvelinus malma)

Named after its colourful fashion, the Dolly Varden occurs in coastal drainages of all sizes around BC. They can be found in riparian, lowland stream and river systems, lakes and estuary environments[86]. Juveniles rear in all forms of freshwater streams, where as adults are free to migrate between fresh and salt water. Spawning in the fall, fry are able to emerge from the gravel in April. This makes the timing of forest harvesting key to this species survival. Although this species is only blue listed in BC, non-native species of brook trout are one of the major declines in some watersheds throughout the province[87].

Bull Trout

The bull trout is found throughout various parts of western North America, but specifically in BC, it is found throughout the interior. Though it is relatively abundant species in BC, it is not found in any of the large coastal rivers throughout the province, making it limited to highly vulnerable, sensitive river estuaries and small streams. Being a cold-water species, the bull rarely inhabits water warmer than 15^0C[88]. Due to warming stream temperatures throughout the Fort St. James Forest District, this makes it increasing hard for this species to survive in the area. The two largest threats of this species include angling and water quality degradation[89], which has made it a blue listed species throughout the province.

Kokanee Salmon (Oncorhynchus nerka)

A landlocked version of Sockeye Salmon, Kokanee live at mid depths in the open waters of lakes[90]. When it is time to spawn, this species travels to neighbouring tributary streams or settles for the shoreline of lakes. Although this species is only yellow-listed in BC, it is relatively susceptible to industrial, agricultural and urban development due to their reliance

---

Environment Canada. (2008). *Aquatc Species at Risk – White Sturgeon*. Retrieved Feb 6, 2011, from Fisheries and Oceans Canada: http://www.dfo-mpo.gc.ca/species-especes/species-especes/white_sturgeon-esturgeon_blanc-eng.htm

[86] Pearson, Mike and Healey, M.C. (2009). *Species at Risk and Local Government: a Primer for BC.* Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 6, 2011 from: http://www.speciesatrisk.bc.ca/node/8078

[87] Pearson, Mike and Healey, M.C. (2009). *Species at Risk and Local Government: a Primer for BC.* Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 6, 2011 from: http://www.speciesatrisk.bc.ca/node/8078

[88] Pearson, Mike and Healey, M.C. (2009). *Species at Risk and Local Government: a Primer for BC.* Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 6, 2011 from: http://www.speciesatrisk.bc.ca/node/8163

[89] Pearson, Mike and Healey, M.C. (2009). *Species at Risk and Local Government: a Primer for BC.* Stewardship Centre of British Columbia, Courtenay BC. Retrieved February 6, 2011 from: http://www.speciesatrisk.bc.ca/node/8163

[90] Ministry of Fisheries. (n.d.). *B.C. Fish Facts.* Retrieved February 7, 2011, from Kokanee : http://www.env.gov.bc.ca/wld/documents/fishfacts/kokanee.pdf

on clear flowing streams. In terms of forestry practices, they are considered at risk due to an increase in sedimentation and water temperature[91].

Rainbow Trout (Oncorhynchus mykiss)

A close relative to salmon and arctic char, Rainbow trout are a native species to the Pacific Ocean, yet one of the most widely introduced species on a global level[92]. Habitat requirements often involve cold, clear water with a fast current[93]. Shallow rivers with moderate flow and gravel bottoms are preferred for the river dwelling population, where as lake residents require deep cool pools. Rainbow trout spawn in the spring immediately following the melting of ice off the rivers and lakes.

[91] Ministry of Fisheries. (n.d.). *B.C. Fish Facts.* Retrieved February 7, 2011, from Kokanee : http://www.env.gov.bc.ca/wld/documents/fishfacts/kokanee.pdf

[92] Fisheries and Oceans Canada (2010). *Ontario-Great Lakes Area Fact Sheets: Rainbow Trout.* Retrieved February 7, 2011 from: http://www.dfo-mpo.gc.ca/regions/central/pub/factsheets-feuilletsinfos-ogla-rglo/rainbowtrout-truitearcenciel-eng.htm

[93] Fisheries and Oceans Canada (2010). *Rainbow Trout.* Retrieved February 7, 2011 from: http://www.dfo-mpo.gc.ca/species-especes/aquatic-aquatique/rainbow-trout-eng.htm

Appendix 3: Socio-Economics

Table 12: Fort St. James THLB Determination

	Area (ha)
Total Distric Area	3,084,653
Non Crown Forest	976,456
Reserve	4,706
Non Forest	26,555
Private Crown Grant	17,392
Small Leases	20
Woodlots	2,768
Crown Forested Landbase	**2,056,758**
Reductions to CFLB	
Non Commercial	22,221
Non Merchantable	76,277
Parks and Protected Areas	90,194
Isolated High Cost Planning Cells	990
Physically Inoperable	2,418
Economically Inoperable	204,710
RMZ	465
Visual Preservation Area	1,229
Caribou Habitat	9,772
ESA's	125,644
Semi Spatial Reductions (Roads, Trails, Landings, Riparian, IWAP)	177,863
Current Timber Harvesting Landbase	**1,344,976**
Future Roads, Trails and Landings	2,985
Long Term Timber Harvesting Landbase	**1,341,991**

Appendix 4: Modelling Programs

TIPSY (Table Interpolation Program for Stand Yields) & VDYP (Variable Density Yield Prediction)

Description

TIPSY and VDYP are growth and yield programs[94]. They generate volumes curves for each age period of a specific species. They are not models that generate information based on inputs. They are based on species, site index, and other stand management treatments.

Limitations

TIPSY cannot generate mixed species or uneven aged stands[95]. It cannot simulate more than one species growing in a stand. To generate a multi- species stand, this yield program averages the two species' growth and yield curves together and presents one curve[96]. VDYP has more specific limitations, but these would not have affected the one growth and yield curve it was used to generate (for SG1200).

Use

TIPSY was used to generate growth and yield curves for some of the new-planted stand groups. VDYP was used to model our mature, or unmanaged, stand group 1200.

ArcGIS

Description

ArcGIS is a geospatial program, which allows users to process large quantities of spatial and tabular data efficiently. In this project, ArcMap was used.

Limitations

In this case, ArcMap and its applications were limited by data and time. Much more could have been done had there been more data and more time.

Use

For the purpose of the *Daiya-Mattess Keyoh*, ArcMap was used to create and analyze buffer treatments, road treatments, and planting treatments.

[94] BC Ministry of Forests and Range. (2007, November 22). *TIPSY Home*. Retrieved April 1, 2011 from Ministry of Forests and Range: http://www.for.gov.bc.ca/hre/gymodels/tipsy/

[95] ibid

[96] ibid

CBM-CFS3 (Carbon Budget Model- Canadian Forest Service)

Description

CBM was developed by the Canadian Forest Service "…to simulate the dynamics of all forest carbon stocks required by the Kyoto Protocol (aboveground biomass, belowground biomass, litter, deadwood and soil organic carbon)[97]. CBM was chosen to model carbon on the *Daiya-Mattess Keyoh* because it is compliant the International Panel for Climate Change's (IPCC) carbon estimation methods, and in general it is a widely accepted carbon model.

Limitations

Our use of CBM was very limited by time and inexperienced users. Had there been more time, it would have been possible to learn the program better to generate more accurate curves. As it was, users relied heavily on the advice and input of other experienced CBM users and may have made decisions that resulted in minor inaccuracies. Most of these decisions revolved around the disturbance regimes and whether they ought to be modeled. It was decided to model them to produce more accurate carbon curves. Due to the inexperience of the users, the full capacity of the program was not used. Users were only able to provide the inputs for the model to run but were unable to manipulate the data due to limited knowledge of the outputs and limited time.

Use

CBM was used to generate the carbon curves for FPS-Atlas inputs.

FPS-Atlas (Forest Planning Studio)

Description

Atlas is a harvest simulation model, which allows users to manipulate numerous harvesting variables such as harvesting volumes (or harvest flows), buffers, no harvest zones and minimum harvest ages[98].

Limitations

Atlas limitations were data, time and user knowledge of the program. There were some outputs that could not be utilized due to a lack of data. For instance, if log grades were part of the database, we could have calculated much more accurate revenue based on Atlas' log grade outputs. Time was a constant constraint. It was challenging to model as many scenarios as possible, providing enough options for the client, while producing data of a high quality. The lack of user knowledge of the program clearly limited how Atlas was used. It was impossible to fully utilize the capabilities of the program.

---

[97] Canadian Forest Service. (2009, August 10). *Forest Carbon Accounting*. Retrieved April 1, 2011 from Natural Resources Canada: http://carbon.cfs.nrcan.gc.ca/CBM-CFS3_e.html

[98] *About Atlas*. (2003, April 9). Retrieved April 2, 2011 from ATLAS/SIMFOR Project: http://www.forestry.ubc.ca/atlas-simfor/atlas/about.html

Use

FPS-Atlas was the most used model. It was used for nearly every treatment. It was particularly useful in modeling the harvest scenarios, but was also used to model carbon.

Appendix 5: Values, Objectives, Indicators, Targets: Evaluation, Results and Discussion

Wildlife

This is an important value for *Daiya-Mattess Keyoh* holder Ken Sam. As explained in our background information (section 2.0), animals have many cultural uses and are valued as an integral part of the forest.

Protect and Restore Habitat

The objective of protecting and restoring habitat addresses the importance of wildlife by ensuring there is habitat. This is one of the most important objectives. In order to comprehensively assess wildlife habitat, a separate wildlife habitat criteria and indicator is applied to six scenarios which were selected based on how successfully they ranked in the ecological and cultural target evaluation. While there is only one indicator for this very important objective, the second wildlife criteria and indicator table ensures that wildlife habitat is protected, and indicates which aspects of habitat need to be restored.

Fragmentation

Indicator & Target Rationale

Fragmentation is a useful indicator for wildlife habitat as it ensures that animals have sufficient area rather than small parcels dotting the landscape (Figure 36). Fragmentation also doubly serves to ensure that END is employed successfully. To properly emulate stand-replacing fire, openings should be few and large rather than common and small. While fragmentation is also a concern due to the number of roads, this indicator was evaluated from the perspective of harvesting impacts rather than logging operation impacts.

Target Evaluation

	Good	Medium	Poor
Target	Clear-cut polygons are aggregated rather than dispersed	Most clear-cut polygons are aggregated, some are dispersed, small polygons	Most clear-cut polygons are small and dispersed

Figure 36: Fragmentation target evaluation

The simplest method of evaluating fragmentation was using the viewer in Atlas. The viewer allows users to see how the land base is changing in each time period. The target is a scale of good, medium, poor. See Figures 37, 38, and 39 below for assessing examples of 'good', 'medium' and 'poor'.

Due to the visual nature of the target evaluation, it was important to maintain the same level of zoom when evaluating each of the harvested areas. In order to ensure consistency, one person evaluated this target for all scenarios. If time was not a constraint, two members would have evaluated this target and the results would have been compared. If there were further discrepancies, a third member would have evaluated the target separately and been the deciding factor.

Although this is a somewhat subjective analysis of fragmentation, it is still indicative of fragmentation and is adequate for assessing whether one scenario results in more or less fragmentation.

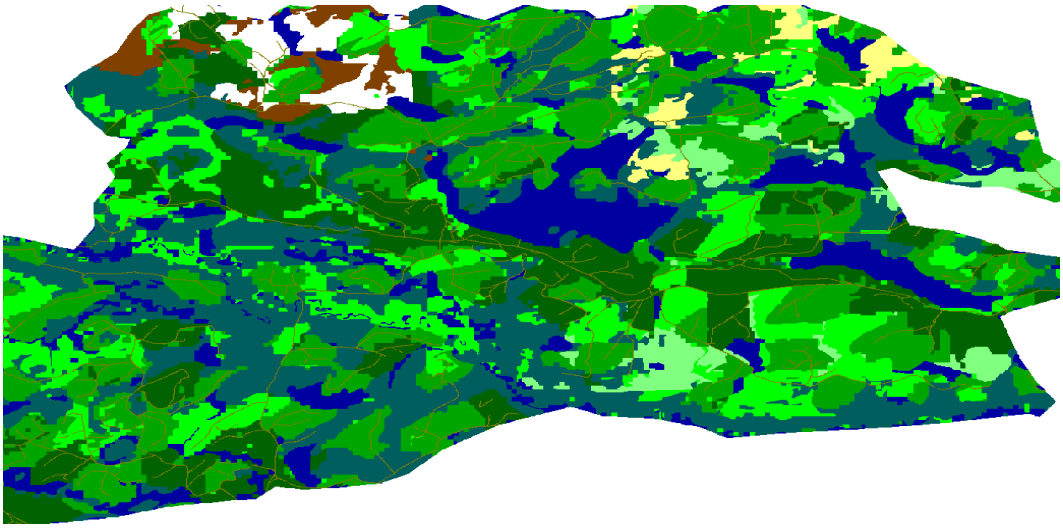


Figure 37: This snapshot of Atlas' viewer display is an image of the four rotating harvest zones scenario: gradual harvest flows, no buffer at 80 years. This was evaluated and deemed "good" as all harvested areas are aggregated.

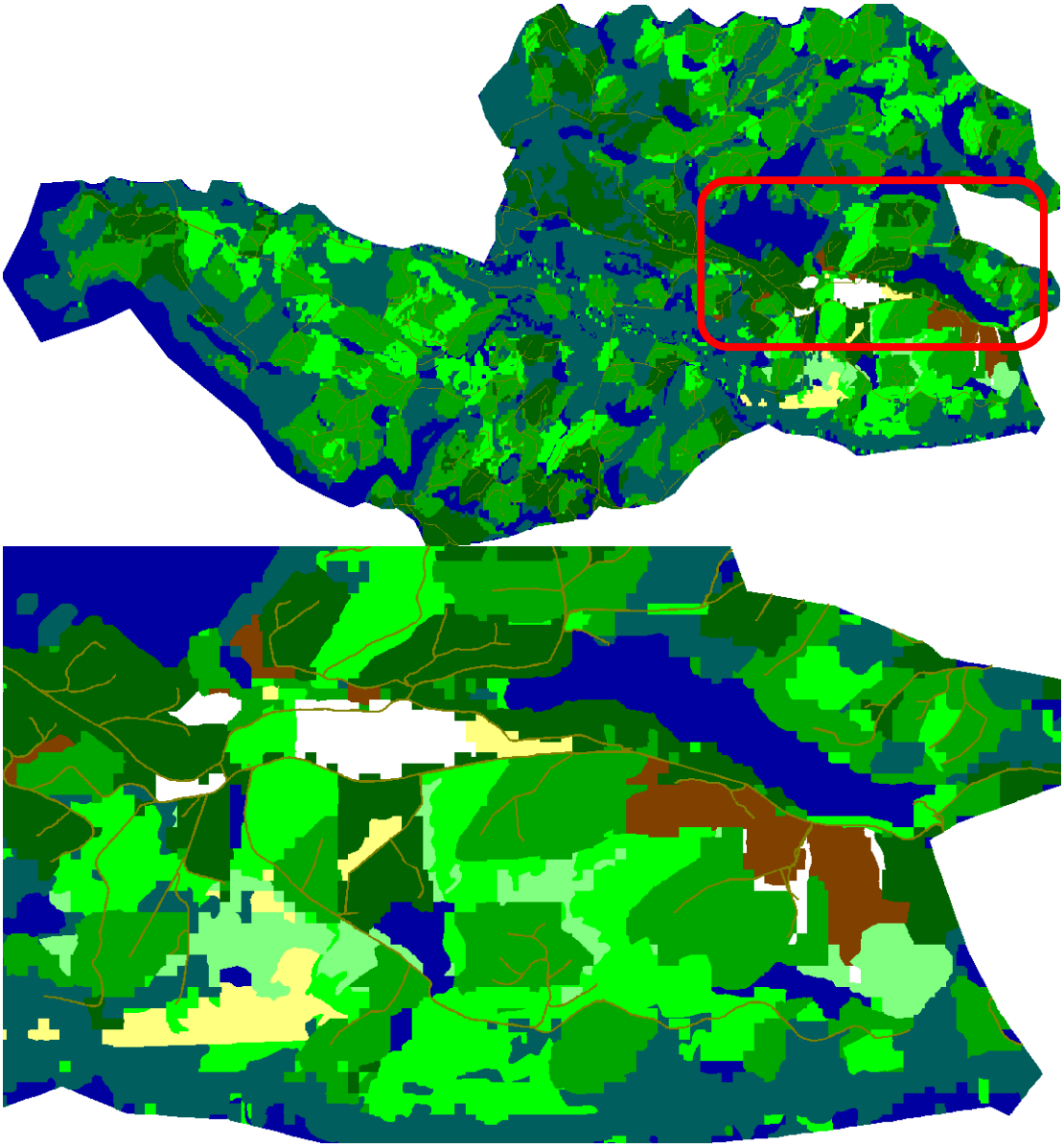


Figure 38: This is the one harvest zone scenario: gradual harvest flows, no buffers at 80 years. This scenario was judged "medium" as there are some large, aggregated cuts and some small cuts. The Top image shows the zoomed area in relation to the rest of the *Daiya-Mattess Keyoh.*

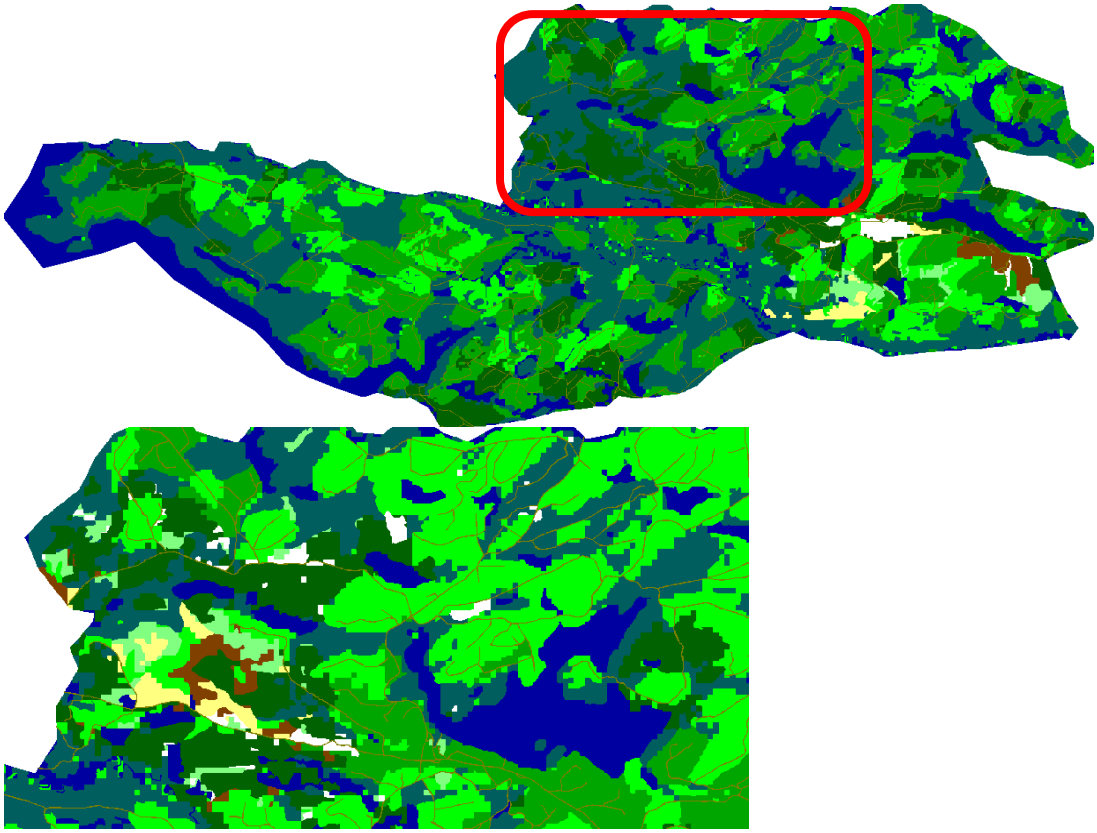


Figure 39: This is the two-combined harvest zones scenario: gradual harvest flows, at 60 years. Deemed "Poor" as there are many small cuts. The top image again provides context for the zoomed in area, but is not representative of the specific scenario being evaluated.

Fragmentation Results

See Appendix 8 for the ecological and cultural summary table for results.

The no harvest baseline and road de-activation, planting and buffer treatments have no fragmentation, as there is no harvesting.

The harvest baseline ranks well because all of the harvested areas are large openings and do not isolate the remaining stands of forest.

The one harvest zone scenario varies. The one harvest zone base case (minimum harvest ages are not modified) does well. As the minimum harvest age rotations increase, the results worsen. However, the one harvest zone scenario which maximizes volume has moderate fragmentation overall.

The four rotating harvest zone scenario fares well. All of the minimum harvest age scenarios have moderate fragmentation. The no buffer scenario does very well, and ranks 'good' in all time periods.

The combined zones scenario does not fare as well overall, however the base case and no buffer scenarios display moderate fragmentation overall. The remaining combined zones scenario mostly received 'poor' fragmentation.

The expanded harvest zone scenario echoes the combined zones scenario in that the base case and no buffer scenario display moderate to good results. The minimum harvest age scenarios do not perform very well.

The road re-vegetation, buffer and planting treatments all do well in this target, as there is no harvesting.

Discussion

The larger the harvest zone the less fragmented the landscape. This is a consequence of having more options when harvesting, and having the ability to clump polygons together when harvesting.

The scenarios with modified minimum harvest ages' results are unexpected. In the one harvest zone scenario, once buffers are applied there is such a small area of land available for timber extraction that it is not surprising that the landscape becomes fragmented as the only available areas are harvested. In the combined and expanded zone scenarios, it appears Atlas does not need to harvest large areas in the maximizing volume scenario. Stand volume is much greater when trees are harvested at the peak of their volume curve, so there is no need to harvest as many stands to meet harvest flow volumes. It should be noted that the harvest flows (a term which can be likened to AAC but on a 10 year period) are much lower in the maximize volume scenarios (see Appendix `Harvest flows``).

The remaining minimum harvest age scenarios with 80 and 100-year rotations result in poor to moderate fragmentation. This is likely because of the large buffers, which limit where harvesting can occur and isolate some harvestable areas. When those isolated harvestable areas are harvested, it creates fragmentation. In reality, this is relatively minor because there is so much retention over the entire *Daiya-Mattess Keyoh* that there need not be overly much concern regarding the 80 and 100 year rotation effects on fragmentation.

Section 5.2 goes into further detail regarding the wildlife criteria and indicator rationale used for this plan.

Water

Water is very important to *Daiya-Mattess Keyoh* holder Ken Sam. There is a long history of fishing on the *keyoh*, and water quality is important in maintaining wildlife habitat. Water values are also important on this *keyoh* as the Salmon River is indirectly a tributary to the Fraser River (Fraser Basin Council, 2004).

Protect aquatic ecosystems and water quality

The objective of maintaining water quality on the *Daiya-Mattess Keyoh* not only protects aquatic organisms on the *keyoh*, but also contributes to protecting aquatic organisms in the Fraser River. Protecting the aquatic ecosystem of the *keyoh* is one component of maintaining healthy, resilient ecosystems. Two indicators were developed to assess this objective: stream and lake proximity to roads and number of stream crossings.

Road Proximity to Rivers, Streams and Lakes

Indicator & Target Rationale

With high value placed on water quality and species habitat, a 200 m buffer was placed on the Salmon River, a 100m buffer was placed on all streams and a 60m buffer on all lakes. There buffers were created from the Riparian Management Area Guidebook from the B.C. Forest Service and were verified using a literature review. For best practice, all the streams were classified as S1 (See Table 13 and 14), the largest class, because stream classification information was unknown. This classification associates the largest riparian management area (RMA) of 100m on either side of the channel, which we then used as our minimum buffer size[99]. For the Salmon River, this buffer size was double to a 200 m buffer to address the client`s concern of protecting this invaluable river. Although most of these mapped streams are most likely S4 or less the 100m buffer meets our water protection objectives of. Based on scientific evidence the buffers are not too small, which was the main concern. All definite, indefinite, and indeterminate streams were included in the analysis.

Wetland buffers were not included in modelling, but have been mapped. They are not included because the majority of stream buffers overlap wetlands. Wetlands should be managed for when implementing treatments and harvesting.

Table 13: Specified minimum RMA slope distances for stream riparian classes[100]

Riparian class	Average channel width (m)	Reserve zone width (m)	Management zone width (m)	Total RMA width (m)
S1 large rivers	≥100	0	100	100
S1 (except large rivers)	>20	50	20	70
S2	>5≤20	30	20	50
S3	1.5≤5	20	20	40
S4	<1.5	0	30	30
S5	>3	0	30	30
S6	≤3	0	20	20

Fish stream or community watershed

Not fish stream and not in community watershed

[99] Ministry of Forests and Range. (1995, December). *Forest Practice Code of BC Act: Riparian Management Area Guidebook*. Retrieved March 25, 2011 from Ministry of Forests and Ranges: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/riparian/Rip-toc.htm

[100] ibid

Table 14: Specified minimum slope distances for lake riparian classes[101]

Riparian class	Reserve zone width (m)	Management zone width (m)	Total RMA width (m)
L1*	10	0	10
L2	10	20	30
L3	0	30	30
L4	0	30	30

L1 Lakes < 1000 ha in area, have a 10-m reserve zone and a lakeshore management zone established by the district manager. L1 lakes > 1000 ha in area only have a lakeshore management zone.

The purpose of measuring the proximity of roads is to see the potential risk for impact they may have on water. The increased amount of sediment to streams from runoff (known as sedimentation) is a major environmental impact of roads. Sedimentation can damage fish food supplies and habitats, injure fish directly, cause bank erosion, fill the channel, widen the channel, or flood it.[102]

The buffers treatments are no harvest zones. Trees and vegetation are left to filter groundwater, intercept precipitation and shade the immediate riparian areas.

Target Evaluation

The stream and lake proximity to roads target is based on the amount of roads within the Salmon River, stream and lake buffers (Figure 40). To evaluate the target, a good, medium, poor ranking system was used. '*Good*' describes scenarios with less than 1% of roads within 100m of water. This limits the roads around water and the number of stream crossings (Appendix 8)

	Good	Medium	Poor
Target	< 1% of roads in 100m buffer	1-25% of roads in 100m buffer	> 26% of roads in 100m buffer

Figure 40: Targets for road proximity to rivers, streams and lakes.

When buffers are applied to all the water bodies over the entire *keyoh,* 20566 ha remains, which is just under 73% of the total land area. Targets were analyzed in ArcGIS. Buffers of 20, 40, 60, 80, and 100 meters were created from stream channels. These buffers were then intersected with the road lines and isolated to determine kilometres of road within each buffer size.

Road Proximity to Rivers, Streams and Lakes Results

In analyzing 100m buffers, there were 100% more roads within the 100m buffer than the 20m buffer (see Figure 41).

[101] Ministry of Forests and Range. (1995, December). *Forest Practice Code of BC Act: Riparian Management Area Guidebook*. Retrieved March 25, 2011 from Ministry of Forests and Ranges: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/riparian/Rip-toc.htm

[102] William Haskins and David Mayhood. 1997. *Stream Crossing Density as a Predictor of Watershed Impacts*. Proceedings of the Seventeenth Annual ESRI User Conference, Paper 457. http://proceedings.esri.com/library/userconf/proc97/proc97/to500/pap457/p457.htm

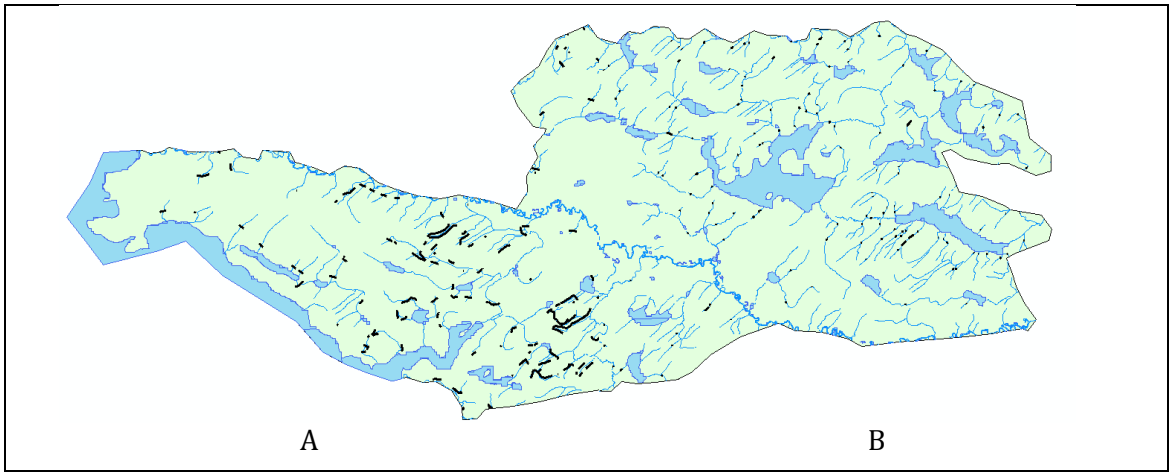


Figure 41: This shows the difference in the density of roads within 100m buffers (left image, A) and within 20m buffers (right image, B). The black lines represent kilometres of road found within the buffers.

As buffer sizes increased from 20m to 80m we saw an increase of about 3-3.5% then a drop to approximately 1.7% increase for 100m buffers of roads that were included within buffers.

There is a large amount of roads within buffers because while Canfor has been harvesting they most likely have been using multiple buffer widths, as they were able to identify each stream classification. The 100m buffer increases the protection of wildlife habitat and maintains natural hydrological processes by maximizing the distance roads must be from water.

Discussion

The only scenario which was classified as `good` was the road de-activation and re-vegetation scenario. This is because minimal roads can be deactivated in the various harvesting scenarios. In the remaining no harvest scenarios (baseline, buffer and planting treatments), roads are not de-activated. All other scenarios range from poor to moderate.

We found the highest number of roads to fall within the 100m buffer, but the increase from 80 to 100m was not as large as from 60 to 80m, so it's possible that 80m would suffice in most situations.

Number of Stream Crossings

Indicator & Target Rationale

The high density of roads and streams throughout the *keyoh*, results in many stream crossings. This is also the case for the CN rail line that runs through the area as well. With the increased number of stream crossings there is increasing risk of sedimentation or other pollutants entering the water from cars, trucks, trains, or other sources. Water quality degradation can affect other water bodies downstream and lower the quality of the aquatic

ecosystem.[103] With any future development of the area, detailed surveys should be used to determine if stream crossings are required. If yes, crossings should be planned with the utmost care.

Target Evaluation

When evaluating the number of stream crossings it's important to realize some of the mainline and Forest Service Road (FSR) stream crossings were required because there was no alternate route for the road (Figure 42). Crossing streams may have been a management decision to avoid areas of higher importance. It is important to realize that in order to meet the future needs for access to Ken Sam's cabins and culturally significant areas, some roads will be left. Other remaining roads are the FSR. In addition to these roads, the crossings for the CN rail cannot be removed due to regulations and operational constraints. To be evaluated as `good`, all roads except the FSR and mainline left for access are deactivated, which removes most of the stream crossings in the *keyoh*. Medium and poor targets were developed by dividing the remaining stream crossings in half. This was done because there is no scientific target for stream crossings.

	Good	Medium	Poor
Target	0 – 47 crossings	47 – 98 crossings	98+ crossings

Figure 42: Number of stream crossing targets

Number of Stream Crossings Results

Using our GIS information on roads and streams, ArcGIS was used to determine where roads crossed water. A tally for each area and each scenario was then evaluated based on the good, medium and poor targets. The Cultural Heritage Preservation Zone has 50 water channels crossings, while the portion of land to the north of the Salmon River has 65 crossings. There are two significant crossings on the Salmon River. One is the FSR and the other is the at the far west end of the *keyoh*. There two crossings are bridges- one is a trestle bridge for the CN Rail line, and the other crosses the Salmon River.

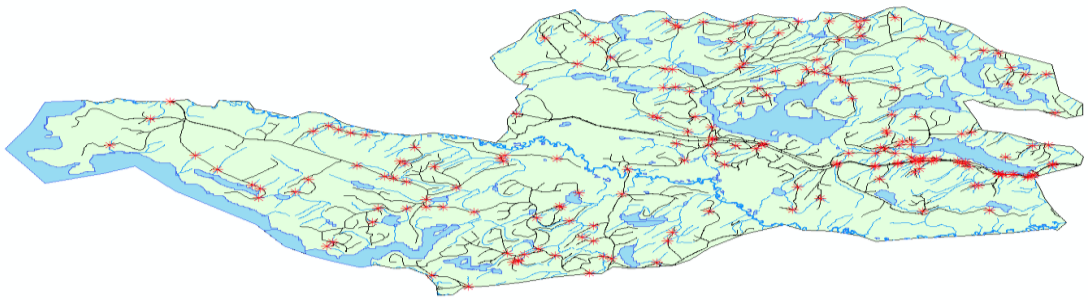


Figure 43: Road and rail stream crossings

[103] William Haskins and David Mayhood. 1997. *Stream Crossing Density as a Predictor of Watershed Impacts*. Proceedings of the Seventeenth Annual ESRI User Conference, Paper 457. http://proceedings.esri.com/library/userconf/proc97/proc97/to500/pap457/p457.htm

Discussion

Similar trends are seen in this target as in the road proximity to rivers, streams and lakes target. The only scenario classified as `good` is the road de-activation and re-vegetation scenario. The one harvest zone and combo zone harvest scenarios are ranked moderate, and all other scenarios are ranked poor.

These results have to do with road de-activation planning within the scenarios. For example, in the expanded harvest zone and the four rotating zones scenario, it is not possible to de-activate as many roads as they must be left open to provide access when harvesting.

There were some difficulties trying to decide when a road was mapped close to a stream so it was included as a crossing. In many cases there were no alternate locations for roads, but to meet the requirements for Ken Sam there must be fewer crossings to impact the rivers and streams.

Heritage

This value is considered synonymous with cultural. It encompasses areas important for familial, cultural or heritage reasons. It also seeks to preserve the aspects of the *keyoh* that make it unique for users of the *Daiya-Mattess Keyoh* and ensure these aspects are preserved for future generations.

Protect Culturally Significant Areas

This objective seeks to maintain the heritage values of the *Daiya-Mattess Keyoh* by protecting areas that are important to the *keyoh* holder and his family. This objective also seeks to protect areas that are known to be high use areas for trapping, fishing or recreation, such as areas surrounding the cabins.

Protect Culturally Significant Area

Indicator & Indicator Rationale

In this area, there are several areas that have high cultural and historical importance to the *Daiya-Mattess Keyoh* and their traditions. There are lakeside family cabins which are used when hunting, trapping, and fishing. There are many cultural land use sites around lakes and rivers which are sources of fish and game. Fish and game are used for food, tools, and apparel. Some of these cultural land use sites have been affected or disturbed by harvesting. All these cultural land use sites are special to the *keyoh* and tell a story of the *Daiya-Mattess Keyoh* people's history. The majority of these locations can be found at the west end of the *keyoh*, which is the primary reason the Cultural Heritage Zone was created (see Figure 43). 1 km radius buffers were placed on the cultural land use sites (Figure 46).

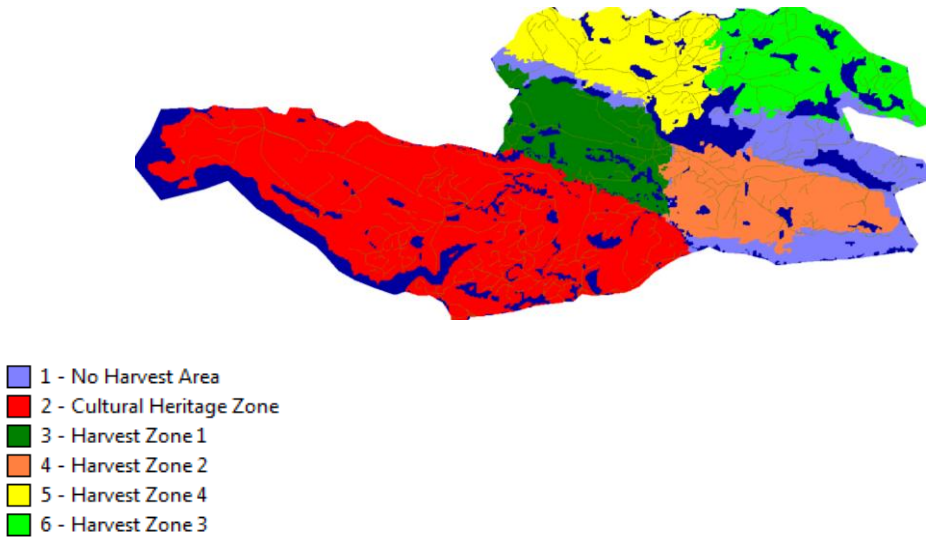


Figure 44: Zoning on the *Daiya-Mattess Keyoh.*

Target Evaluation

To meet the objective of protecting the culturally significant areas, ArcGIS was used to determine whether scenarios were good, medium or poor. `Good` protects areas that are located closer to the mouth of the Salmon River. These areas see the most hunting and trapping. To ensure protection of the area as a whole so it provides resources for wildlife habitat, the scenarios which are classified as `Good` protect the Cultural Heritage Zone. Medium and poor targets were created by dividing the remaining protected areas in half. This was done because there is no scientific target for culturally protected area.

	Good	Medium	Poor
Target	> 13,662 ha protected	13,662 ha – 9563 ha protected	< 9563 ha protected

Figure 45: Targets for evaluating the protection of culturally significant area.

Protect Culturally Significant Area Results

To analyze this target, information was gathered from the cultural land use site locations provided by the *Daiya-Mattess Keyoh* and industry maps. Points were created and buffered using a 1 km radius. 1km buffers retain as much forest around the sites and minimally disturb those areas. Most of the cultural land use sites are located in the Cultural Heritage

Zone in the southwest portion of the *keyoh*. Provincial recreation sites were also buffered because they provided access to some of the cabins.

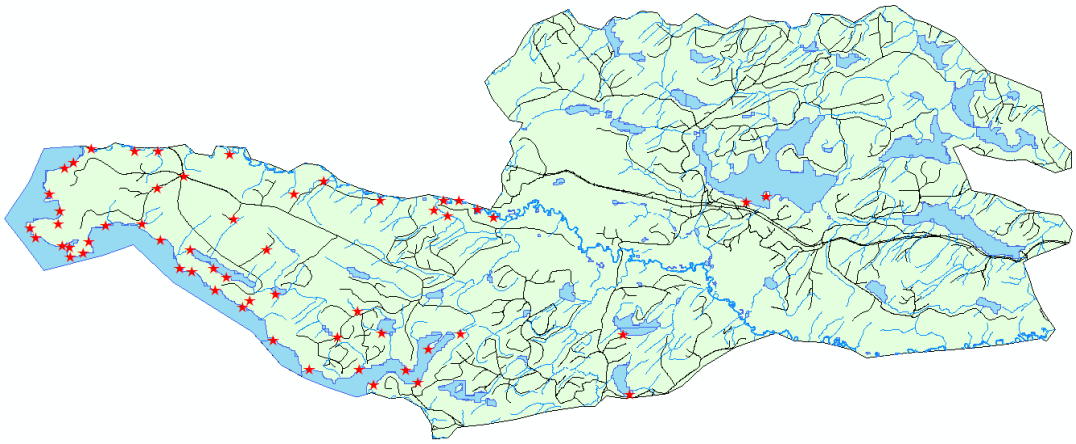


Figure 46: Cultural land use sites

Discussion

The smaller the areas available for harvest, the better the cultural areas are protected. The less area available for harvesting, the more roads can be de-activated and the more access is limited. However, the cultural zone protects the majority of the cultural land use sites. Many of the cultural land use sites are also covered by the water buffers because they are located along rivers or lakes.

De-activated Roads

Indicator & Target Rationale

This indicator focuses on reducing the number of roads throughout the *keyoh* to decrease the access and allow de-activated road areas to naturally regenerate. The amount of roads throughout the *keyoh* has fragmented the forest, disrupting wildlife movement and habitat requirements. A road kill analysis examined the increased potential for animal mortality due to hunting, accidents, and predation. Within 500m of road animals have a higher chance of being affected by noise, pollution or injury. As roads are deactivated, they are left to return to natural stands regenerated by the tree and shrub species along the roadsides (see Figure 47).

Figure 47: Natural regeneration following road deactivation.

Target Evaluation

Using ArcGIS, the number of deactivated roads was analyzed (Figure 48). To be classified as `good` all roads except those important for access on the *Daiya-Mattess Keyoh* are deactivated. Medium and poor targets were developed by dividing the remaining road deactivation lengths in half. This was done because there is no scientific target for road deactivation.

	Good	Medium	Poor
Target	488 km – 441 km deactivated	441 km – 244 km deactivated	243 km – 0 km deactivated

Figure 48: Road deactivation targets.

To evaluate the scenarios, the roads which would be deactivating were selected to calculate the distance of deactivated roads.

De-activated Roads Results

The majority of roads, 191.8km, are found in the portion of the *keyoh* north of the Salmon River, and the Cultural zone has 171.5km for comparison. As a result, most of the harvesting scenarios do a moderate job of road de-activation.

Discussion

Road de-activation trends are similar to trends seen in the cultural area protected target. The smaller the area available for harvest, the better the road-deactivation targets is met.

Road deactivation should also include a barrier to vehicles to prevent access.[104] It was challenging to decide which roads should be left open in the Cultural Heritage Zone. The best option is to deactivate all the roads in the *keyoh* except the FSR as it is provincial and outside of our jurisdiction, and the main road in the Cultural Heritage Zone. If harvesting is to occur in the *keyoh* then other roads will have to be left active because it's not financially feasible to deactivate roads only to reactivate them for harvest. In most cases, road de-activation is difficult to implement because of the high costs.

[104] Ministry of Forests and Range. (2003, December). *Forest Practice Code of BC Act: Forest Road Regulation.* Retrieved March 30, 2011, from Ministry of Forests and Range: http://www.for.gov.bc.ca/tasb/legsregs/archive/fpc/fpcaregs/forroad/froadr.htm

Forest

This ecological value seeks to protect one of the *Daiya-Mattess Keyoh's* most valuable resources. The forest provides habitat, protects water quality and has the potential to generate revenue.

Maintain ecosystem health and vitality

This objective ensures the forest is productive and healthy for use in future generations. In this context, healthy does not only mean free of disease. A healthy forest is also within its natural range of variation. For example, forests should not be modified to the extent that the species composition no longer represents a composition that could be found elsewhere on the natural landscape.

This objective also maintains ecosystem resilience. Should a disturbance occur, the ecosystem will be able to cope and maintain its functions of providing habitat, filtering water and air, storing carbon, sustaining organisms and so on. Meeting this objective is one way to help a forest cope with climate change.

Seral stage

Indicator & Target Rationale

Seral stage is an indicator of ecosystem health and vitality because it ensures that the forest is within its natural range of variation.

Seral stage is a term similar to forest age but conveys information regarding stand structure. Seral stage can be used to describe three broad forest cohorts or age groups: early/young (0-40 years), mid/mature (80-120 years) and late/old (>120 years)[105].

This indicator provides insight into stand turnover due to disturbances. It also ensures there is a range of seral stages to meet the many and varied requirements of wildlife.

Target Rationale

To meet this target, stands must comprise of more than 17% late seral stage. 17% is based on recent research by Craig De Long regarding the Moist Interior Natural Disturbance Unit (NDU), in which the *Daiya-Mattess Keyoh* is located. All the operators in the Fort St. James forest district derived 17% from the Sustainable Forest Management plan developed

It is also important to note that while 17% may not seem like much, in an area that is disturbed by large stand replacing fires, it is not natural to have an abundance of late seral forest as the fire risk becomes quite high.

[105] BC Ministry of Forests. (2005). *Biodiversity Guidebook.* Retrieved on March 10, 2011, from http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/app4.htm

Target Evaluation

The seral stage target was evaluated using a constraint in Atlas, which monitored stands older than 120 years. The constraint grid was used to create a text file, which was exported into Excel and modified to fit into the Criteria and Indicator evaluation table.

Seral Stage Results

In all scenarios except the baseline harvest scenario, seral stage increases from year 0 to 100. Increases of up to 63% occur in the no harvest baseline and the planting, buffer and road treatments. The one harvest zone scenario has the next highest late seral stage increases, reaching nearly 60% of the forest.

The four rotating harvest zones have seral stages, which hover around 60 % by year 100, but the no buffer scenario has a late seral stage composition of 48% in year 100.

The combined harvest zones scenario has slightly lower seral stage compositions than the previous scenarios, ranging from 56-59% in the buffered scenarios. However the no buffer scenario results in 45% late seral in year 100, and maintains late seral composition from 30-34% in periods 0-80.

The expanded harvest zone echoes the other harvest scenarios, with buffered scenarios having high seral stage compositions ranging from 53-56% and the no buffer scenario hovering around 30%, reaching 35% in year 100.

Discussion

These results are as expected. It is important to remember that nearly half the *Daiya-Mattess Keyoh* is reserved in a cultural heritage zone (Figure 44). The remaining half is either being used for timber, as in the expanded harvest zone, or allocates a small section to timber and places the rest in reserve, as in the one harvest zone. It is expected that late seral stage compositions will become quite high as harvesting is restricted and can no longer be used as a tool to maintain seral stage compositions. This can be seen in the no buffer scenarios do a better job of maintaining late seral stages as they are able to regulate the ages by harvesting more.

Considering the minimum value for seral stage is 17%, it is difficult to say at which point late seral stage compositions are too high. However, given the nature of the fire disturbance in the area, anything over 50% late seral can be considered high and fire risk should be monitored. At this point, it may be necessary to take steps to mitigate fire.

It is also important to note that while everything is considered late seral, it incorporates a wide range of ages. In this case, late seral simply describes stands over 120 years. This contributes in part to the large amounts of forest comprised of late seral.

Species composition

Indicator & Target Rationale

In maintaining a natural, healthy stand, it is important to ensure species composition is within natural ranges. This helps maintain biodiversity, stand structure and regulates stand development through competition.

This target was derived from the Timber Supply Review data package (TSR) based on unmanaged stands using a weight average species composition for the SBS mk1 zonal site (see Figure 49)[106]. The TSR was used as it is a relatively recent, reliable source based on inventory conducted by the province of British Columbia.

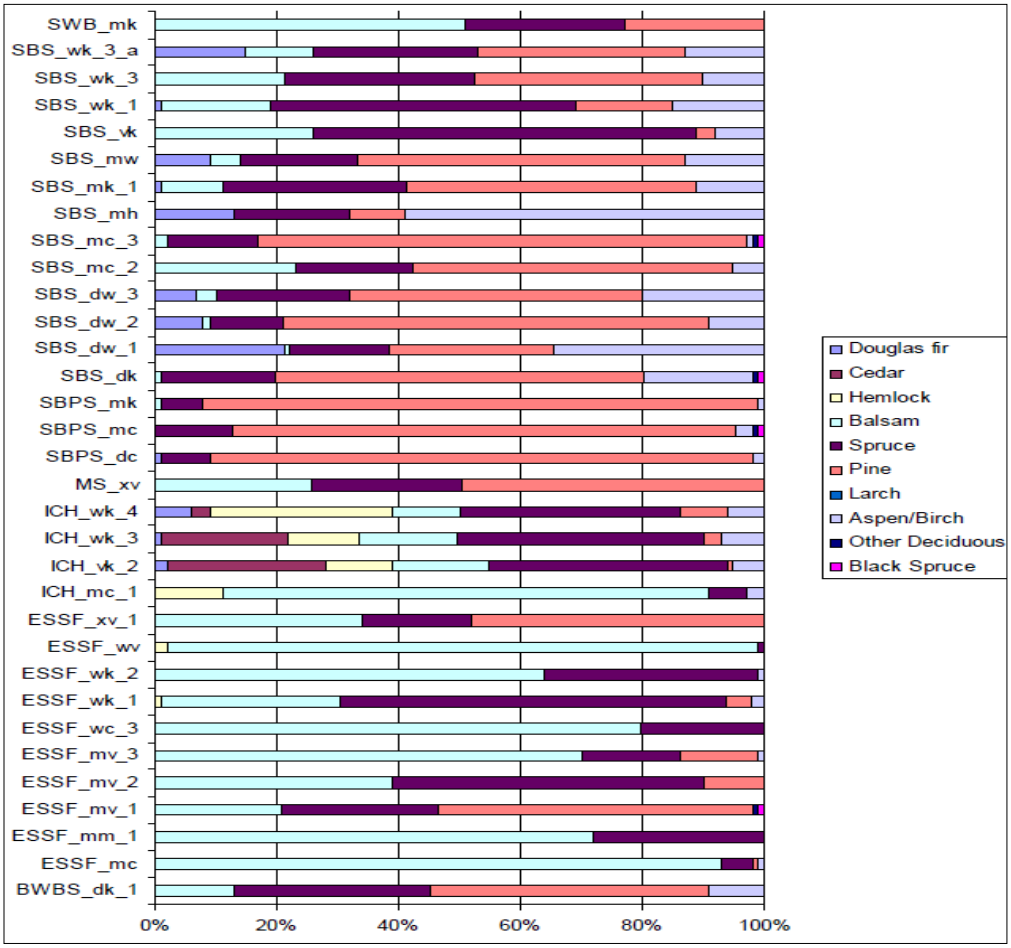


Figure 49: This shows species compositions in natural stands in the SBSmk1 zone in the Prince George Timber Supply Area

[106] Ministry of Forests and Range. (2008, November). *Prince George Timber Supply Area: Timber Supply Review Data Package.* Retrieved March 25, 2011, from Ministry of Forests and Range: http://www.for.gov.bc.ca/hts/tsa/tsa24/tsr4/24ts08dp.pdf

Target Evaluation

Species composition was calculated in Atlas using the growing stock grid to analyse the area in each stand group. Since stand groups are based on leading species, it was assumed that this would suffice for determining species composition over the entire *Daiya-Mattess Keyoh*.

Species Composition Results

None of the scenarios meet the species composition target. In all scenarios, pine is a very large component of the stand, much larger than the target composition of 45%. These compositions do not vary much and all scenarios show an increase in pine composition.

Discussion

While this target is specific for the SBS mk1, it would be surprising if the *Daiya-Mattess Keyoh* met the species composition target. However, the results do indicate that there is a problem that should be investigated further.

The fact that pine composition is so much higher and is consistently in the 80 % range in every scenario is troubling. If this is a result of harvesting and conversion to pine stands, then pine stands should be targeted for harvest when possible and converted to their natural species compositions. It is possible that this pine composition is natural, as there is always a wide range of variation and pine may simply do well on the *keyoh*, however for the entire *keyoh* to consist of 80% pine seems too high as it creates a risk for beetle infestations which is something that would naturally be avoided as much as possible by nature. This is why it may be a result of harvesting. However, historical data or knowledge of the land would be needed to confirm this.

There is 0% fir composition on the *keyoh*. This may simply be because fir is such a minor component of the *keyoh*. It does not mean that there is no fir at all; it simply means that the stands with fir as a leading species are not playing a major role on the *keyoh.* The creation of some fir stands where fir is suited to grow is one potential strategy for creating a more diverse forest.

Douglas-fir composition is just below half a percent. The target is 1%, and considering the compositions of the remaining species, Douglas-fir is currently best meeting the target.

Spruce composition is surprisingly low, about one third of what the targeted composition is. Due to the amount of wetter areas on the *Daiya-Mattess Keyoh*, more spruce was expected. Potentially some spruce stands have been converted to pine stands, which would explain the high pine and low spruce compositions. However, as this is speculation, more research is needed.

Aspen/birch compositions are adequate, though still below the targeted 15% composition. They range from 6-9 % depending on the scenario. No deciduous stands are being harvested. This helps mitigate fire risk. However, the fact that none of these stands are being harvested yet are still below the target indicates that in order to meet the target, it may be necessary to plant. However, planting is not suggested strategy to increase the

deciduous stands. These deciduous species are excellent competitors, but have lower longevity than the conifers. It may be that they have higher compositions than the results indicate, but are dying out earlier, allowing the conifers to take over.

Road Density

Indicator & Target Rationale

Similar to deactivated roads, the densities of roads are substantial for this area due to timber development over the past three decades. To return the forest to a natural, continuous stand there should be less fragmentation and openings caused by roads (Figure 50). These roads also have an average right of way (ROW) of 20m. A ROW is cleared for safety and operability of the roads but naturally regenerates with roadside species over time.

Figure 50: Aerial image of *keyoh* fragmentation due to roads

Target Evaluation

The optimal situation is for the *keyoh* to have a low density of roads (Figure 51). This would limit fragmenting stands beneficial to wildlife.[107] Such a goal is only feasible if the entire area is a reserve zone, eliminating harvesting and human disturbances. Area of road was calculated using 20 m ROW and length of road to provide percentage of roads in the *Daiya-Mattess Keyoh.* The calculated values were then used to create an index of the *keyoh* to compare road densities.

	Good	Medium	Poor
Target Values:	≤ 0.4% land base	0.41-3.8% land base	≥ 3.9% l land base

[107] Canadian Land Reclamation Association. (2010). *Canadian Reclamation: Resource Road Reclamation*. Retrieved Apr. 1, 2011. Hemmera Consultants: http://www.hemmera.com/upload/PDF/ResourceRoadReclamation_CanadianReclamationMagazine.pdf

Figure 51: Road density targets used for scenario evaluation.

Road Density Results

ArcGIS was used for this analysis. In the *Daiya-Mattess* Keyoh there are 488km of road or just under 976ha of ROW area. This works out to 19.32m of road per hectare of land or 3.87% of the *keyoh* land. If the cultural area was to be deactivated then the road density would decrease to 2.51%. It is important to note that not all of the roads mapped have 20m of right of way; block roads and spur roads may have significantly less amount of area affected.

Discussion

The only scenario classified as 'good' is the road-deactivation scenario. As with the previous targets, the smaller the area designated for harvest, the better the target is met.

In road deactivation, problems arise with respect to future harvesting activities. These are mainly scheduling problems and are avoided if roads remain open and are maintained.

Emulate natural disturbances (END)

This objective ensures a healthy, resilient forest. Disturbances are nature's way of re-setting a forest and eliminating old, decadent stands that are diseased or unproductive. Emulating fire disturbance is natural. In this area, END ensures that forests aren't loading fuel and creating an immense fire hazard.

Harvest area sizes

Indicator & Target Rationale

This indicator is useful for emulating the spatial aspect of a fire disturbance. Harvest sizes should range from 40-100 ha, but due to clear-cut size constraints in the interior, will range from 40-60 ha[108]. Openings should have varied edges than straight, square cut blocks. Intense fires often skip stands. This can also be emulated by harvesting. However, fragmentation should be avoided.

This target was developed using recent research by Craig DeLong, the regional research ecologist with the Ministry of Forests, Lands and Natural Resource Operations in the Prince George. It should be noted that in fact, stand replacing fires are much larger than 40-60 ha. Large, intense, natural fires can be over 1000 ha[109]. DeLong suggests creating patches that are greater than 100 ha.

[108] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

[109] DeLong, S.C. 2010. *Land units and benchmarks for developing natural disturbance-based forest management guidance for northeastern British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Tech. Rep. 059. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr059.htm

Target Evaluation

This harvest area size target was evaluated in three components: area <40 ha, area 40-60 ha and area >60 ha. The 60 ha area was included as pine beetle salvaged stands can be greater than 1000 ha if there is more than 25% retention.

Harvest Area Size Results

As expected, the no harvest baseline and road, buffer and planting treatments have no harvesting and do not apply to this target.

When examining the results, percentage of harvest area <40 ha should be smaller than the 40-60 ha and >60 ha targets.

The baseline harvest has many polygons that are less than 40 ha. The remaining harvest scenarios display the same trend. The more area available for harvesting, the better the harvested area results. Consequently, most of the no buffer scenarios do well- specifically the four rotating no buffer harvest scenario and the one zone no buffer scenario.

Discussion

Many of the openings are less than 40 ha. This is simple to change during planning. When determining long-term harvest plans and laying out harvest blocks on the ground, consider harvest area size. The harvest area trends are a result of Atlas choosing which stands to harvest. It is important to note that in the one harvest zone and the four rotating zones, it may be more challenging to meet these increased opening sizes, as there is limited area available for harvest.

Stand ages

Indicator & Target Rationale

This indicator ensures that stands are even-aged. Even-aged stands are a component of emulating fire disturbances as fire results in even-aged stands.

This target should not contribute to the creation of an even aged forest. The target forest is comprised of multiple ages composed of even-aged stands. In other words, the forest is made up of a number of large areas, with one age associated with each large area.

Target Evaluation

This target was evaluated based on four age classes: 0-20 years, 21-40 years, 41-60 years and 61-80 years. The emphasis is on younger age classes as these are the stands that will contribute to the forest over time.

This target was calculated in Atlas using the age class grid. This provided age class distribution based on area. This information was exported into Excel and formatted into the Ecological and Cultural Evaluation Table (Table 15).

Stand Ages Results

The trends for this target do not emulate fire well. Within 20 years of no harvesting in the no harvest baseline, road, buffer and planting treatments, there is no 0-20 age class. It follows that by period 100, there are no 0-80 year stands.

The harvesting scenarios fare slightly better, but the areas in the early age classes quickly decrease in the one harvest zone, the four rotating harvest zones and the combo zone. The expanded harvest zone and all of the no buffer scenarios are adequate in maintaining early age class distributions, but never come close to the age class areas in the period 0 starting point.

Discussion

It is important to note that while the starting point can be used as a reference point for where targets ought to be, the *Daiya-Mattess Keyoh* has been heavily salvaged. The values at time 0 are not necessarily representative of what the *keyoh* should be at. Careful planning and valid information should be applied to seek balance within the targets.

This is a doubly useful indicator as it also assess fire risk. The more area in the earlier age classes, the lower the risk of fire. It is also important not to have too much in the earlier age classes, as they will all mature at the same time and create an imbalance and possibly result in an extreme fire risk around the same period. Balancing the age classes is important in mitigating fire risk and managing a natural forest.

Scenarios that have limited harvest areas have difficulty regulating the age classes, as we see in the one zone and four rotating zone scenarios. The most harvest area available, the easier it is to regulate and balance the age classes, as the no buffer scenarios indicate.

Forest ages

Indicator & Target Rationale

This indicator ensures that old trees do not comprise of too much of the *Daiya-Mattess Keyoh*. This indicator can also be used to assess fire risk as it minimizes old forest ages.

This target seeks to identify stands that are greater than 200 years old based on their percentage of the forest. This target was developed using DeLong's natural disturbance unit research.

Target Evaluation

This target was calculated in Atlas using a seral stage constraint, which tracked stand ages of 200 years or more. This information was then exported using the constraint grid and formatted into the Ecological and Cultural Evaluation (Appendix 8).

Forest Ages Results

Trends indicate that without harvest, the percent of old forest increases to as much as 37 % in the no harvest scenarios. Even with harvest, old forests are approximately 30 %. The

baseline harvest scenario eliminates old forest by period 100. In either case, the target is not being met as there is either too much old forest, or not enough.

Discussion

This target can also be used to assess fire risk on the *keyoh*. This target also indicates that without harvest, fire risk increases and it may be necessary to pursue fire management strategies (Page 28). In scenarios with no harvest or in the one harvest zone scenario, it is important to monitor these areas, as they may be prone to disease outbreaks in addition to fire.

The target is to classify forests older than 200 years as 'rare'. Rare would be a target percentage of around 10% or less. Anything over 10% is no longer being considered rare. The scenarios do not adequately meet this target after period 40. It may be necessary to either harvest more area or ensure monitoring is in place to protect the forest from disease and fire.

Land disturbed

Indicator & Target Rationale

This indicator looks at the land disturbed, mainly due to harvest. Road area is not considered disturbed as it is too challenging to incorporate, and road densities have been accounted for in other targets. Analysing the land disturbed helps ensure that period disturbances are occurring and forest health is being maintained by these disturbances.

The target for this indicator is based on DeLong's recent research on natural disturbance units in the Fort St. James area. His targets indicate that 0.75-1.25 % of the land base should be disturbed per year.

Target Evaluation

This target was evaluated using Atlas outputs from the treated areas grid. Using the areas `treated` with clear cuts, land base disturbance was calculated by dividing the clear-cut area by total area to determine the percent of land disturbed.

Land Disturbed Results

All scenarios have some level of disturbance except for the no harvest scenarios. However, many scenarios do not meet the 0.75-1.25% target. The only scenario that meets the target in every time period is the expanded harvest zone that maximizes volume.

Discussion

This target was applied to the entire *Daiya-Mattess Keyoh*, although half of the *keyoh* is in reserve. If it were evaluated based on the disturbance in the harvestable area, the results would be quite different. It is also important to remember that disturbance is constantly taking place in the same areas- areas being harvested. This is not ideal unless the rotations are longer allowing stands to recover and provide habitat.

Socio-Economic

This value generates benefit to *Daiya-Mattess Keyoh* family and contributes to the community by providing jobs. This value is not as important as providing habitat and maintaining a healthy forest, but was provided for the consideration of *Daiya-Mattess Keyoh* holder Ken Sam should his management objectives shift in priority.

Maintain and enhance long-term benefits to the *Daiya-Mattess Keyoh*

This objective addresses concern for the well being of Ken Sam's family, and seeks to identify scenarios which practical to implement and have the potential to fund other treatments.

Revenue Generated

Indicator & Target Rationale

Analysing the revenue generated in each scenario seeks to identify those scenarios, which are the most practical to implement on the land base. If a scenario does not generate much revenue, then it will likely not be able to cover the costs of implementation. Profit would have been the preferable indicator, but was challenging to evaluate for the number of scenarios, so revenues are used instead.

Target Rationale

The target is to break-even. If a scenario is break-even and the ecological effects of management meet the objectives, then it will be worth implementing. Any scenario that results in financial losses is too challenging and would not be implemented.

Target Evaluation

The evaluation for this target can be seen in more detail in the business plan.

Revenue generated Results

The results for this target are predictable. The scenarios that allowed the most timber harvesting yielded the best revenues. Scenarios that generated carbon yielded high revenues, but also have high implementation and start-up costs.

Discussion

Revenue is a consideration to fund other treatments such as planting and road deactivation. While it isn't a high priority for *Daiya-Mattess Keyoh* holder Ken Sam, it was examined to ensure treatments were feasible, and to determine which treatments were possible and practical.

Job Creation

Indicator Rationale

Job creation examines how much benefit the Sam family sees either by providing jobs within the family or within the Fort St. James Community. This may be a more important consideration in the future. For now, it helps to provide a sense of the labour involved for

each treatment in that the more jobs, the more work a treatment requires, and the more it will cost.

Target Rationale

As long as the number of jobs created is greater than 0, the target is considered met.

Target Evaluation

The evaluation for this target can be found in more detail in the business plan.

Job creation Results

The jobs created by harvesting scenarios are the most consistent through time. Jobs created through planting and road de-activation treatments are 12 and 5 respectively, but only occur in period 0.

Discussion

While jobs created by road de-activation occur only in period 0, in reality they may be spread through time, as it may not be realistic to pay for the road-deactivation treatments in one lump sum. It is also important to note that while jobs related to harvesting only occur for each 20-year period, they are actually providing jobs on an annual basis as well.

Table 15: This table outlines the assumptions made when evaluating the scenarios to determine whether they met the targets.

Target	Assumptions
Fragmentation	Wildlife is already present on the *keyoh* so there is already adequate habitat, just need to ensure harvested areas which will become habitat are not fragmented
Road proximity to rivers, streams and lakes	All streams classified as S1 and given a 100 m buffer
	There is no harm in having a buffer too large
	The stream, river and lake data is accurate and complete
Number of stream crossings	Size and lengths of crossings are all equal
	Anywhere a road crossed a stream or river in ArcGIS, there was a stream crossing
	All streams crossings present in the data are active
	All active stream crossings would be removed if the road was de-activated
Protect culturally significant area	No harvesting or human disturbance other than the *keyoh* holder's family within cultural land use site buffers
	Cultural land use sites are areas used for trapping, hunting, fishing, cabins
	Included recreational sites as they provide access
	All land use sites were either located on the land use occupancy map provided or were indicated by *keyoh* holder Ken Sam during our meeting
	1 km buffers are sufficient
De-activated roads	Mainlines and cultural land use site access should remain open
	All roads are active
	Current road data is comprehensive and accurate
	De-activation in this scenario means de-building roads (remove stream crossings, re-contour the land)
	Entire length of road must be de-activated due to provincial regulations regarding road maintenance
Seral Stage	No limit on late seral stage, but should consider fire hazard
Species composition	*Daiya-Mattess Keyoh* is not an anomaly and it is appropriate to apply the TSR's species composition for the SBSmk1 zone
Road density	Right of way (ROW) is 20 m
	Applied 20 m of ROW to all roads, including spur and block roads

	All roads on Canfor's Winter Harvest Map are active
Harvest area sizes	Pine beetle salvage regulation allows the emulation of intense fires greater than 60 ha
	Harvest areas <40 ha do not effectively emulate fire
Stand ages	Period 0 does not provide a good reference point due to the amount of salvage logging
	The lack of early age class representation is indicative of increasing fire risk
Forest Ages	Rare means 10% or less
Land disturbed	Does not account for areas disturbed by road
	Does not account for disturbing different areas with each harvest (same areas may be repeatedly disturbed)
Revenue Generated	Successful management strategies only need to be break even, since objectives are to protect the values and generate jobs rather than make money
Job creation	Number of jobs reflects the cost of the treatment (the more jobs, the more expensive the treatment)
	Number of jobs reflects the intensity of treatments (the more jobs, the more treatment intensity increases)

Appendix 6: Carbon Graphs

Planting Scenarios Graphs

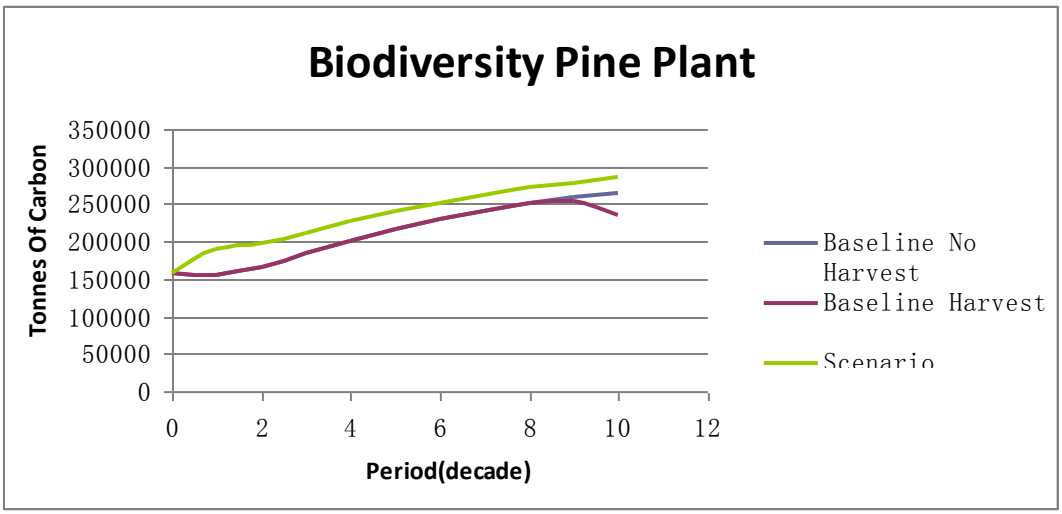


Figure 52: Graph 1

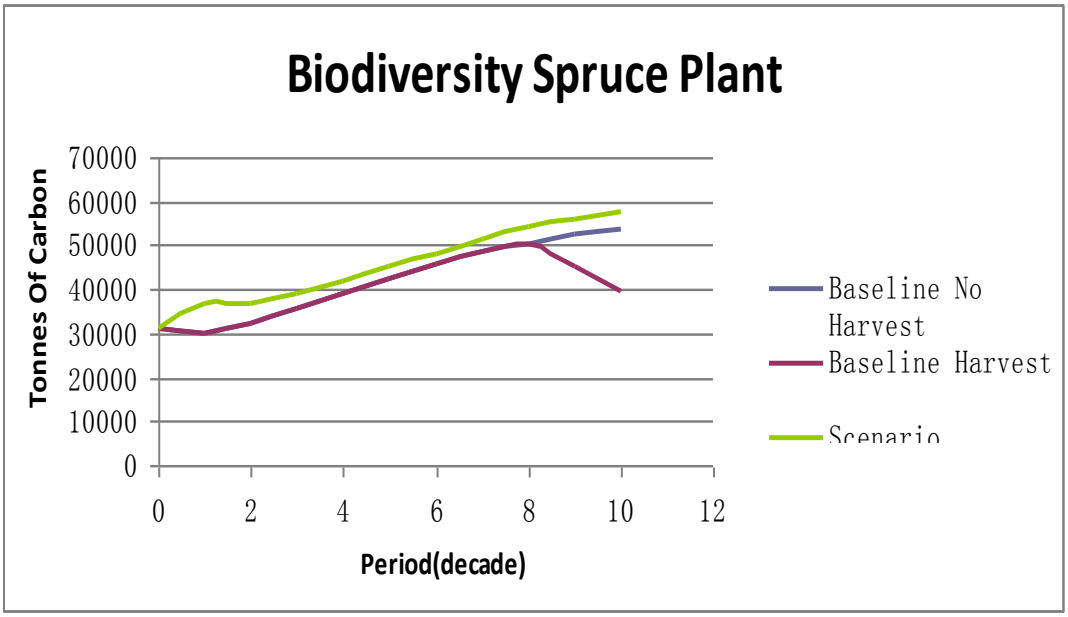


Figure 53: Graph 2

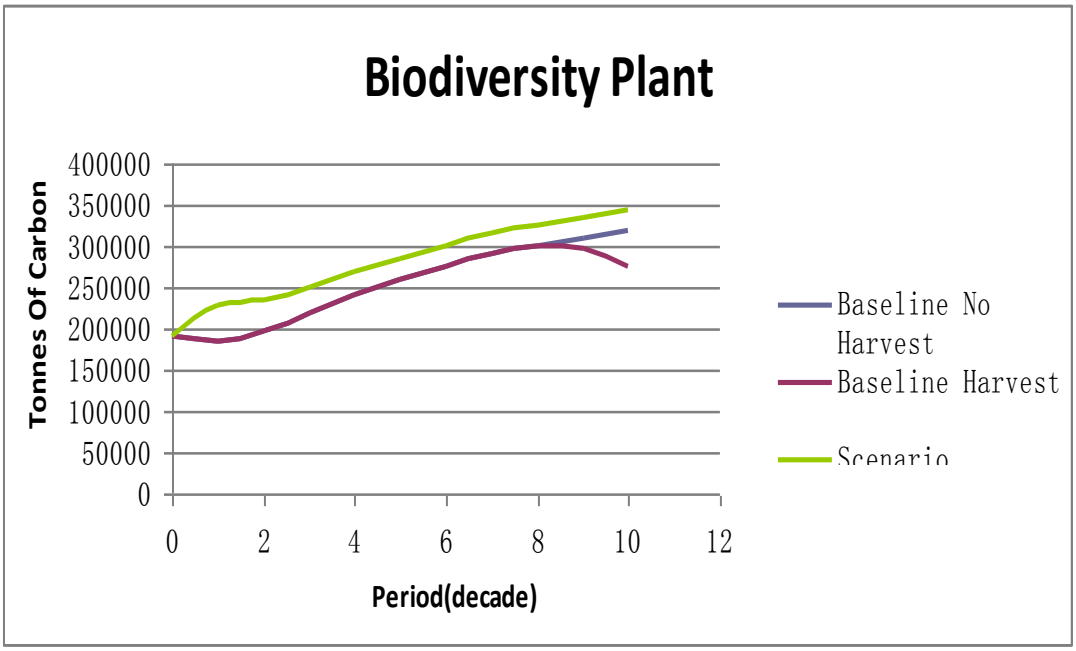


Figure 54: Graph 3

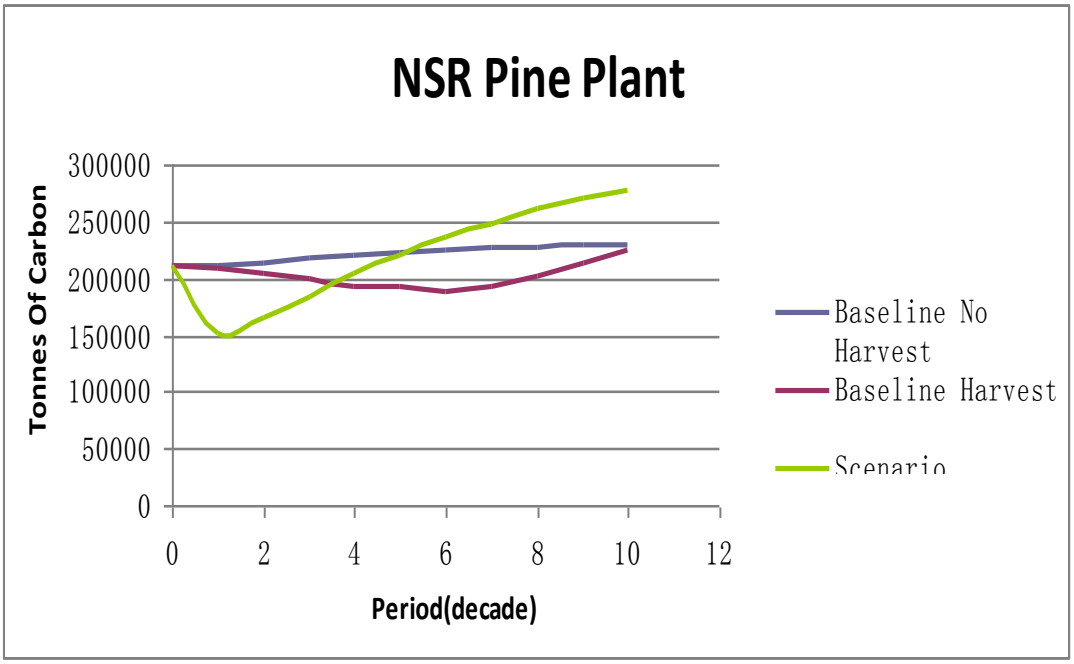


Figure 55: Graph 4

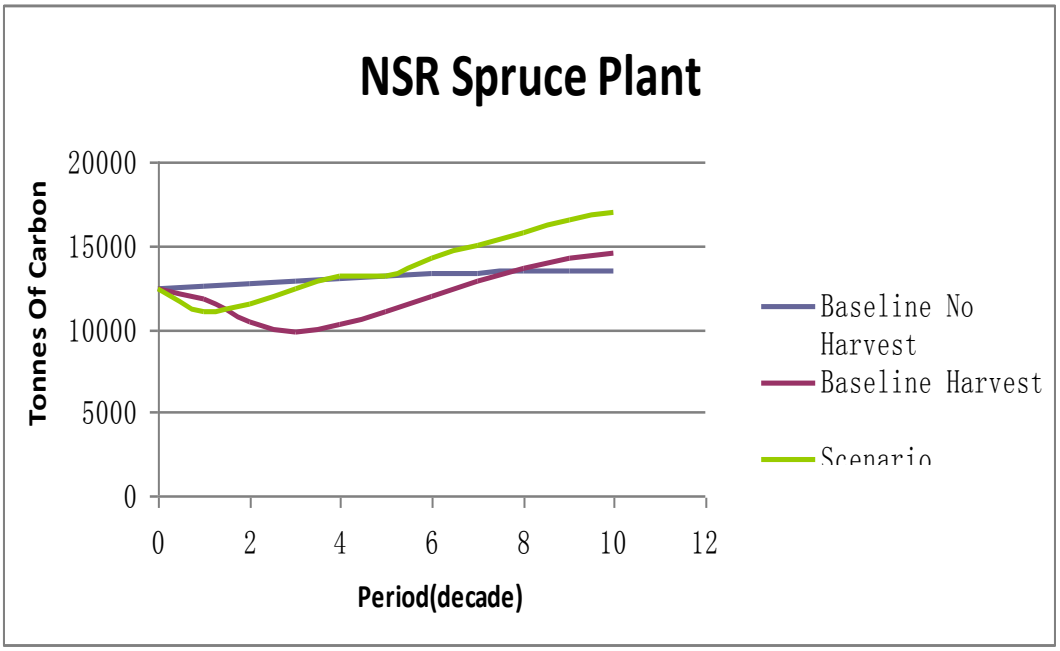


Figure 56: Graph 5

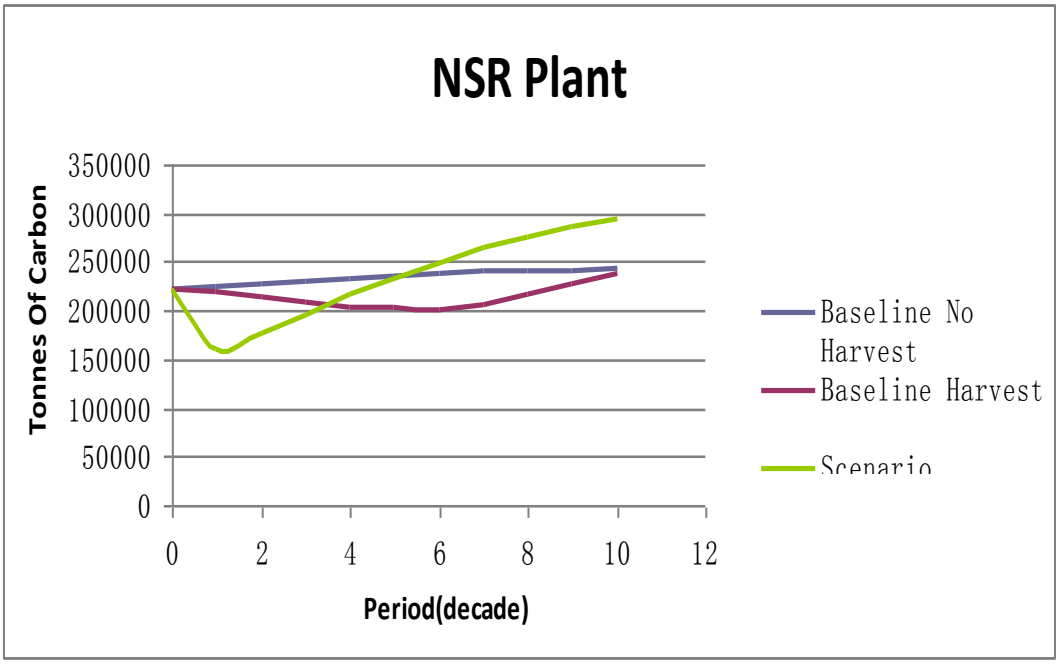


Figure 57: Graph 6

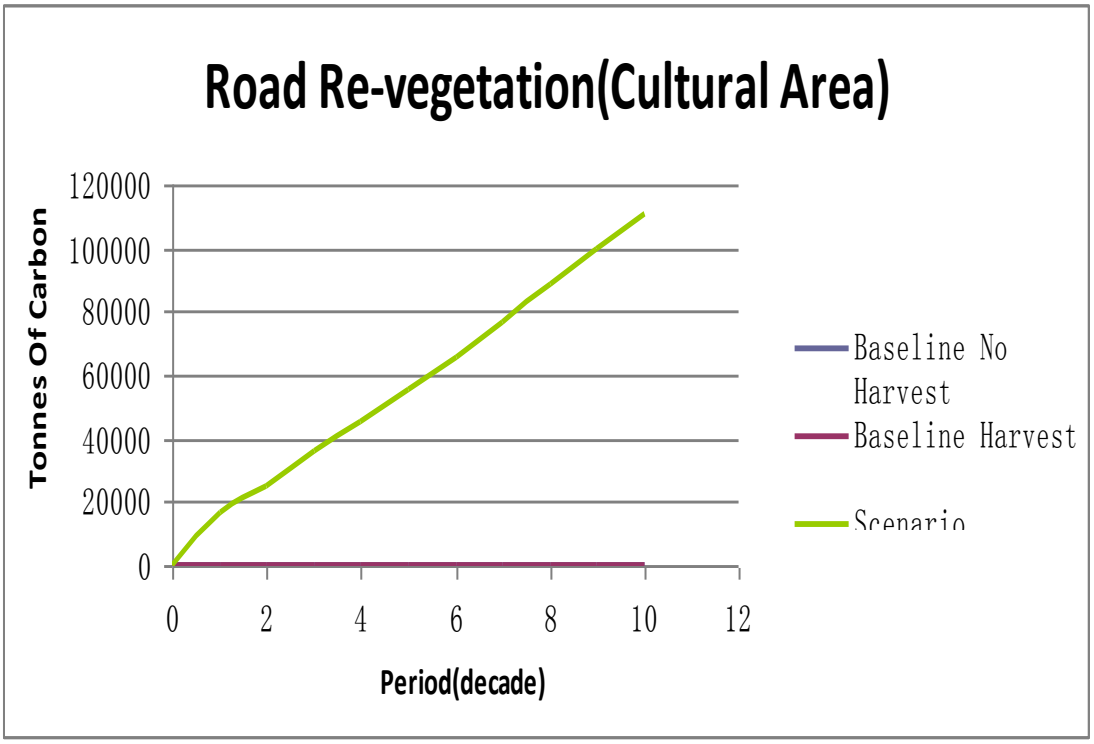


Figure 58: Graph 7

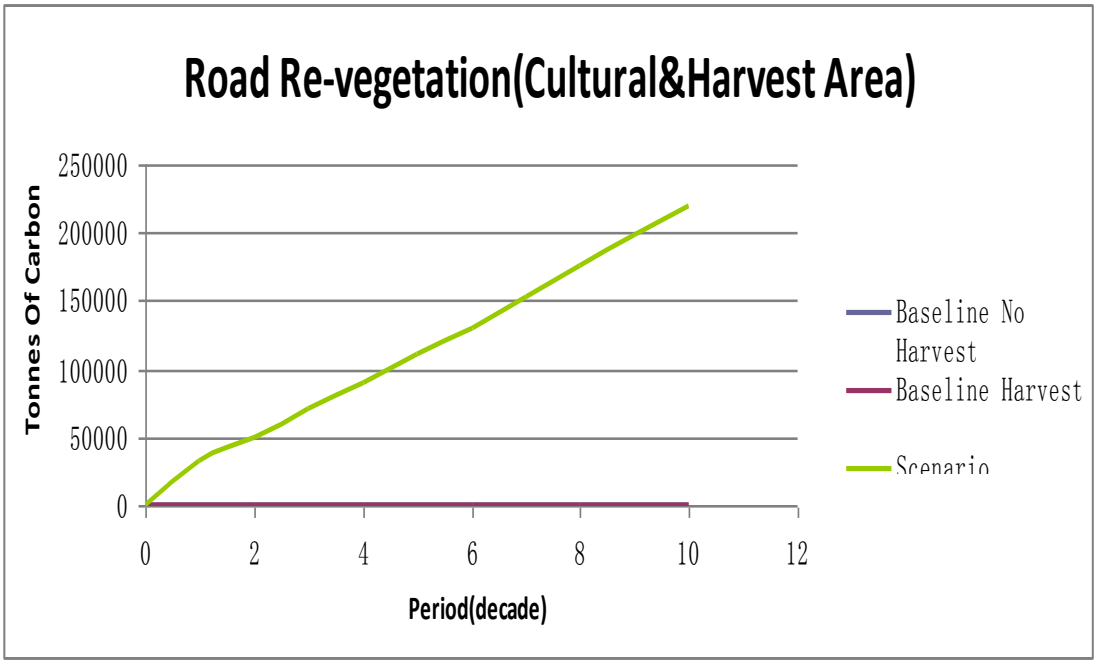


Figure 59: Graph 8

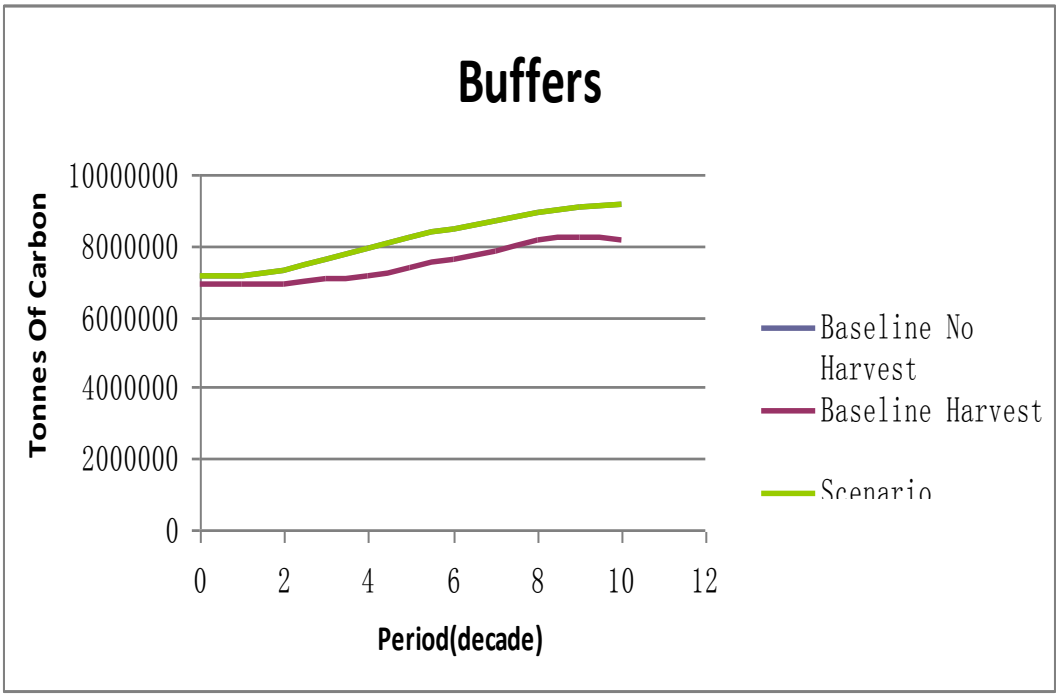


Figure 60: Graph 9

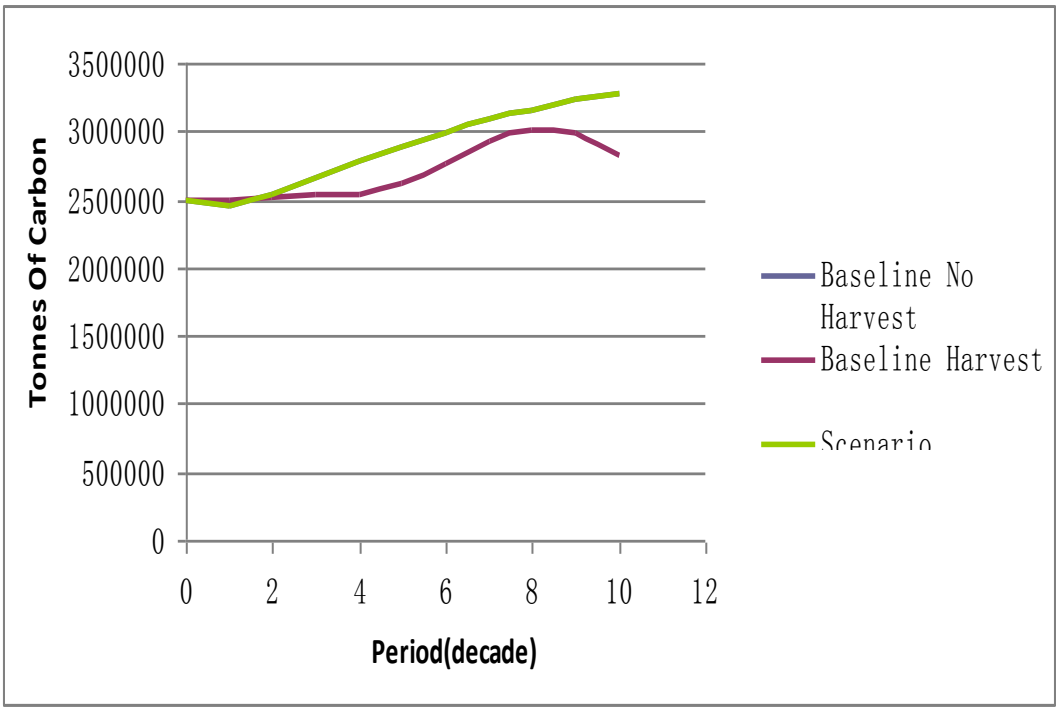


Figure 61: Graph 10

Harvesting Scenarios Graphs

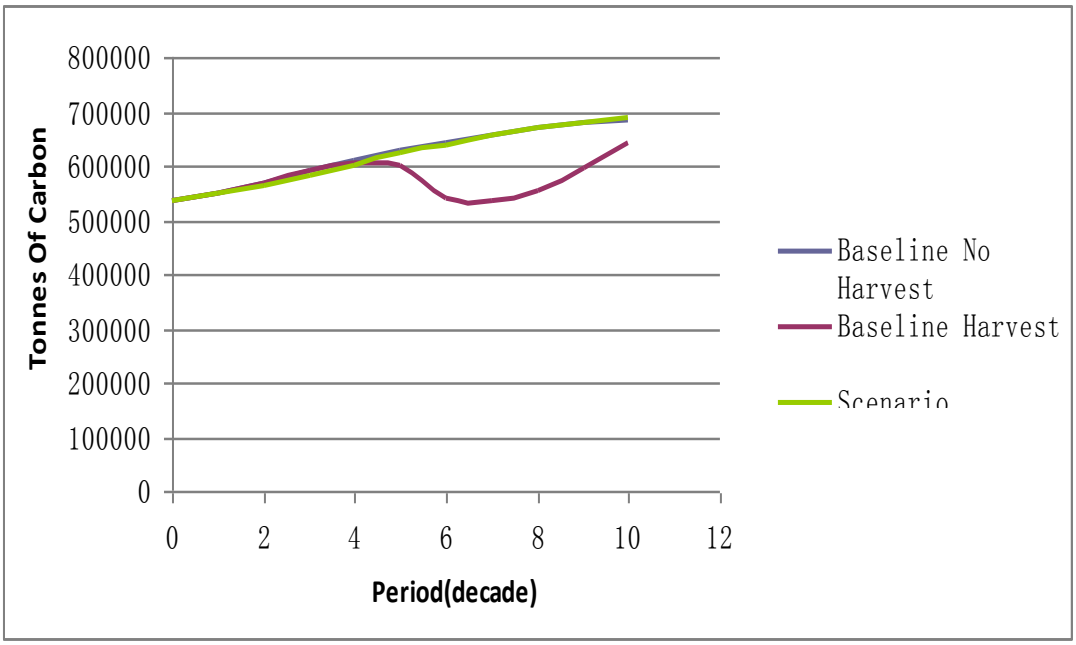


Figure 62: Graph 11

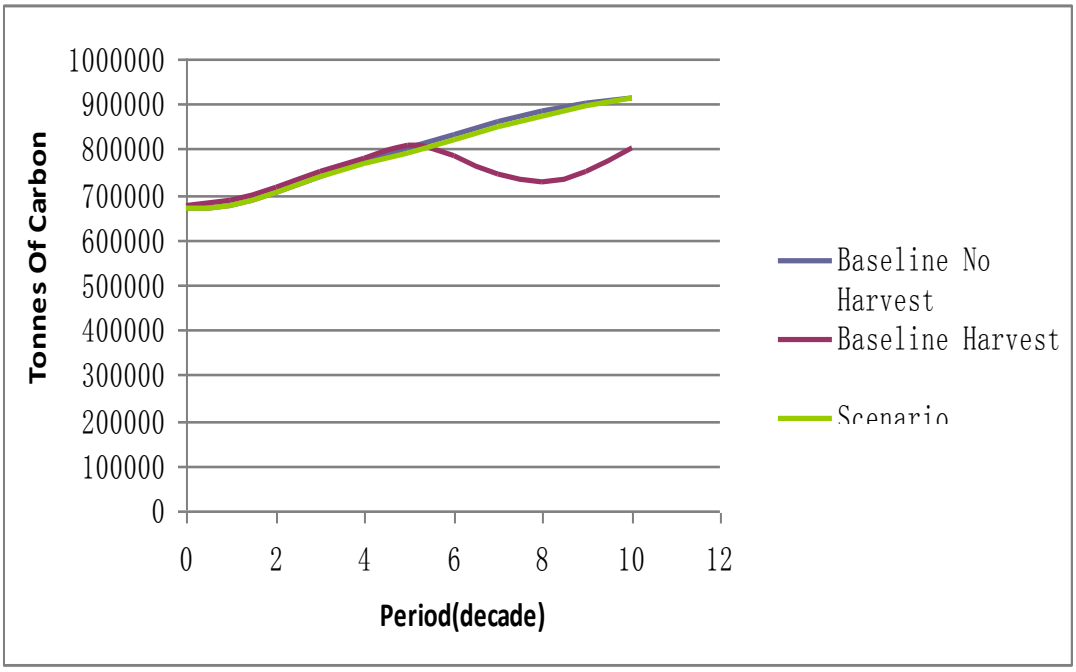


Figure 63: Graph 12

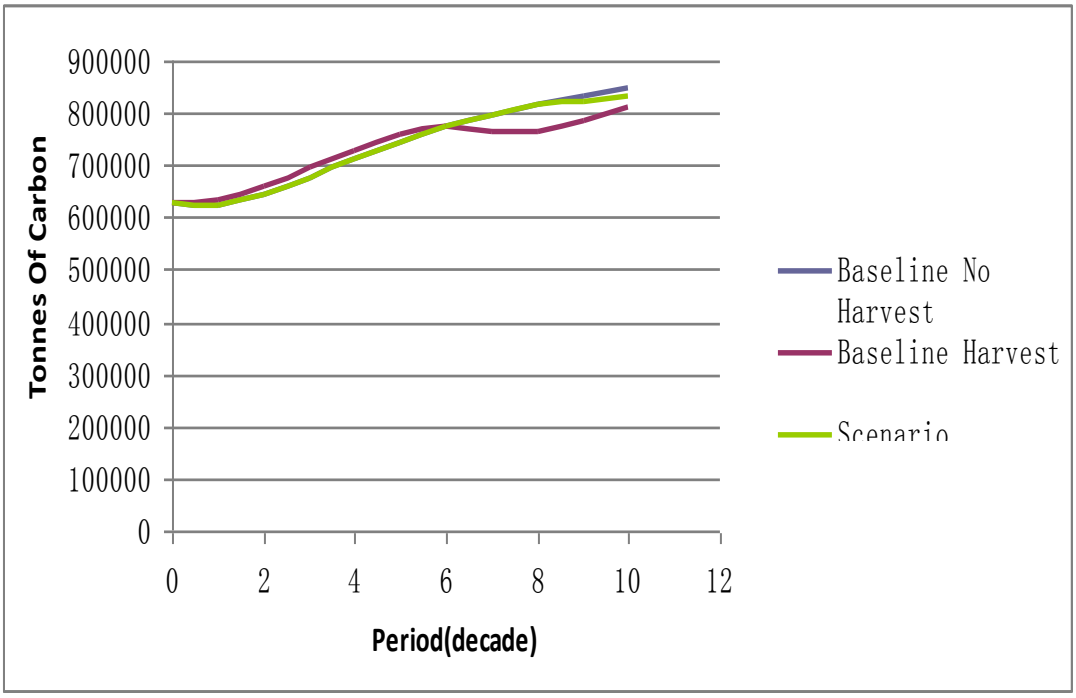


Figure 64: Graph 13

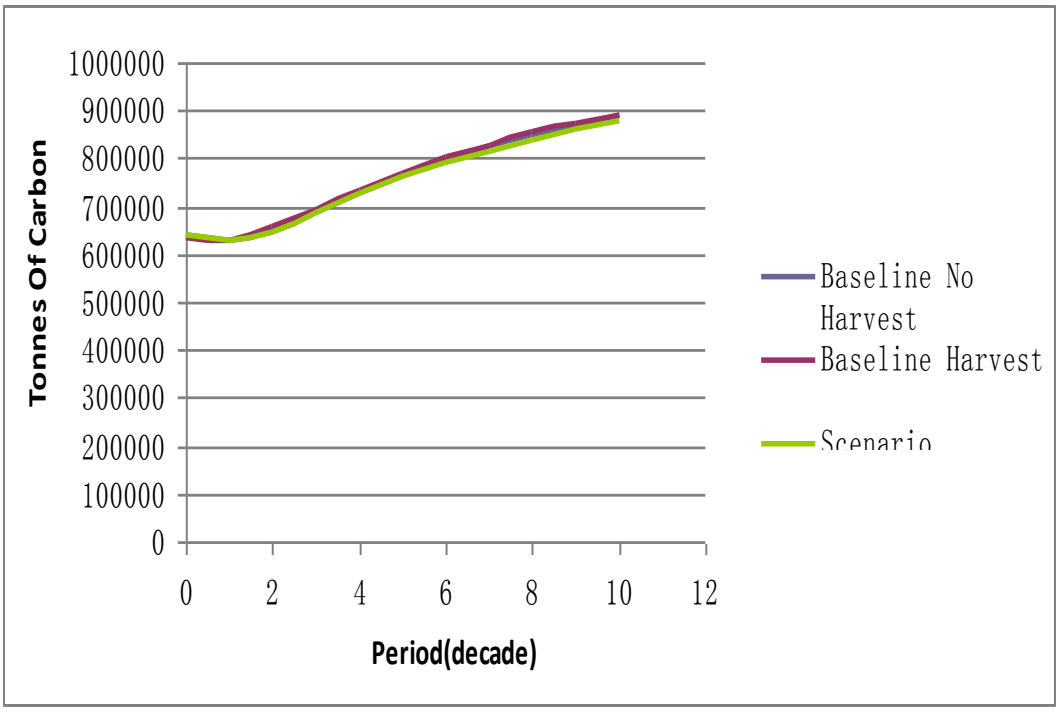


Figure 65: Graph 14

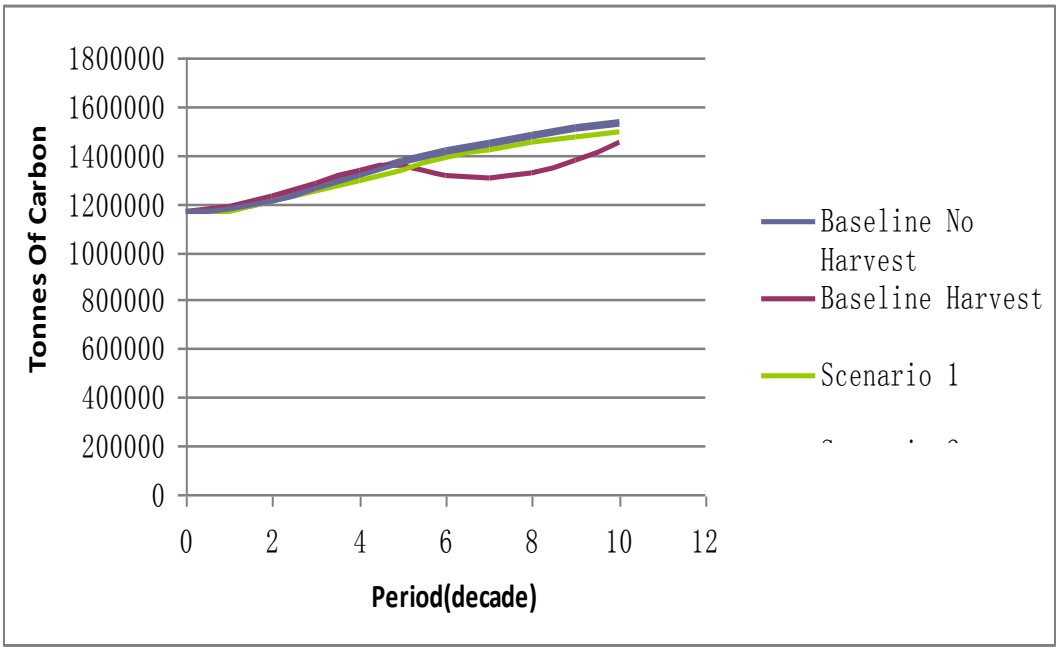


Figure 66: Graph 15

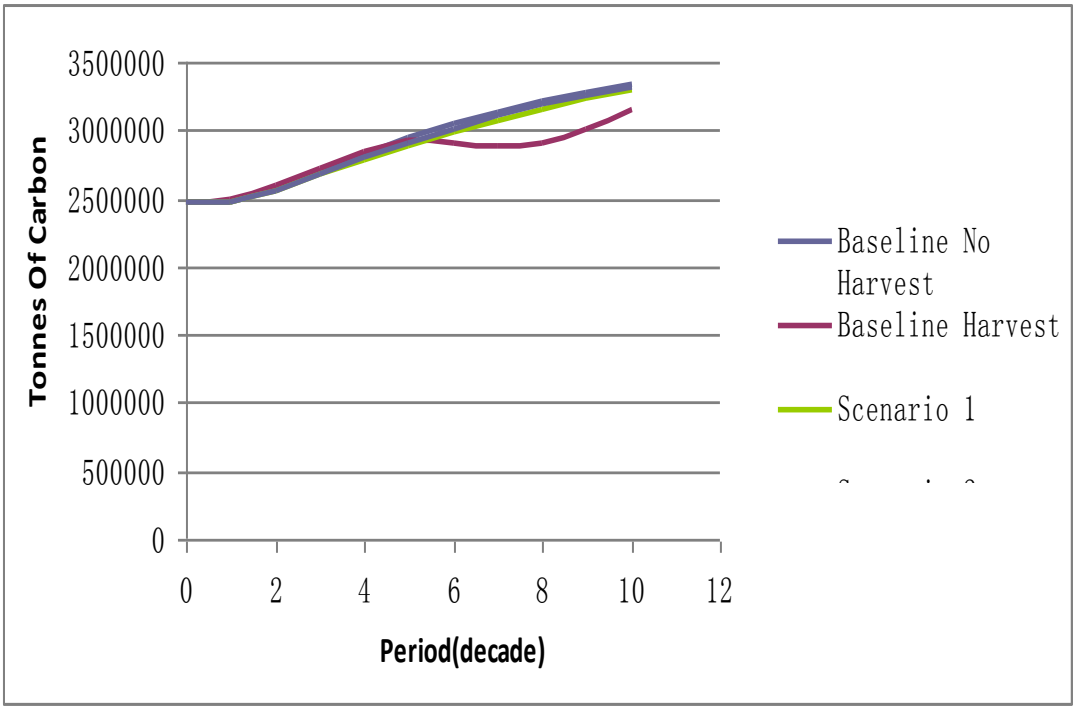


Figure 67: Graph 16

Appendix 7 – Awareness Survey

Daiya-Mattess Keyoh Knowledge Survey

1. **Address (Town is acceptable):**
    a. How long have you lived at this address?
2. **Ethnicity:**
    a. Eg. Caucasian, Asian, First Nations, Black, Hispanic
3. **Age:**
4. **What recreational activities do you participate in?**
    eg. Hiking, fishing, etc. (If hunting or fishing is answered please indicated what species)
    a. Summer:
        i. How frequently? Daily, Weekly, Monthly?
    b. Winter:
        i. How frequently? Daily, Weekly, Monthly?
    c. Year-round:
        i. How frequently? Daily, Weekly, Monthly?
5. **Do you know about the *Daiya-Mattess Keyoh*?**
    a. *If yes*, how do you know about them?
6. **Do you know about the *Maiyoo Keyoh*?**
    a. *If yes*, how do you know about them?
7. **Have you met any *Daiya-Mattess Keyoh* people?**
    a. *If yes*, who?
8. **Do you know where the any *Daiya-Mattess Keyoh* is?**
    If yes:
    a. How many times have you visited?
    b. Why did you visit the area?
    c. How long did you stay?
    d. Will you go back?
    e. Please describe where it is and how you accessed it:
    If no:
    f. Would you visit if you knew where it was located?
9. **Have you visited any of the recreation sites in the area?**
    If yes:
    a. How many?
    b. Which ones?
    c. On average how long was your stay at these recreation sites?
    If no:
    d. Would you visit them if you knew more about the area?
10. **While at the recreation sites, did you see any wildlife?**
    If yes:

a. What type of animals did you see?
b. Approximately how many did you see of each kind?

If no:

c. Do you know why you did not see any animals?

11. Would you like to see signs to know when you're entering the *Daiya-Mattess Keyoh*?

a. If no, please explain why:

12. Would you like to see signs to know when you're leaving the *Daiya-Mattess Keyoh*?

a. If no, please explain why:

Appendix 8: Ecological and Cultural Evaluation Table