UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

Malcolm Knapp Tree Top Down Business and Management Plans

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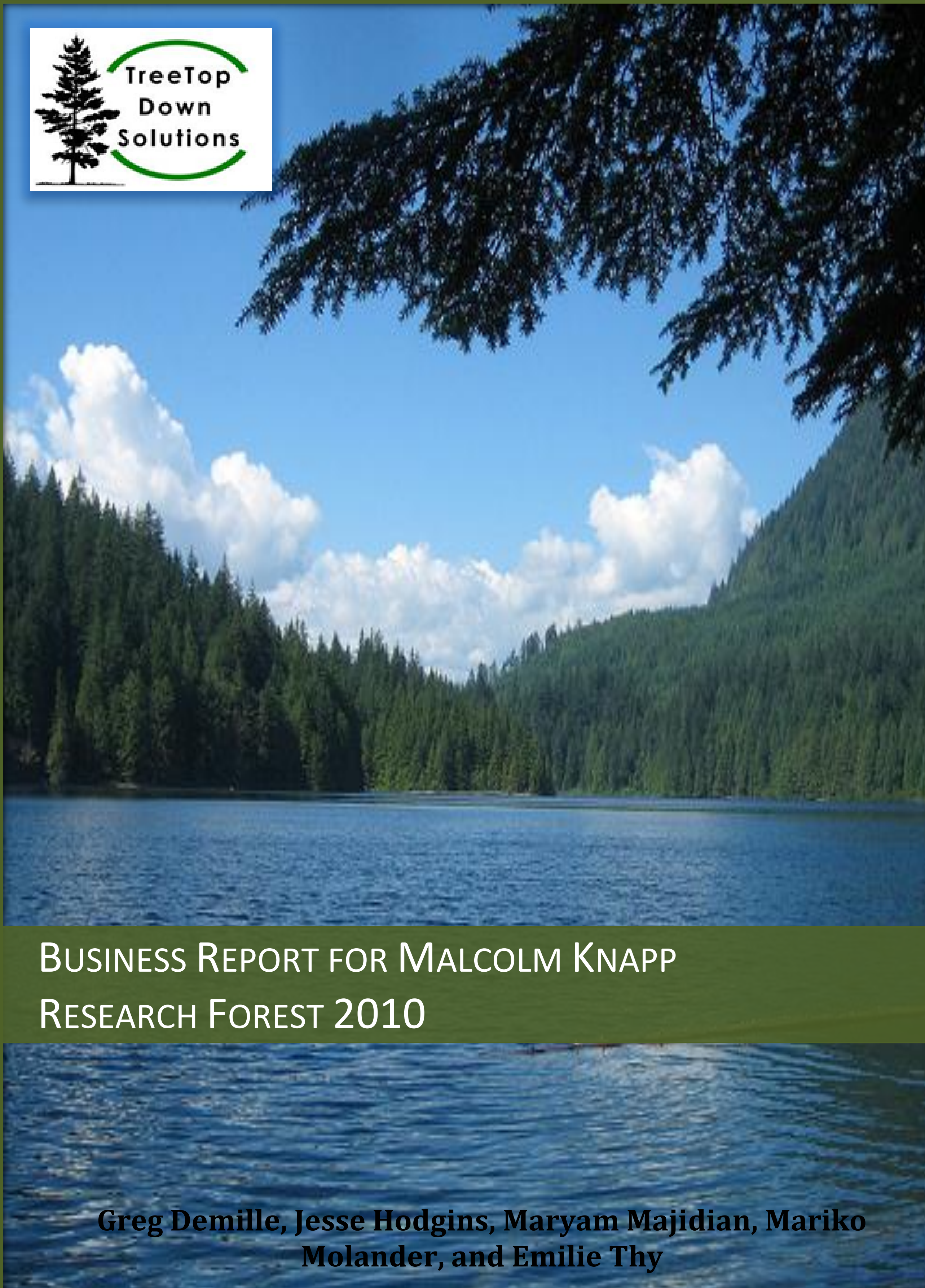

Business Report for Malcolm Knapp Research Forest 2010

Greg Demille, Jesse Hodgins, Maryam Majidian, Mariko Molander, and Emilie Thy

Executive Summary

The recent economic downturn has had an overall adverse affect on market conditions, and the forest industry in particular has suffered as a result. The Malcolm Knapp Research Forest (MKRF) has been negatively affected by the decrease in log, timber, and wood product prices, and is seeking to explore financial prospects through the emerging carbon market while maintaining its current business endeavors.

This business plan has been prepared in conjunction with MKRF: Carbon Management Plan, with the objective of evaluating the economic feasibility of scenarios which have been developed by TreeTop Down Solutions. The scenarios were specifically developed in the management plan to pursue revenue-generating potentials within the emerging carbon market while maintaining and balancing several other objectives and interests, including log and timber sales. The three scenarios considered in this report include the following: No Harvest, Extended Rotation, and Select Seed. These scenarios are compared to the 2007 Base Case, which serves a datum to measure net change in carbon stocks (i.e. additionality). An overall positive gain in carbon pools leads to the generation of carbon credits, which can be sold to regulatory and voluntary carbon markets.

It was determined that the Extended Rotation scenario best meets MKRF's objectives and interest as well as being economically feasible. The financial analysis indicates that the net present value of this scenario yields approximately $8M in profits, using a 6% discount rate.

A general overview of MKRF's current business is provided, and timber and carbon market trends are discussed to provide the quantitative context for the financial analysis. To open up market opportunities within the regulatory market, third party certification through the Sustainable Forest Initiative (SFI) is considered. Risks associated with the proposed ventures are also discussed.

A financial analysis is presented for each scenario to evaluate the potential profit which can be generated within the carbon and/or timber market. Due to the uncertainty surrounding both of these markets, a sensitivity analysis is also provided to evaluate the effect on profit potential using different discount rates which are indicators for different levels of risk tolerance. Lastly, the current emissions of the University of British Columbia (UBC) are discussed and compared to the total number of carbon credits produced by each scenario.

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Acronyms and Abbreviations

AFOLU	Voluntary Carbon Standard Guidance for Agriculture, Forestry, and Other Land Use Projects
BC	British Columbia
CBM-CFS3	Carbon Budget Model of the Canadian Forest Sector
CO_2E	Carbon Dioxide Equivalent
CSA	Canadian Standards Association
FPS-Atlas	Forest Planning Studio-Atlas
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
MKRF	Malcolm Knapp Research Forest
PCT	Pacific Carbon Trust
US	United States
VCM	Voluntary Carbon Market

1.0 General Company Description

1.1 Business Description

Malcolm Knapp Research Forest (MKRF) is an operational forest located in Maple Ridge, British Columbia (BC). An area of approximately 5,136 hectares was granted by the Province of British Columbia in 1949 and remains in UBC's private ownership. In order to maintain the deed, the University must maintain research and education opportunities at MKRF. A small staff –partly comprised of UBC alumni— aim to sustainably manage the research forest and its interests. MRKF aims to balance forest operations, research opportunities, and educational facilities.

Log and timber sales previously dominated the research forest's revenue stream, but have been less prevalent in recent years. In addition to log sales, milling is sub-contracted out to Gallant Enterprises who operates within the MKRF and strives to retain value through the milling and sales of value-added wood products. However, MKRF has suffered with the recent economic downturn, which has created a need for a shift in MKRF's dependence on forest operations.

Recently, logging revenue has been supplemented by revenues generated from the Loon Lake Research and Education Centre. The facility and its services make up approximately half of MKRF's revenue, and this is expected to increase with future developments (Lawson, Financing the Research Forests, 2010). The Centre hosts a variety of events including children's camps, conferences, tours and retreats. Its most notable event is the Canadian Cancer Society's Camp Goodtimes, which provides children and teens with a safe camp experience.

MKRF will continue to maintain the Loon Lake facility, and hopes to continue the generation of revenue through its log and timber sales; however, at this juncture, MKRF seeks to explore opportunities to further supplement its income through participation in the emerging carbon market.

1.2 Key Objectives

TreeTop Down Solutions was given the task to investigate new management strategies and initiatives to increase MKRF's current revenue stream. Through consultation with our clients, it was suggested that TreeTop Down explores the generation of carbon offset credits to boost MKRF's economy. It is believed that carbon offsetting could provide MKRF with an additional source of revenue without compromising current forest operations, camp operations, or fulfillment of the research mandate. The objective of this document is to deliver an analysis of the financial benefits associated with entering into the carbon market, while balancing the other business interests and goals of MKRF.

1.3 Report organization

Firstly, the market section discusses trends in the timber and carbon industries. Moreover, this section relates MKRF's interests in these industries. The following section discusses the financial results of the 2007 Base Case and three carbon management scenarios. Viable scenarios include the No Harvest, Extended

Rotation, and Select Seed scenarios. These scenarios have considered the economic, environmental and social constraints imposed on MKRF (see MKRF: Carbon Management Plan); however, but for the purpose of this report, an emphasis has been placed on the profitability and long-term flexibility of the scenarios. Thirdly, due to the considerable risks associated with the proposed ventures, a sensitivity analysis was developed to enable the client to evaluate their risk tolerance. Finally, UBC's carbon neutrality targets and associated offset requirements are considered and related to the offsets produced by the carbon management scenarios.

It should be noted that Loon Lake Research and Education Centre is excluded from this financial analysis, as it is independent of the commercial forest operations or carbon offset projects.

2.0 Markets

Both timber and carbon markets have been considered due to the synergy that exist between the two fields. The following section demonstrates the combined net benefit of managing these two resources.

2.1 Timber

BC's forest industry is highly dependent on its neighbors to the south in the United States (US). Approximately 81% of the industry's wood products (i.e. lumber and logs) are exported to the US; remaining exports are shared between Asia, Europe and other countries (Woodbridge Associates, 2009).

In recent history, lumber and log prices have been in steady decline. Figure 1 shows that lumber prices have decreased from about \$360/mbf to \$250/mbf in 2009 (TD Economics, 2009).

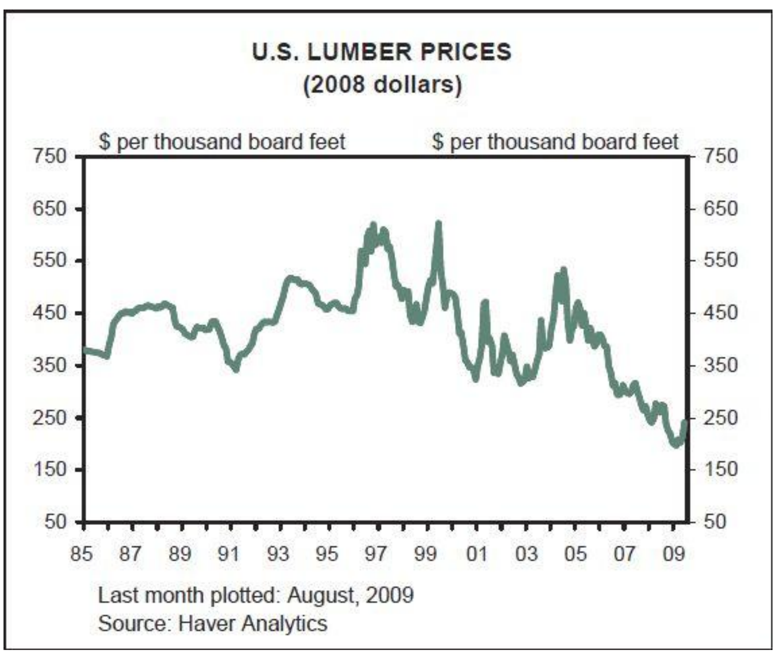

Figure 1: The US lumber prices per thousand board feet from 1985-2009 (TD Economics, 2009)

Both commodity-based forest companies and small scale value-added producers have been subject to market fluctuations. MKRF is among the producers that are suffering through the challenging economic period. It is expected that these prices will remain at current levels in the future –"we are now in a *new normal*" (Lawson, 2010). Figure 2 demonstrates how MKRF harvesting income fluctuates with the market conditions as illustrated in Figure 1. Note that despite increased harvest levels (see Figure 3); the revenue from this operation has not increased.

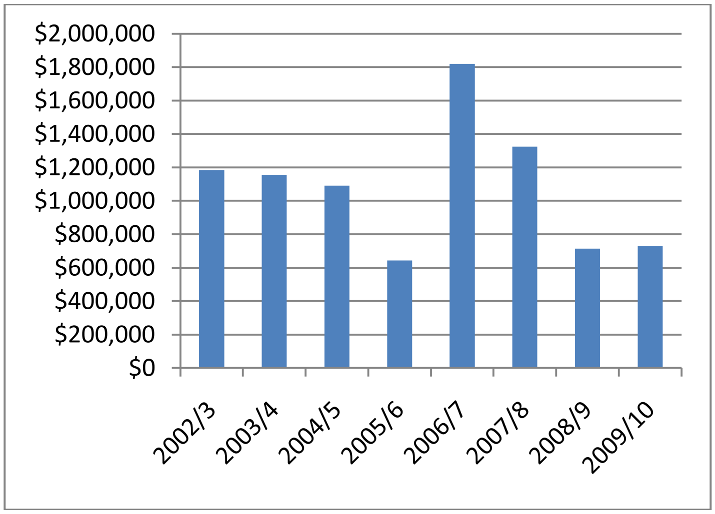

Figure 2: Timber harvesting revenue 2002-2011 (Lawson, 2010)

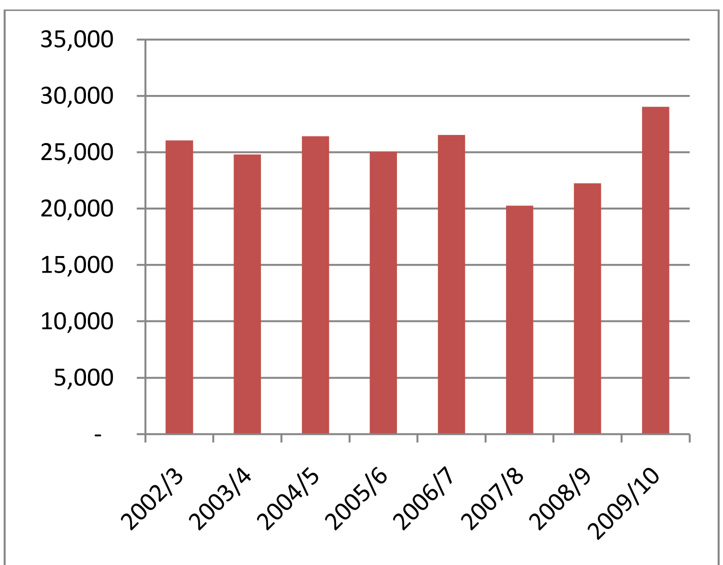

Figure 3: Timber harvest volume (m^3) 2002-2011 (Lawson, 2010)

If current trends persist, commercial forest operations will not be able to continue as a viable business strategy for MKRF. It is therefore necessary for MKRF to diversify its current forest practices so alternative forms of revenue can be derived from the forest.

2.2 Carbon

Carbon credits resemble a commodity product; however, projects implemented to reduce emissions are very diverse. They range from afforestation projects to clean energy initiatives. Carbon credits can be purchased anywhere in the world with the intent of offsetting emissions. Projects fixed in one country may still attract the interest of nations, businesses and individuals abroad. For this reason as well as a the increasing environmental awareness, the carbon industry has experienced rapid growth (see Figure 4).

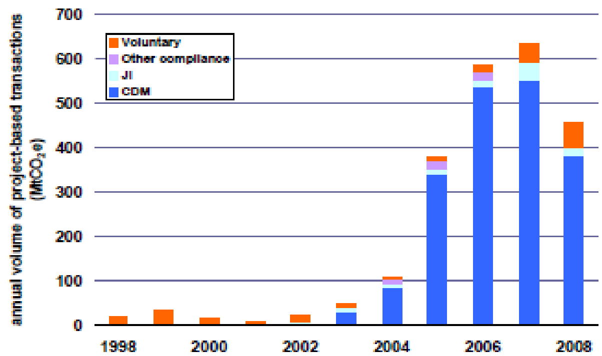

Figure 4: Annual volumes (Mt CO_2E) of project-based emission reductions transactions (Capoor & Ambrosi, 2009)

Moreover, interest is expected to grow as local and international governments develop compulsory regulations for the public and private business sectors. Namely BC's *Greenhouse Gas Reduction Target Act* requires that the public sector reach carbon neutrality by 2010. By 2012, non-compliant agencies will be required to pay a tax of $30 per tonne of carbon dioxide equivalent (CO_2E) in excess of set targets (BC Provincial Government, 2007). It is uncertain if the same obligation will be required of BC's private sector; nevertheless, businesses have voluntarily positioned themselves within the carbon industry in anticipation of similar developments or simply to further their own green initiatives.

The price of project-based emission reductions has paralleled the growth of the carbon industry. International prices were hovering between $10-25 per tCO_2E prior to the 2009 recession (see Figure 5) (Capoor & Ambrosi, 2009). Although there has been a decrease in value, the price per tonne is expected to return with economic growth and global demand (Capoor & Ambrosi, 2009).

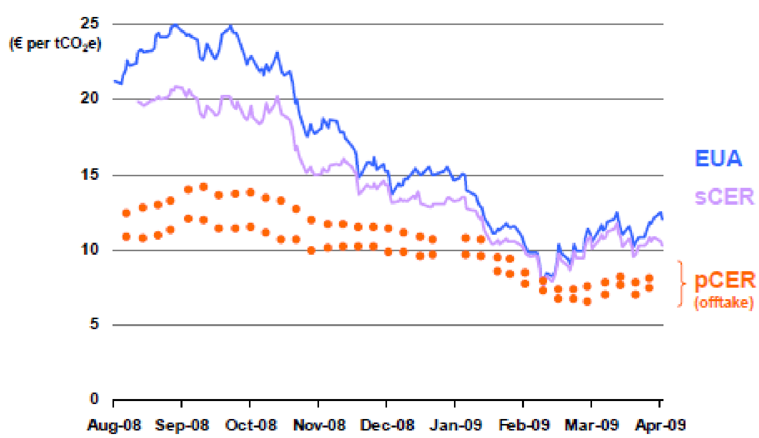

Figure 5: Carbon response to the recession (Capoor & Ambrosi, 2009)

Meanwhile, North American markets developed under the Voluntary Carbon Standards indicate that carbon credits—specific to forest management projects—are currently valued in the $4-10.50 price range (see Figure 6) (Hamilton *et al.*, 2009).

Although the BC Provincial Government has set the carbon tax at $30 per tCO_2E, it is expected that the Pacific Carbon Trust (PCT)—a Crown corporation of the BC Provincial Government— will purchase credits for $20 (Carr, 2010).

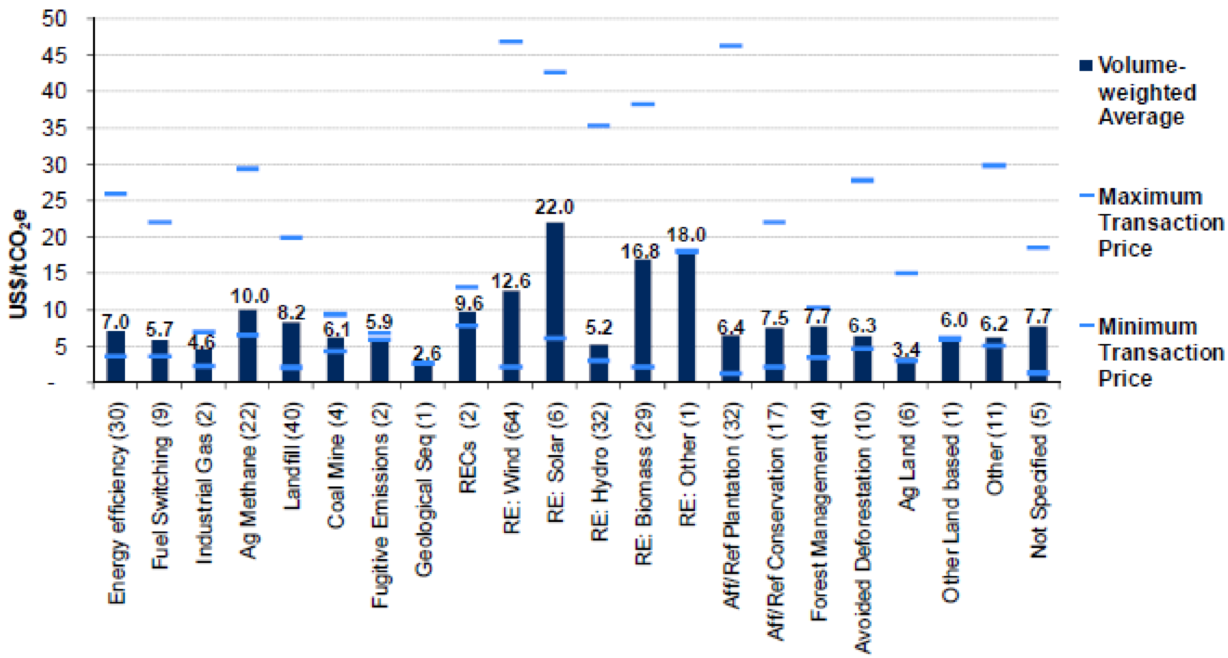

Figure 6: Credit price ranges and averages by project type (Hamilton *et al.*, 2009)

2.3 Market Opportunities

MKRF has the opportunity and ability to capitalize on the developing carbon industry while simultaneously maintaining its enterprise in forest operations and research/education.

The following outlines the positive factors of success:

- private ownership ensures that MKRF would be entitled to the *carbon rights* and the accompanying financial remuneration
- MKRF's experienced staff provides the institutional capacity to carry out a carbon management plan
- major investments in infrastructure have already been delivered for forestry purposes and thus can be used as an asset in a carbon management scenario

Based on the accompanying document –MKRF: Carbon Management Plan— three scenarios were developed to increase carbon stocks (i.e. additionality), thereby producing carbon credits eligible for sale. These scenarios include:

- No Harvest
- Extended Rotation
- Select Seed

The scenarios were intended to meet the requirements of several carbon standards applicable to both BC's regulatory and voluntary carbon markets. Management strategies consider the anticipated release of PCT's Forestry Protocol. Summarized below are the potential markets where economic opportunities exist to sell carbon credits.

- **Pacific Carbon Trust:** PCT is a provincial government agency that is responsible for purchasing carbon offsets for BC's public sector. Projects eligible for registration under PCT must begin commercial operations after November 29, 2007, and must comply with the *BC Emission Offsets Regulation* (EOR) (Pacific Carbon Trust, 2010). Currently, PCT has not adopted any standards—however, it is expected that PCT will follow standards similar to the California Action Reserve Forest Project Verification Protocol Version 3.0 (CAR). CAR accepts forest improvement projects that increase and/or conserve forest carbon stocks, and which are third-party approved through either Forest Stewardship Council or Sustainable Forest Initiative requirements.
- **Voluntary Carbon Market (VCM):** The Voluntary Carbon Standard Guidance for Agriculture, Forestry, and Other Land Use Projects (AFOLU) accepts improved forest management projects and extended rotations of evenly aged managed forests for the creation of carbon offsets (Voluntary Carbon Standard, 2007). Projects are required to use a 1990 datum for baseline comparisons. VCS does not currently require third-party certification.

2.3.1 Third Party Certification

There are three sustainable forest certifications recognized in Canada. They are as follows:

- Forest Stewardship Council (FSC)
- Canadian Standards Association (CSA)
- Sustainable Forestry Initiative (SFI)

The financial commitments needed to achieve approval for these certification schemes vary significantly. Start-up and auditing costs associated with FSC are beyond the financial means of the MKRF (Lawson, 2010); furthermore, current research projects at MKRF do not meet FSC standards. Although the MKRF meets both CSA and SFI sustainable forest management criteria, only SFI is recognized under the CAR carbon standards. Moreover, the costs associated with SFI certification are significantly lower than those associated with CSA. At this time, SFI certification is therefore considered to be the most feasible certification option for MKRF.

3.0 Risks

Carbon markets are associated with considerable risks. Five apparent risks to a MKRF carbon project are identified below; however, this list is not comprehensive as unforeseeable changes could occur in the future.

3.1 UBC

As a public institution, UBC is required to offset its carbon emissions by 2010. There is a potential that UBC could use MKRF carbon stocks as removals from the University's Greenhouse Gas (GHG) inventory. However, there are currently no indications that UBC would use MKRF's stocks as a carbon sink for their own benefit without adequately compensating MKRF.

3.2 Opportunity costs – Increasing Prices

Participation in the carbon market will require MKRF to maintain their verified and accounted stocks for a period of 100 years. The opportunity cost associated with a long-term carbon contract is significant. For example, although the price of lumber may increase, MKRF will not be able to increase their harvest activities accordingly to capture a greater share of this market. Similarly, MKRF may not be able to pursue more lucrative carbon markets in the future.

3.3 Abiotic and biotic disturbances

Abiotic and biotic disturbances are naturally occurring events that cannot be predicted and may significantly alter the forest composition, and accordingly, the amount of carbon stored. In order to mitigate such losses, MKRF must participate in a buffer pool and may also purchase insurance against such events.

3.4 Carbon modeling vs. ground verification

Carbon-based models are used to predict the total amount of carbon sequestered in a forest over a 100 year period, based on specific carbon management strategies. However, the model may not accurately portray the actual carbon stored, as determined by ground verification surveys. If over-estimations are produced by the carbon based model, this may compromise the economic feasibility of MKRF's carbon management plan.

4.0 Scenario Financial Analysis

Four alternative scenarios were proposed in the MKRF: Carbon Management Plan, and are as followed:

- 2007 Base Case
  - Harvest level: 26,000m^3/year
  - Used to set 2007 Baseline
- No Harvest
- Extended Rotation
  - Harvest level: 13,000m^3/year
  - 30 year extension to minimum harvest age
- Select Seed
  - Harvest level: 26,000m^3/year
  - Use of 100% select seed

In addition, the 1990 Baseline was modeled to evaluate the additionality and number of carbon credits produced under the VCM.

The three alternative scenarios – No Harvest, Extended Rotation, and Select Seed – pursue different carbon management strategies and were developed to rely on the timber market, the carbon market, or a combination of the two to varying degrees.

This section will provide a financial analysis for each scenario, including profits generated from the timber market and/or the carbon market (both PCT and VCM). All analyses are presented in net present values (before taxes), based on a 100 year planning period, and use a discount rate of 6%.

4.1 Timber Analysis

Timber prices used in this financial analysis were set at $78.71 based on MKRF's overall short-term historical averages. Logs harvested from previously thinned stands are assigned a premium-grade of 20% more than the normal log price at $94.45[1]. The modeling program – Forest Planning Studio-Atlas (FPS-Atlas) was used to determine the actual long-term harvesting flow.

[1] These logs are assigned premiums based on conservative recommendations made by Paul Lawson (2010). Note also that the first premium logs will be harvested in 30 years.

[2] Although the genetic gain is expected to increase for the stock, it is assumed that the price for these seedlings will

The Operational costs associated with harvesting activities can be seen in Table 1 below.

Table 1: Total delivered log costs per cubic metre

Total Delivered Log Costs			
Direct Costs			
	Stump to Dump	$	45.82
	Silviculture	$	3.27
Indirect Costs			
	Road Construction	$	8.05
	Road Maintenance	$	2.22
	Head Office & Administration	$	10.62
Total		**$**	**69.98**

To calculate the total profit generated on the timber market, the following assumptions were made:

- timber prices remain stable over the 100 year period
- operational expenses are determined on a per cubic metre basis, except for the No Harvest scenario where annual administration and road maintenance costs of $128,400 are applied
- an additional cost of $0.05 per seedling is added to the stock used in the Select Seed scenario[2]
- no premium is assigned to the logs produced by the Select Seed scenario as it is currently difficult to predict its effect on log grade—a conservative estimate is used in this scenario

As seen in Table 2 below, the highest profit from timber harvesting is generated by the 2007 Base Case scenario, followed closely by the Select Seed scenario. Although both scenarios have similar harvest levels, the Select Seed scenario incurs greater silvicultural costs through the 100% usage of genetically improved stock. The Extended Rotation scenario generates about $1.5M. However, the No Harvest scenario operates at a loss under the timber profit because revenue is only generated from carbon management activities, and administration and maintenance costs are accounted for under the operational expenses.

Table 2: Net present value of profits generated by timber sales

Scenario	Harvesting Revenue	Operational Costs	Total Profit
2007 Base Case	$ 26,471,571	-$ 23,104,644	$ 3,366,927
No Harvest	$ -	-$ 161,878	-$ 161,878
Extended Rotation	$ 13,331,049	-$ 11,824,854	$ 1,506,194
Select Seed	$ 26,471,571	-$ 23,154,168	$ 3,317,403

[2] Although the genetic gain is expected to increase for the stock, it is assumed that the price for these seedlings will remain relatively constant over time, as breeding and production costs are expected to remain constant.

4.2 Carbon Analysis

The proposed scenarios incorporate different carbon management strategies that store different amounts of carbon in MKRF over time. In the first part of this analysis, the carbon credits produced by the scenarios will follow the standards set by CAR, and be sold to PCT. The second part will adhere to the VCS and will be sold on the voluntary market.

The Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) was used to determine the amount of carbon credits produced by each scenario. The additionality was modeled for a 100 year period, and verification and payments from carbon credits were assumed to occur on a ten-year basis (see Figure 7).

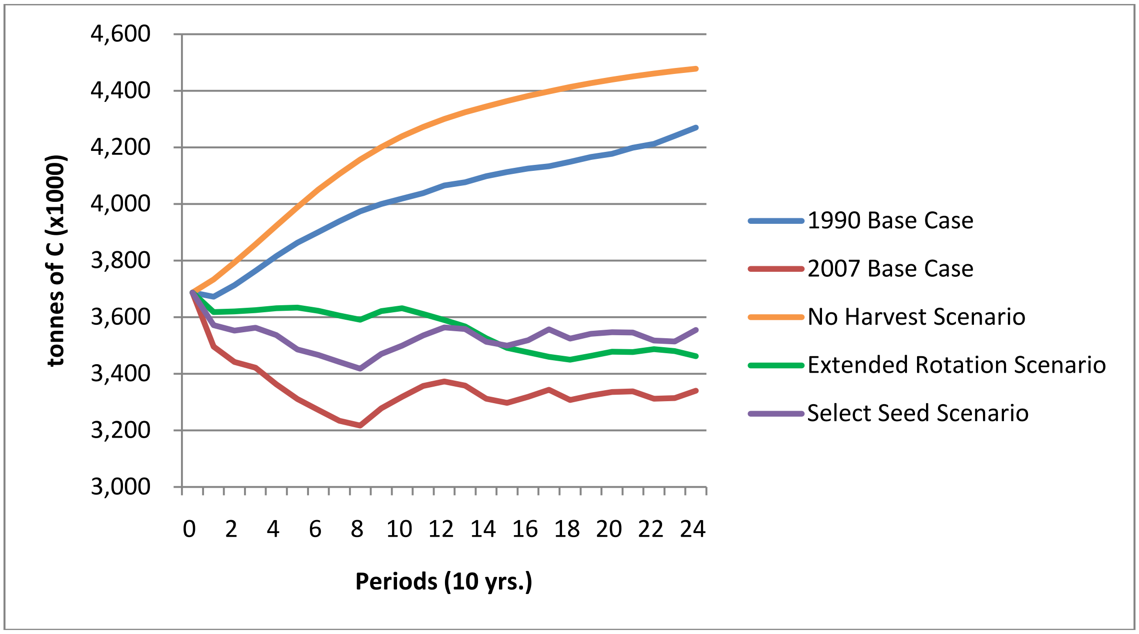

Figure 7: Total ecosystem carbon stored over time

Costs associated with validation of the carbon management plan, annual desktop approval of the activities, and ten-year verification of carbon credits produced are shown in Table 3. The costs are applied regardless of which carbon market is pursued. Internal costs associated with validation and verification have not been included in this analysis as they are hard to estimate; however, these additional costs should be considered if a carbon management plan is adopted.

Table 3: Costs associated with validation and verification

Validation & Verification		
External Costs		
Initial Validation	$	20,000
Annual Desk Top Approval	$	4,000
5 Year Verification	$	10,000

4.2.1 PCT

Carbon credits sold to PCT were given a value of $20 per CO2E for the entire length of the planning period.

In addition to validation and verification costs, MKRF must become third-party certified in order to meet the requirements of PCT. The costs associated with SFI certification can be seen in Table 4. The external costs were provided by Dave Eaket from PricewaterhouseCoopers (2010), while the internal costs are rough estimates.

Table 4: Costs associated with SFI certification

SFI Certification	
External Costs	
Initial Certification	$ 8,000
Annual Auditing	$ 4,000
Internal Costs	
Initial Document Preparation	$ 16,000
Annual Survey/Monitoring/Reporting	$ 8,000

The carbon profit calculations were based on the following assumptions:

- carbon credit price remains constant over the next 100 years
- 16.8% of the credits produced are deducted from the total sales and put into a “buffer pool” to account for risk of non-permanence
- MKRF will not encounter any non-permanence issues, and will therefore receive a “payback” of all the “buffer pool” credits at the end of the 100 year planning period

Table 5 below displays the total profit generated for each scenario when selling carbon credits to the PCT. As expected, the No Harvest scenario produces the largest amount of additionality and therefore has the most carbon credits available to sell. The estimated profit generated for this scenario is $13M. The Extended Rotation scenario generates about half the profit of the No Harvest scenario, while the Select Seed scenario generates about $4M in profit. The 2007 Base Case does not create any carbon credits as this scenario represents the 2007 baseline against which all the other scenarios are compared.

Table 5: Net present value of carbon profit for each scenario - PCT

Scenario	$/Ton CO2E	Carbon Revenue	Validation & Verification Costs	Certification Costs	Total Profit
2007 Base Case	$ 20.00	$ -	$ -	$ -	$ -
No Harvest	$ 20.00	$ 12,633,891	-$ 117,988	-$ 415,186	$ 13,167,066
Extended Rotation	$ 20.00	$ 6,149,004	-$ 117,988	-$ 415,186	$ 6,682,180
Select Seed	$ 20.00	$ 3,827,234	-$ 117,988	-$ 415,186	$ 4,360,410

4.2.2 Voluntary Carbon Market

The voluntary carbon market is a more volatile market than the regulatory market, and prices paid per carbon credit vary depending on the buyer and market conditions at any given time. Based on recent publications about current market trends, a low price of $4 and a high price of $10.50 per carbon credit were used in this financial analysis (Hamilton *et al.*, 2009). VCS requires a 1990 baseline, and as a result, the No Harvest scenario is the only carbon management strategy that creates additionality.

The carbon profit calculations were based on the following assumptions:

- 27.5% of the credits produced are deducted from total sales and put into a “buffer pool” to account for risk of non-permanence
- MKRF will not encounter any non-permanence issues, and will therefore receive a “payback” of all the “buffer pool” credits at the end of the 100 year planning period

Since No Harvest is the only scenario applicable to VCS, other scenarios are excluded from this analysis. Based on the maximum and minimum price per carbon credit, the No Harvest scenario generates a maximum of $1M and minimum of $0.2M (see Table 6).

Table 6: Net present value of carbon profit for the No Harvest scenario - VCM

Scenario	High ($10.50)/Low ($4) Estimated Carbon Credit Price	Carbon Revenue	Validation & Verification Costs	Admin/Maintenance Costs	Total Profit
No Harvest	High	$ 1,299,527	-$ 117,988	-$ 161,878	$1,019,659
	Low	$ 495,058	-$ 117,988	-$ 161,878	$ 215,190

4.3 Combined Profit Analysis

The two previous sections independently explored the profit generated by timber and carbon. This section will combine both sources of revenue and show the total profit generated by each scenario. The carbon profit used in this comparison assumes that PCT is the buyer, as this produced the greatest profit margin, despite the extra cost incurred by SFI certification.

Table 7 shows the total profit generated by each scenario. All scenarios generate profit; however the profit margins differ. The No Harvest scenario produces a profit of almost $13M, while the Extended Rotation scenario produce about $8M, Select Seed around $7.5M, and the 2007 Base Case generates a net present value of profit of $3.5M.

Table 7: Total scenario profit

Scenario	Harvesting Profit	Carbon Profit	Total Profit
2007 Base Case	$ 3,366,927	$ -	$ 3,366,927
No Harvest	-$ 161,878	$ 12,905,192	$ 12,743,313
Extended Rotation	$ 1,506,194	$ 6,440,824	$ 7,947,019
Select Seed	$ 3,317,403	$ 4,261,503	$ 7,578,906

5.0 Sensitivity Analysis

Two potential market opportunities exist to generate revenue (i.e. timber and carbon). Both of these sources of revenue are associated with considerable risk, and they have therefore been analyzed to determine sensitivities around different risk tolerances. The long-term commitment required by both markets, creates a level of uncertainty surrounding potential profits. To assess risk tolerance, a variety of discount rates were applied to produce net present values and present a sensitivity of potential profit. A higher discount rate indicates a low risk tolerance and a lower discount rate reflects high risk tolerance.

Table 8 shows the effect of varying discount rates on the potential timber profit under each scenario. Using three different discounts rates (i.e. 3%, 6%, and 9%), a range of potential timber profits can be seen. The 2007 Base Case and Select Seed scenarios have the largest range of values for profit due to the higher volume rates (26,000m^3/year) in each of the scenarios. The Extended Rotation scenario profit range is roughly half of the other two scenarios due to the fact that the timber volume harvested is half of the previous two scenarios (13,000 m^3/year).

Table 8: Sensitivity analysis of timber sales profit

Scenario		Discount Rate	
	3%	6%	9%
2007 Base Case	$ 7,772,019	$ 3,366,927	$ 1,901,084
No Harvest	-$ 353,920	-$ 161,878	-$ 93,886
Extended Rotation	$ 3,416,102	$ 1,506,194	$ 869,296
Select Seed	$ 7,663,717	$ 3,317,403	$ 1,872,373

Table 9 shows the effects that various discount rates have on the future potential profit of the carbon revenue generated by each scenario. In this table, the carbon credits produced are sold to the PCT. As previously outlined, the 2007 Base Case represents the baseline and therefore does not generate any carbon credits. Similar to the timber revenue, the largest range of potential profits occurs in the No Harvest scenario which generates the greatest revenue. Depending on the scenario, the potential profit could range roughly from as low as $2M to as high as $22M.

Table 9: Sensitivity analysis for carbon profits - PCT

Scenario	Discount Rate		
	3%	6%	9%
2007 Base Case	$ -	$ -	$ -
No Harvest	$ 22,932,994	$ 12,328,497	$ 7,913,601
Extended Rotation	$ 10,219,066	$ 5,843,610	$ 3,833,689
Select Seed	$ 5,922,492	$ 3,521,840	$ 2,325,589

Table 10 shows the effects that the discount rates have on the high and low price profit calculations for the No Harvest scenario. Credits generated by this scenario are sold under the Voluntary Carbon Standard.

Table 10: Sensitivity analysis for carbon profits - VCM

Scenario	High ($10.50)/Low ($4) Estimated Carbon Credit Price	Discount Rate		
		3%	6%	9%
No Harvest	High	$ 2,247,677	$ 1,229,543	$ 820,137
	Low	$ 783,217	$ 425,074	$ 279,969

6.0 Offsetting UBC's Emissions

An option exists for MKRF to sell their offset credits to UBC. Currently, UBC's total GHG emissions in 2008 were 62,670 tCO_2 E (Henderson, 2010). This puts the university in a position where it will be required to purchase offset credits in order to meet its requirement to become carbon neutral by 2010 under the *Greenhouse Gas Reduction Act*. MKRF will therefore be in a position to negotiate with UBC about directly purchasing its credits.

Table 11 lists the carbon credits produced by each scenario. As the current purchasing price for offset credits by PCT is $20, this price was used to determine the potential revenue per year if selling to UBC. It should be noted that MKRF would still have to validate and verify their project by an applicable carbon standard to ensure that the credits produced are of high quality. It should be noted that the costs of validation and verification—as well as certification costs—have been excluded from this analysis, and can be found in the previous financial analysis section.

Table 11: Amount of carbon credits produced and the associated potential revenue

Scenario	Total Number of Carbon Credits Produced	Number of Carbon Credits Per Year	Potential Revenue per year ($20 negotiated price)
No Harvest	3,442,766	34,427	$ 688,540
Extended Rotation	1,370,772	13,707	$ 274,140
Select Seed	762,486	7,624	$ 152,480

7.0 Recommendation

As previously stated, successful scenarios will meet the following criteria:

- maximize revenue flow
- maintain long-term flexibility
- balance MKRF's other enterprises

Based on these criteria and MKRF's overall objectives, it has been determined that Extended Rotation is the recommended scenario. This scenario successfully fulfills the research mandate, while meeting timber and carbon objectives. Although the financial analysis indicates that the No Harvest scenario will generate the largest profit margin, this scenario is not a viable option. It does not adequately meet the interests and objectives of MKRF, particularly because it does not fulfill the research mandate and is deemed to have low long-term flexibility.

8.0 References

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TreeTop Down Solutions

9.0 Appendix

9.1 PCT Additionality to 2007 Base Case

	2007 Base Case	No Harvest			
Year	Tonnes of Carbon	Tonnes of Carbon	Carbon Additionality	Carbon Additionality CO2E	10 Year Carbon Credits
0	3,686,472	3,686,472	0	0	0
10	3,496,212	3,733,003	236,791	868,313	868,313
20	3,441,543	3,793,068	351,525	1,289,042	420,730
30	3,420,705	3,857,161	436,456	1,600,484	311,442
40	3,362,389	3,923,088	560,699	2,056,083	455,599
50	3,310,901	3,988,531	677,630	2,484,869	428,786
60	3,271,849	4,050,355	778,506	2,854,782	369,912
70	3,233,582	4,106,345	872,763	3,200,422	345,640
80	3,217,306	4,156,157	938,851	3,442,767	242,345
90	3,277,399	4,200,471	923,072	3,384,905	0
100	3,318,778	4,238,743	919,965	3,373,512	0

	2007 Base Case	Extended Rotation (T)			
Year	Tonnes of Carbon	Tonnes of Carbon	Carbon Additionality	Carbon Additionality CO2E	10 Year Carbon Credits
0	3,686,472	3,686,472	0	0	0
10	3,496,212	3,617,860	121,648	446,083	446,083
20	3,441,543	3,619,956	178,413	654,240	208,157
30	3,420,705	3,624,566	203,861	747,558	93,318
40	3,362,389	3,631,854	269,465	988,128	240,570
50	3,310,901	3,633,751	322,850	1,183,891	195,763
60	3,271,849	3,622,211	350,362	1,284,777	100,887
70	3,233,582	3,605,312	371,730	1,363,134	78,356
80	3,217,306	3,591,119	373,813	1,370,772	7,638
90	3,277,399	3,621,325	343,926	1,261,177	0
100	3,318,778	3,631,499	312,721	1,146,748	0

	2007 Base Case	*Select Seed (T)*			
Year	**Tonnes of Carbon**	**Tonnes of Carbon**	**Carbon Additionality**	**Carbon Additionality CO2E**	**10 Year Carbon Credits**
0	3,686,472	3,686,472	0	0	0
10	3,496,212	3,571,704	75,492	276,829	276,829
20	3,441,543	3,552,697	111,154	407,602	130,773
30	3,420,705	3,562,614	141,909	520,380	112,779
40	3,362,389	3,536,080	173,691	636,925	116,545
50	3,310,901	3,485,484	174,583	640,196	3,271
60	3,271,849	3,466,367	194,518	713,298	73,102
70	3,233,582	3,441,514	207,932	762,487	49,189
80	3,217,306	3,418,149	200,843	736,491	0
90	3,277,399	3,469,823	192,424	705,619	0
100	3,318,778	3,498,666	179,888	659,649	0

8.2 VCS Additionality to 1990 Base Case

	1990 Base Case	*No Harvest*			
Year	**Tonnes of Carbon**	**Harvest Volume**	**Carbon Additionality**	**Carbon Additionality CO2E**	**10 Year Carbon Credits**
0	3,686,472	3,686,472	0	0	0
10	3,672,538	3,733,003	60,465	221,725	221,725
20	3,712,129	3,793,068	80,939	296,803	75,078
30	3,763,780	3,857,161	93,381	342,428	45,625
40	3,815,742	3,923,088	107,346	393,638	51,210
50	3,862,839	3,988,531	125,692	460,913	67,275
60	3,900,753	4,050,355	149,602	548,591	87,678
70	3,938,086	4,106,345	168,259	617,006	68,415
80	3,973,997	4,156,157	182,160	667,981	50,975
90	3,999,080	4,200,471	201,391	738,501	70,520
100	4,019,061	4,238,743	219,682	805,574	67,073

TreeTop Down Solutions

Carbon Management Plan for Malcolm Knapp Research Forest 2010

Greg Demille, Jesse Hodgins, Maryam Majidian, Mariko Molander, and Emilie Thy

Executive Summary

The Malcolm Knapp Research Forest (MKRF) comprises a total area of 5,136 hectares and is located approximately 60km east of Vancouver, British Columbia (BC). MKRF's land base was placed in the control of the University of British Columbia (UBC) in 1949 in the form of Crown grants from the Provincial Government of BC, and has been privately maintained and operated by MKRF staff since that time. The following plan was developed with the intent of exploring potential financial prospects for MKRF through the emerging carbon market.

The significant drop in timber value over the last three years has resulted in a need for MKRF to pursue different financial markets for long-term revenue generation. TreeTop Down Solutions has developed this plan with the intent to explore new markets while continuing to fulfill MKRF's research mandate and to maintain sustainable management practices. This plan investigates carbon standards and markets applicable to forest projects initiated by MKRF, and develops five scenarios to explore financial opportunities through the generation of carbon credits. This plan also seeks to meet and satisfy interest groups and their values through the establishment of a set of Criteria and Indicators.

Criteria were designed to fulfill the main values of interest groups and to ensure that sustainable forest practices are maintained. Goals, objectives, indicators, targets, and management strategies were identified for each of the nine established criteria. In accordance with these values and applicable carbon standards, two base cases and three carbon management scenarios were developed. They include the following:

- 1990 Base Case
- 2007 Base Case
- No Harvest
- Extended Rotation
- Select Seed

Each of the base cases and scenarios were modeled to generate carbon stock information. Scenarios were then compared against the base cases to measure the carbon additionality gained through the implementation of carbon management strategies. A multi-criteria analysis was also conducted to evaluate the scenarios according to the criteria and indicators identified for MKRF—this provided the basis for our final recommendation. Issues relating to leakage, non-permanence, and risk were also discussed.

Based on the results of our modeling and analysis, it was determined that the Extended Rotation scenario best suits the needs of MRKF.

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Acronyms and Abbreviations

ANSI	American National Standards Institute
BC	British Columbia
BEC	Biogeoclimatic
CAR	California Action Reserve Forest Project Verification Protocol version 3.0
CBM-CFS2	Carbon Budget Model of the Canadian Forest Sector
CCBA	Climate Community and Biodiversity Alliance
CCFM	Canadian Council of Forest Ministers
CCS	Canadian Cancer Society
CDM	Clean Development Mechanism
C&I	Criteria and Indicators
CSA	Canadian Standards Association
EOR	BC Emission Offsets Regulation
ER	Emission Reduction
ET	Emissions Trading
FPS-Atlas	Forest Planning Studio-Atlas
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
IFM	Improved Forest Management
ISO	International Standard Organization
JI	Joint Implementation
MKRF	Malcolm Knapp Research Forest
PCT	Pacific Carbon Trust
SCC	Standards Council of Canada
SFI	Sustainable Forestry Initiatives
SFM	Sustainable Forest Management
SSR	Sources, Sinks and Reservoirs
UBC	University of British Columbia
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market
VCS	Voluntary Carbon Standards for Agriculture, Forestry and Other land use projects
WCI	Western Climate Initiatives
WRI	World Resources Institute and World Business Council on Sustainable Development
WWF	World Wildlife Fund

Prologue

TreeTop Down Solutions was created at the University of British Columbia in response to the FRST 424 project management requirements. Our group consists of the following members: Greg Demille, Jesse Hodgins, Maryam Majidian, Mariko Molander, and Emilie Thy. We have been offered the opportunity to develop a sustainable management plan for the Malcolm Knapp Research Forest with emphasis on pursuing potential financial prospects through the emerging carbon market.

The proposed goals, objectives, and management actions focus on fulfilling the main values of interest groups. The scope of the project entailed a comprehensive overview of existing carbon standards and markets, and sought to prepare a detailed management plan for implementation. Three scenarios have been developed and compared to 1990 and 2007 base cases in order assess the financial opportunities through the generation of carbon credits. A multi-criteria analysis was also conducted to evaluate the scenarios according to criteria and indicators identified for MKRF. However, due to time and knowledge constraints, the plan may require further improvements and amendments.

TreeTop Down Solutions would like to thank Dr. John Nelson and Dr. Stephen Mitchell for their continuous assistance throughout the project. We would also like to thank Dr. Gary Bull for his time and expertise, and Dr. Ronald Trosper for his guidance and support. Finally, we would like to thank the MKRF staff—Paul Lawson, Cheryl Power, and Ionut Aron—for their patience and on-going collaboration with the development of this plan.

1.0 Introduction

1.1 Context

MKRF is a privately owned forest which covers an area of 5,136 hectares. The forest is managed by staff from the Faculty of Forestry at the University of British Columbia, and serves as an institution for research, demonstration, and education in forestry related fields. TreeTop Down Solutions' management plan was developed to aid MKRF in future management of the forest to increase its revenue, and more specifically to explore the possibility of pursuing future financial prospects in the emerging carbon market.

1.2 Purpose and Objectives

The purpose of the plan is to explore options for revenue generation while maintaining sustainable forest management practices and fulfilling MKRF's research mandate. The project provides a comprehensive overview of existing carbon standards for regulatory and mandatory markets, and investigates certification as an option for MKRF to further increase the value of its carbon credits. The project seeks to satisfy interest groups and values by establishing a set of Criteria and Indicators, and models two base cases against three scenarios to illustrate increased financial opportunities for MKRF through the generation of carbon credits. A multi-criteria analysis is done to determine which scenario best fulfills the criteria for MKRF while producing sufficient carbon credits to generate significant revenue for the Forest.

1.3 Location and Geographical Information

MKRF is located approximately 60km east of Vancouver, British Columbia at the base of the Coast Mountains (Malcolm Knapp Research Forest, 2009). It reaches the Golden Ears Mountains from the north and east, and connects to the community of Maple Ridge from the west and south (Malcolm Knapp Research Forest, 2009). Pitt Lake borders the north-west corner of the forest, and more than half of the Alouette watershed is located within the boundary of the forest (UBC Malcolm Knapp Research Forest, 2009). The 5,136 hectares of the Research Forest is 4km wide and 13km long.

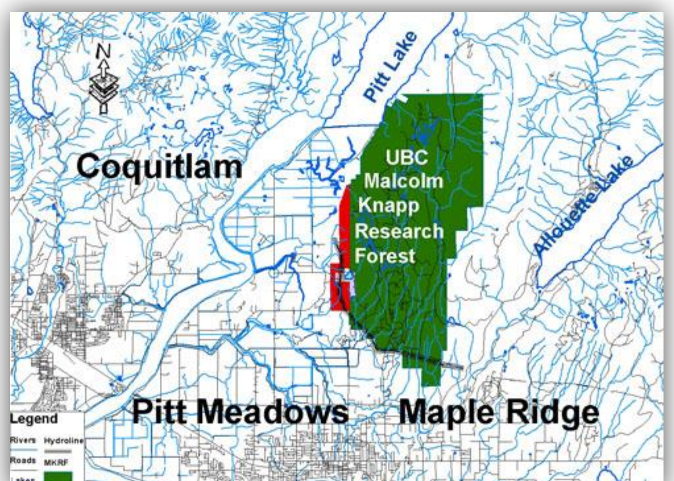


Figure 1: Location of MKRF (Malcolm Knapp Research Forest, 2009)

1.4 Climate and Forest Ecology

MKRF is located in the lower Coastal region of BC and is influenced by the maritime environment. It is generally characterized by mild, wet winters and relatively dry summers. As a result of the large amount of precipitation (2200-3000mm/year) in the forest, MKRF has long growing seasons and high plant productivities (Malcolm Knapp Research Forest, 2009). Snow cover is typical for approximately four months of the year in the higher elevations of the forest to the north.

The lower elevation forest in MKRF falls within the Dry Maritime Coastal Western Hemlock biogeoclimatic Subzone (CWHdm) and the Very Wet Maritime Subzone Submontane Variant (CWHvm1). The higher elevation forest falls into the Very Wet Maritime Subzone Montane Variant (CWHvm2) (Malcolm Knapp Research Forest, 2009). Refer to Table 1 below for a detailed descrition of each BEC subzone. Appendix 1 shows the biogeoclimatic distribution of MKRF by subzone.

The climate influences the species composition of the forest, which consists of a substantial amount of Douglas-fir (*Pseudotsuga menziesii*), and lesser amounts of Western hemlock (*Tsuga heterophylla*) and Western redcedar (*Thuja plicata*) (Pojar, Klinka, & Demarchi, 1991). The main deciduous tree species are red alder (*Alnus rubra*) and big-leaf maple (*Acer macrophyllum*). Appendix 2 shows the tree species distribution for MKRF. The shrub and moss layers are typified by the presence of the following species: salal (*Gaultheria shallon*), dull Oregon-grape (*Mahonia nervosa*), red huckleberry (*Vaccinium parvifolium*), salmonberry (*Rubus spectabilis*), Oregon beaked moss (*Kindbergia oreganum*), stair step moss (*Hylocomium splendens*), lanky moss (*Rhytidiadelphus loreus*), and flat moss (*Plagiothecium undulatum*).

Table 1: Description of BEC subzones*

	CWHdm	CWHvm1	CWHvm2
Distribution/Elevation	Seal level (or above CWHxm if present) – 650m	0 – 400m	400 – 800m
Climate	Warm, relatively dry summers. Moist, mild winters with little snowfall.	Wet, humid, mild maritime climate. Relatively little snow, with a long growing season.	Cooler, with a short growing season. Heavier snowpack than CWHvm1.
Dominant Tree Species	Fd, Hw, Cw	Hw, Cw, Hm	Hw, Hm, Cw
Understory Species	Salal, red huckleberry, dull Oregon-grape, bracken fern, sword fern	Salal, salmonberry, Devil's club, deer fern, sword fern	Salal, blueberry, salmonberry, foamflower, sword fern
Area of MKRF	1887ha	2187ha	1046ha

*Note: Based on information from Ministry of Forests and Range website (Ministry of Forests and Range, 2008)

The most common natural disturbance in this area is fire, which typically recurs every 200 years, and has resulted in the separate age class stands that exist in the forest today (Malcolm Knapp Research Forest, 2009). Appendix 3 shows the current age class distribution for MKRF. The non-fire disturbed patches of MKRF consist of 400 year+ old growth. Half of the western side of the forest consists of 120 year-old stands, and most of the eastern half of the forest is comprised of 70 year-old stands. Harvesting is another significant cause of disturbance in the forest. Historical and current harvesting operations have created a range of age classes throughout the forest.

1.5 History

UBC began leasing Crown Land from the Provincial Government in 1943 due to a need for forested areas suitable for the University's research and training of future foresters (Hives & Heger). This land was removed from Garibaldi Park in Maple Ridge, and initially leased for twenty-one years to the University. In 1949, the forest was placed in the control of UBC in the form of Crown grants under the agreement that the forest continue to be used primarily for research and educational purposes (Lawson, 2010). With additional aid from the forest industry, the Research Forest developed into an educational facility, providing accommodations for instructors, students, and workers at Loon Lake (Hives & Heger) and resources for demonstrations and research experiments throughout the forest. In 1988, the forest was officially renamed the Malcolm Knapp/UBC Research Forest in honour of Professor Malcolm Knapp who was instrumental in the negotiations with the Province that led to the transfer of the land to UBC (Malcolm Knapp Research Forest, 2009).

Today, MKRF is managed and operated by staff from UBC's Faculty of Forestry. The forest continues to fulfill its mandate by providing appropriate facilities and resources for students and researchers (Malcolm Knapp Research Forest, 2009). More than 100 research projects are currently active on the land base and road systems are maintained throughout the forest to ensure accessibility. MKRF also operates its own sawmill in partnership with Gallant Enterprises (Malcolm Knapp Research Forest, 2009), and produces a variety of specialized and value-added products and structural lumber for sale to the general public. In order to sustain mill activities, harvest levels must be maintained at or above 11,000m^3 per year (Lawson, 2010). Harvesting continues to be carried out yearly on a sustainable yield basis. MKRF also manages a 250 hectare woodlot on government-owned land directly adjacent to the forest, in efforts to promote sustainable community forest initiatives (Malcolm Knapp Research Forest, 2009).

1.6 Land Management and Interest Groups

Interest groups place several constraints on MKRF's current and future activities. The government-registered covenant against the deed of the property states that the granted land must be used "for the purpose of instruction and demonstration in the practices of forestry and forest engineering" (Lawson, 2010). MKRF is therefore obliged to fulfill its research mandate in accordance with this agreement with the Provincial Government and in connection with UBC. MKRF must also satisfy the interests of the Katzie First Nation, the Canadian Cancer Society, recreational users, and the community of Maple Ridge.

Figure 2 illustrates the various interest groups:

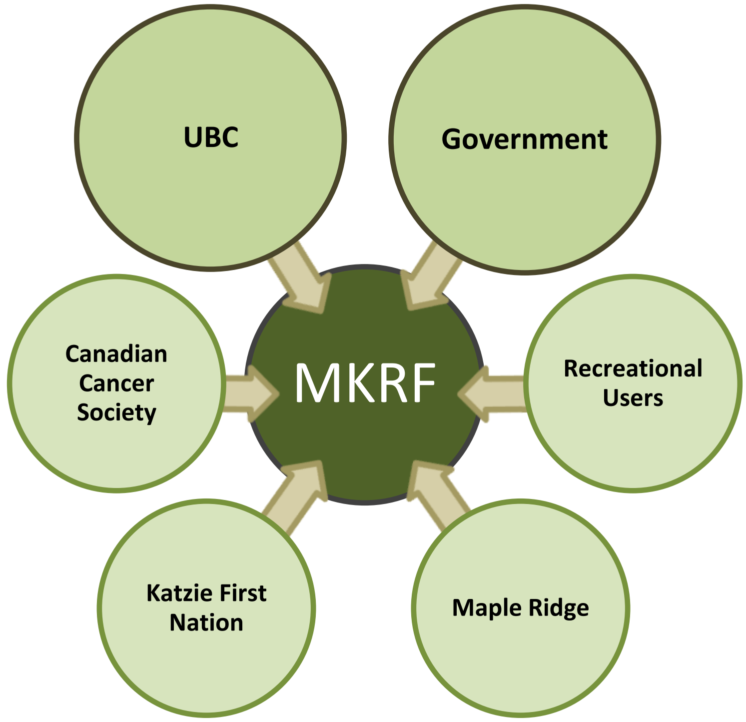


Figure 2: MKRF interest groups

- **UBC:** Due to forest's proximity to the urban community, demonstration and education helps educate the public about natural resources and sustainable management. UBC mainly designates the forest for research, demonstration and educational purposes while enabling the Research Forest to maintain its forestry practices and generate revenue as a private enterprise. Through MKRF, UBC is able to make connections to many researching organizations and universities from all over the world.

- **The Provincial Government of BC:** Although MKRF is privately owned, it must fulfill its research mandate in accordance with its agreement with the Provincial Government. Moreover, the Crown grant provides MKRF with rights to operate as private land, but the forest itself must continue to be open for public use.

- **Katzie First Nation Community**: The traditional land of the Katzie First Nation Community extends into MKRF's private land base. The Katzie do not claim title to the land but it is MKRF's responsibility to ensure that all management activities and harvesting operations take the Katzie's interests into consideration. MKRF works closely with this community to maintain the band's values through continuous consultation and accommodation efforts. MKRF also employs members of the Katzie band in its operations, including harvesting and silviculture (Lawson *et al.*, 2010).

- **Canadian Cancer Society:** The Canadian Cancer Society (CCS) is a sponsor of the Cadillac Fairview Trevor Linden Gymnasium at Loon Lake, which is used by Camp Goodtimes throughout the year (Carrick, 2007). In July 2004, the CCS celebrated the 20th anniversary of Camp Goodtimes at its new location at Loon Lake (Dexter, 2004). Since then, the CCS has held Camp Goodtimes' activities at MKRF. Revenues for the forest's maintenance are derived largely from the use of Loon Lake's facilities by the CCS (Lawson *et al.*, 2010).

- **Recreational Users:** The forest is managed for the local community by maintaining an extensive trail system for its recreational users. Approximately 55,000 local and out-of-town visitors use MKRF's trails annually (Lawson *et al.*, 2010).

- **Maple Ridge:** MKRF is located at the forest-urban interface and must therefore uphold its visual quality standards and take into consideration municipal bylaws that may place limits on certain activities that affect the community of Maple Ridge, such as prescription burning and harvesting operations. The Alouette community watershed is also located within the Research Forest (UBC Malcolm Knapp Research Forest, 2009).

1.7 Plan Organization

Carbon markets and standards applicable to MKRF's potential project activities will be discussed in section 2.0, followed by a comprehensive overview of criteria and indicators in section 3.0. Criteria and indicators will be used to evaluate the scenarios which we have developed. Goals, objectives, indicators, targets and management strategies will be outlined for each of the nine criteria presented in this plan.

Section 4.0 will discuss the methods used in developing and modeling our two base cases and three carbon management scenarios. Assumptions and constraints associated with modeling will be highlighted, and the modeling results of targets associated with criteria and indicators will also be discussed.

An analysis of the scenarios will be done in section 5.0 through use of an ordinal ranking method and a multi-criteria analysis. Following a discussion of the analysis results, a final recommendation for MKRF will be made in section 6.0. Section 7.0 will summarize leakage and permanence issues associated with carbon project activities and section 8.0 will conclude the management plan with an assessment of risks associated with carbon management and investigate ways to mitigate such risks through participation in a buffer pool or through insurance.

2.0 Carbon Markets and Standards

Two types of markets currently exist for carbon offsets: regulatory/compliance markets and voluntary markets. Participation in both regulatory and voluntary markets is considered in our management plan, in order to provide MKRF with the flexibility and maximum potential for revenue generation through the sale of its carbon offsets. MKRF may sell a portion or the entirety of its offsets to offset buyers, such as the Pacific Carbon Trust (PCT) or to the Voluntary Carbon Market; however, offsets can only be sold once, and must be produced through forestry projects that meet the standards adopted by the purchasing organization. Appropriate standards have been selected for each market, and forestry projects initiated by MKRF will be eligible to sell its offsets to more than one buyer. Appendix 4 provides further information with regard to the development of the carbon market and standards that are relevant to this project.

2.1 ISO 14064

Both regulatory and voluntary markets recognize the International Organization Standard 14064 (ISO 14064) standard for greenhouse gas (GHG) emission verification, accreditation and trading systems. Projects initiated by MKRF should meet this standard, as well as standards appropriate for each respective market. This standard is internationally regulated and includes principles for determining project baseline scenarios, and for monitoring, qualifying and reporting project performance levels relative to the baseline scenario (Spence, 2009).

2.2 Regulatory Markets

As a forestry-related mitigation initiative and Crown corporation of the Government of BC, PCT is expected to be the primary buyer of offsets if MKRF chooses to enter into this market. Although MKRF is operated as a private enterprise, its affiliation with UBC has led to discussions of the possibility of collaboration between the two organizations to offset UBC's emissions. No plans are currently in place to formally establish such a relationship; however, UBC anticipates that MKRF offsets will either be sold directly to PCT or listed as "removals" from the University's GHG inventory (Henderson, 2010).

Projects eligible for registration under the PCT must begin commercial operations after November 29, 2007, and must comply with the *BC Emission Offsets Regulation* (EOR) (Pacific Carbon Trust, 2010). Currently, PCT has not adopted any standards—however, it is expected that PCT will follow standards similar to the California Action Reserve Forest Project Verification Protocol Version 3.0 (CAR). CAR accepts forest improvement projects that increase and/or conserve forest carbon stocks, and which are third-party certified through either FSC or SFI. However, CAR does not approve projects which include broadcast fertilization.

2.3 Voluntary Markets

This market has been growing considerably over the last few years and is expected to become a significant market for carbon offsets trading in the future. The Voluntary Carbon Standard Guidance for Agriculture, Forestry, and Other Land Use Projects (VCS) accepts improved forest management projects (Voluntary Carbon Standard, 2007). VCS does not currently require third-party certification.

The Standards Council of Canada (SCC) and American National Standards Institute (ANSI) are currently preparing a voluntary North American standard—the Draft Forest Carbon Standard, which is expected to compete with standards established by regulatory North American standards. Projects that are likely to be approved by the Draft include improved forest management projects that seek to protect and/or enhance forests through sustainable forest management treatments and increase overall forest biomass (Forest Carbon Standards Committee, 2009). The project must be verified by according to ISO 14064 standards, and be third-party certified through CSA or SFI.

2.4 Certification

Certain standards—e.g. CAR and SCC-ANSI—require third-party certification of forest projects in order to be eligible. Certification schemes in Canada are validated primarily through three organizations: the Forest Stewardship Council (FSC), the Canadian Standards Association (CSA), and the Sustainable Forestry Initiative (SFI). MKRF is not currently certified, and is unable to pursue certification under FSC due to costs and overall ineligibility because of current and past research projects, such as the use of tree seedlings created by somatic embryogenesis (Lawson, Forest Certification, 2010). A cost-benefit analysis will be done to determine if proposed scenarios will benefit from certification, in which case SFI has been proposed as the certification scheme which would best suit MKRF's objectives, financial constraints, and management practices.

Table 2 below provides a summary of carbon markets and standards applicable to MKRF, including baseline year, project eligibility, and ISO and certification requirements.

Table 2: Summary of carbon markets and applicable standards, including baseline year, project eligibility for MKRF, and ISO and certification requirements

Market	Buyer	Standard	Baseline Year	Eligible Projects for MKRF	ISO 14064 Requirement	Third-Party Certification
Regulatory	Pacific Carbon Trust	California Action Reserve Protocol Version 3.0	2007	Improved forest management (an example maybe?) Extended rotation	Recommended	FSC or SFI
Voluntary	(VCM)	Voluntary Carbon Standard Guidance for Agriculture, Forestry and Other Land Use Projects	1990	Improved forest management Extending the rotation age of evenly aged managed forests Conversion of logged forests to protected forests	Yes	Not required
Voluntary	(VCM)	SCC-ANSI Draft Forest Carbon Standard	January 1 of enrollment year	Improved forest management Protection and/or enhancement of forest conditions through management treatments	Yes	CSA or SFI

SFI endorses Sustainable Forest Management (SFM), and is approved by the Canadian Council of Forest Ministers (CCFM) as a forest certification standard that meets its criteria (Canadian Council of Forest Ministers, 2008). Refer to Appendix 5 for detailed objectives endorsed by SFI to fulfill SFM standards and practices.

3.0 Criteria and Indicators

The Canadian Council of Forest Ministers' (CCFM) Framework of Criteria and Indicators (Canadian Council of Forest Ministers, 2005) can be used to meet SFI certification standards, and has been adopted by TreeTop Down to ensure that sustainable management goals and objectives are fulfilled. The majority of the criteria presented here has been directly adopted from the CCFM framework and will be applied to measure the success of the management scenarios; however, additional criteria have been developed by TreeTop Down to accommodate the goals and objectives that are an integral part of a carbon management plan.

Nine criteria have been developed for this plan. Each criterion is outlined with a description of its significance and value within a forest management context, and states general goals that are specific to MKRF. Criteria are further outlined with objectives, targets, and management strategies that serve to ensure that the criteria are met.

> *Objectives:* Objectives provide clearer goals that MKRF will incorporate into their management plan in order to sustain or enhance the stated criterion.
>
> *Indicators:* In relation to the stated objectives, indicators identify specific scientific factors (CCFM C&I) that assess the state and progress of the forest over time.
>
> *Targets:* Targets are useful tools to evaluate whether or not objectives are met. They are assigned to each indicator and place thresholds on the acceptable levels of change over time; however, not every target can be modeled. In these instances, best predictions are used to evaluate how the targets are met.
>
> *Management Strategies:* Suggested management strategies are provided to meet the general goals and objectives of each criterion. Management strategies should be periodically monitored and assessed for effectiveness.

3.1 Criterion 1: Biological Diversity

Biological diversity comprises all levels of variety among living organisms and the ecological complexes within which they exist. Biological levels range from "complete ecosystems to the chemical structures that are the basis of heredity" (Canadian Council of Forest Ministers, 2005), and can be classified in three broad categories, which are defined by the CCFM as follows:

> *Ecosystem Diversity*: the variety and relative abundance of ecosystems and their plant and animal communities
>
> *Species Diversity*: the number of different species, and species population levels and distribution throughout a particular area (Boyland *et al.*, 2006)
>
> *Genetic Diversity*: the variation of genes within a particular species

The maintenance of the variety and quality of diversity within these levels is fundamental to the conservation of species and genetic variation within species, and is an important criterion to meet in any management plan. Any significant change or disturbance at the ecosystem level necessarily causes a change in species distributions and populations (Canadian Council of Forest Ministers, 2005); anthropogenic changes must therefore seek to conserve biodiversity at all levels in order to prevent or decrease the rate of species extirpation.

A list of Red and Blue listed species found in MKRF and their habitat requirements can be found in Appendix 6. Currently, 69.6 hectares of the forest have been reserved for Old Growth Management Areas (Appendix 7), and all seral stages are represented throughout the forest (Appendix 8). Old growth for MKRF is defined as forest stands older than 250 years (BC Ministry of Forests, 2001). For the purpose of evaluating suitable habitat, seral stages are defined as early seral (≤40 years), mid seral (<120 years), mature seral (≥120 years), and old seral (≥250 years) (Boyland, Nelson, Bunnell, & D'Eon, 2006).

General goals for the protection and enrichment of biological diversity at MKRF are to:

- ensure that old growth areas and a significant representation of all seral stages are maintained to conserve habitats
- ensure that management and operational activities have a positive or minimal level of impact on all levels of biodiversity
- reduce the overall number of invasive species in the forest to protect and conserve unique habitats
- promote the conservation of current levels of genetic diversity in plant and animal species

3.1.1 Objective 1: Ecosystem Diversity

Through management, maintain and conserve a variety of naturally occurring ecosystems, biotic communities, and habitats with no net loss in biodiversity.

Indicator: Representation of all three BEC subzones in reserves

Target: Maintain representation

3.1.2 Objective 2: Species Diversity

Maintain current species diversity by incurring no net loss of biodiversity, and maintain or increase the population level of species at risk (both red- and blue-listed).

Indicator: Significant representation of all seral stages in the forest

Target: Maintain representation

Indicator: Area of old growth

Target: Increase, or maintain at current levels

3.1.3 Objective 3: Genetic Diversity

Maintain and/or enhance natural and regenerated stand genetic diversity in all age classes, while conserving existing mechanisms for natural genetic flow.

Indicator: Genetic diversity of reforested stock
Target: No net loss

3.1.4 Management Strategies

Ecosystem Diversity:

- maintain old growth reserves throughout MKRF
- place adjacency constraints on harvest activities to ensure adequate representation of seral stages
- through regeneration strategies, ensure a variety of naturally occurring forest cover types throughout the forest
- minimize regeneration delay

Species Diversity:

- ensure old growth reserves and seral stages are adequately represented
- use a coarse filter approach to ensure the protection of species at risk in MKRF
- monitor populations of red- and blue-listed species (see Appendix 6). If populations are in decline (beyond variation in natural cycles), initiate fine filter approach to ensure increased protection of suitable habitat areas
- manage species diversity through seed selection and planting

Genetic Diversity:

- ensure that Class A seedlings originate from orchards that guarantee a high level of genetic diversity

3.2 Criterion 2: Carbon Storage

Forests act both as sinks and sources in the global carbon cycle, and play a fundamental role in the mitigation of climate change and the reduction of greenhouse gas emissions into the atmosphere (Greig & Bull, 2009). Forests sequester carbon by storing atmospheric carbon in above- and below-ground plant biomass and soil (e.g. carbon pools); forests can also emit carbon through decomposition, disturbances (e.g. fire and insect damage), and operational activities. Through carbon management activities, a forest's natural capacity to store carbon may be enhanced, contributing in the long-term to a positive carbon balance in the global carbon cycle (Canadian Council of Forest Ministers, 2005)

MKRF should seek to contribute positively to the global carbon cycle by meeting the following general goals in its carbon management plan:

- maintain and enhance the forest's ability to sequester above- and below-ground biomass and soil carbon
- maximize the number of carbon credits produced by MKRF's management strategies
- reduce the forest's carbon emissions and emissions associated with forest operations activities
- maintain forest conditions that contribute to long-term sequestration, while maintaining ecosystem health and biodiversity

3.2.1 Objective 1: Carbon Emissions

Ensure that forest management and operations activities are not contributing disproportionately to global carbon emissions (CCFM).

Indicator: Net change in total emissions from MKRF and related operations
Target: Maximum 5% increase from current levels

3.2.2 Objective 2: Carbon Sequestration

Increase and/or accelerate carbon sequestration in forest stands.

Indicator: Net change in carbon sequestration from SSRs
Target: Increase by minimum 10% above base cases

Indicator: Number of carbon credits produced
Target: Increase by minimum 10% from current levels

Indicator: Conversion of forested land base to non-forest development
Target: 0% loss

3.2.3 Management Strategies

Carbon Emissions:

- increase focus on fire and pest management
- limit prescribed fires
- limit emissions associated with harvesting activities
- salvage merchantable dead wood outside old growth reserves
- encourage harvesting activities that do not increase wood debris in harvested areas
- implement continuous monitoring program of carbon emitted

Carbon Sequestration:

- reforest harvested areas promptly
- encourage planting of fast-growing tree species
- reforest de-activated roads with red alder
- maintain area of forested land base
- incorporate management activities that increase carbon sequestration (e.g. fertilization, select seed use, longer rotations)
- implement continuous monitoring program of carbon sequestered

3.3 Criterion 3: Economic Benefits from Current Activities

MKRF generates revenue from forest management activities and the use of camp facilities by various organizations. Currently, the majority of revenue is generated from the use of Loon Lake's camp facilities by the Canadian Cancer society. The second largest source of revenue is from value-added forest products such as cedar poles and house logs. Approximately a quarter of the revenue is from timber sales (5 year average ~ 1M/year) (Figure 3). An important aspect of MKRF's management strategies is the maintenance or enhancement of these activities, which could help ensure long-term economic well-being.

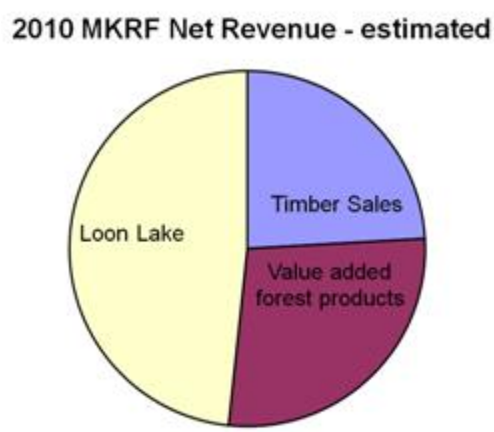


Figure 3: Estimated net revenue from three main revenue-generating activities at MKRF in 2001 (Lawson, Financing the Research Forests, 2010)

General goals for the management of current economic benefits are as follows:

- provide a balance between economic benefits derived from timber harvesting and carbon management
- minimize impacts of management strategies on different interest groups

3.3.1 Objective 1: Maintain or increase revenue generated by MKRF

Maximize revenue of all profit-generating activities in MKRF from use of educational/camp facilities and timber sales.

Indicator: Number of camp days

Target: No decrease from current levels

Indicator: Timber sales

Target: Maintain harvest levels at minimum 11,000m^3/year

Indicator: Total growing stock

Target: Long-term, non-declining even flow

3.3.2 Management Strategies

- Management activities should not conflict with the Loon Lake Camp facilities
- Continuous research into new market opportunities for MKRF products (e.g. timber, carbon credits)
- Manage for valuable species and high quality timber
- Increase focus on value-added products

3.4 Criterion 4: Social Benefits

MKRF's management strategies seek to ensure the maintenance or enhancement of long-term social well-being. Social benefits are acquired through the employment of local forest workers, including members of the Katzie First Nation. Traditional use of the forest by the Katzie is encouraged by MKRF. MKRF further contributes to the Katzie by providing them with a year-round supply of firewood. Neighboring communities also benefit from the use of the forest—due to MKRF's proximity to Maple Ridge, the forest is heavily visited by local recreational users. Visitor days per year are estimated to be approximately 50,000. However, since MKRF does not charge for the use of its trails, trail-building and maintenance is not considered a priority. Donations are occasionally made for trail improvements, and volunteers are encouraged to participate.

General goals for the management of current economic benefits are as follows:

- provide a balance between social benefits derived from timber harvesting and carbon management
- maintain or increase local employment
- manage recreation in accordance with other resource objectives of MKRF
- create a user-friendly environment for different user groups
- continue educational efforts to inform users about considerate use of the forest

3.4.1 Objective 1: Maintain or increase employment rate in the forestry sector

Ensure minimal impact on local and First Nation's employment levels due to management strategies

Indicator: Number of local people employed in forestry related positions
Target: No decrease from current levels

3.4.2 Management Strategies

Social Benefits:

- continue provision of employment opportunities at MKRF for the Katzie First Nation and local community members
- encourage the local community to participate in trail maintenance days

3.5 Criterion 5: Responsibilities to First Nations

The traditional territory of the Katzie First Nation extends into MKRF's private land base, and although the Katzie do not claim title to the lands, it is nevertheless MKRF's responsibility to ensure that all management activities take the Katzie's interests into consideration. MKRF must fulfill its obligations to consult with and accommodate the band prior to the adoption of a new plan, and should work closely with the community to uphold and respect its values. As good stewards, MKRF should continue to seek to employ members of the Katzie throughout the year, and strategically manage the forest to preserve the Katzie's values and interests in the land.

MKRF should seek to uphold its responsibilities to the Katzie First Nation by meeting the following general goals in its carbon management plan:

- continue to maintain a positive relationship with the Katzie First Nation through consultation and accommodation
- encourage Katzie participation in development of management plans
- prioritize Katzie members for job opportunities

3.5.1 Objective 1: First Nations

Maintain a positive relationship with the Katzie First Nation

Indicator: Appropriate consultation and accommodation prior to plan modifications or adoption of a new plan
Target: Consult with representatives of the Katzie First Nation

Indicator: Employment opportunities for members of the Katzie First Nation
Target: Increase, or maintain current levels

Indicator: Respect the interests and traditional values of the Katzie First Nation
Target: 100% compliance

3.5.2 Management Strategies

- hold periodical meetings with Katzie representatives
- consider all concerns put forth by the Katzie First Nation
- document and keep records of all Katzie's concerns and ideas for management of MKRF
- respond to the Katzie's concerns in a timely manner

3.6 Criterion 6: Responsibilities to Local Communities

As good stewards of the forest, MKRF makes commitments to the community of Maple Ridge to uphold visual quality standards, ensure public health and safety through strategic forest management techniques, and maintain open communication channels with the general public. MKRF is adjacent to Maple Ridge, and must therefore ensure that harvesting operations are carried out to minimize visual impacts; efforts must also be made to ensure that MKRF activities do not negatively affect the Alouette watershed, which is located within the boundary of the MKRF land base. Smoke and fire management is also paramount. MKRF does not currently conduct any slash burning, and prescription burns are conducted only under appropriate conditions (e.g. during unstable atmospheric conditions, and favorable wind conditions). Several water reservoirs have been constructed throughout the forest to facilitate access to water in the event of fire. MKRF's extensive road network also serves to facilitate quick access. The forest is also heavily patrolled during fire season to ensure the safety of its recreational users and adjacent communities. MKRF also seeks to maintain open communication with the community through conducting public meetings, and facilitating access to annual reports and management plans.

MKRF should seek to uphold its various social responsibilities and commitments by meeting the following general goals in its carbon management plan:

- continue to maintain a positive relationship with the local communities
- uphold visual quality standards through strategic management techniques
- maintain high smoke and fire management standards to ensure the safety and health of neighboring communities
- encourage public input and facilitate access to public documents

3.6.1 Objective 1: Visual Quality

Minimize visual impacts of harvest in cut blocks and other areas through strategic harvesting techniques

Indicator: Tactical harvesting methods that maintain visual quality

Target: 100% compliance

Indicator: Area of in-block retention

Target: Minimum 20% for low operability areas and 10% for operable areas

3.6.2 Objective 2: Public Contribution

Maintain and encourage public input through meetings and access to public documents

Indicator: Public access to the projects

Target: Increase, or maintain at current levels

Indicator: Periodic public meetings

Target: Increase, or maintain at current levels

3.6.3 Management Strategies

Visual Quality:

- continue designing small cutblocks to increase visual quality
- prior to implementation, conduct Visual Impact Assessments of proposed roads and cut-blocks
- ensure that Visual Impact Assessments can be reviewed and commented on by interested community members and advisory committee members
- apply adjacency constraints to harvesting schedule and limit regeneration delay
- retain select windfirm trees in cutblocks to promote visual quality

Public Contribution:

- *maintain periodical public meetings*
- document and keep records of interest group concerns and ideas for management of MKRF
- regularly update MKRF website

3.7 Criterion 7: Soil and Water

Soils at MKRF are predominantly podzols that have been formed in colluviums or ablation till. These soils overlie basil till or granitic bedrock, and have average depths of one metre (HydroEcological Landscapes and Processes, 2009). Forest management practices at MKRF should pay careful attention to minimize soil disturbance and compaction. Failure to do so can lead to a decrease in productivity of the forests, and problems related to erosions and mass wasting. Erosion usually leads to loss of aquatic ecosystem productivity and a decline in drinking water quality. Mass wasting can result from improper road building activities, particularly in wet climates and on steeper slopes. It can lead to a loss of productive area, the degradation of stream channel morphology and fish habitat, and road washout. Management considerations related to soil conservation is therefore an important part of maintaining forest productivity, biodiversity, and water resources.

General goals for the protection of values associated with soil and water in MKRF are to:

- maintain and conserve unique soil characteristics
- prevent soil erosion and mass wasting
- maintain soil productivity
- maintain water quality and quantity
- maintain suitable fish/riparian habitat

3.7.1 Objective 1: Minimize soil degradation/compaction

Minimize soil degradation and compaction to maintain or improve soil structure and stability, and thereby avoid or minimize soil erosion and mass wasting; soil disturbance will also be minimized, and soil productivity will be maintained.

Indicator: Percent of disturbed forest floor classified as having very high soil sensitivity
Target: 100% compliance with FRPA

Indicator: Percent of disturbed forest floor classified as having moderate and low soil sensitivity
Target: 100% compliance with FRPA

3.7.2 Objective 2: Maintain suitable fish/riparian habitat

Through management, maintain suitable fish/riparian habitat by keeping sediment levels at current or lower than current levels to maintain acceptable levels of water quality. The quantity and temperature of water should also remain at near current levels.

Indicator: Area of riparian buffers around lakes/streams, especially on steeper slopes (≥30%)
Target: 100% compliance with BC Forest Practices Code

Indicator: Temperature of water in streams/lakes
Target: No net change

Indicator: Amount of sediment in stream/lakes
Target: No net change

Indicator: Net area of riparian habitat
Target: No net change

3.7.3 Management Strategies

Soil:

- harvesting activities on sensitive sites should be conducted mainly during the drier periods in late summer to minimize soil disturbance
- increase focus on low impact harvesting methods overall
- low impact harvesting methods should be utilized in areas classified as having high soil sensitivity
- re-plant slopes to increase soil stability
- develop plans for road deactivation, rehabilitation, and restoration

Water:

- establish procedures for sediment control in road construction and reactivation
- continue to incorporate stream buffers and management zones in relevant cutblocks
- implement careful harvesting on steep slopes and areas upslope from important riparian habitat
- monitor water quality closely to evaluate the effects of fertilization

3.8 Criterion 8: Long-term Flexibility

Forest management requires long-term planning and must therefore be flexible to account for varying social, economic, and environmental conditions. The recent economic downturn and the subsequent drop in demand for lumber have caused economic hardship for many licensees and private landowners. To mitigate the effects of such unforeseeable events, forest management should strive to diversify its activities and sources of revenue. MKRF is already more diversified than most land owners as it generates revenue from a variety of activities through the use of the Loon Lake camp facilities, timber sales, and value-added product sales.

When venturing into a new and relatively uncertain market such as the carbon market, emphasis on diversification becomes increasingly important. MKRF must continuously strive for flexibility in order to meet its economic goals, regardless of varying market conditions for carbon and log and lumber prices.

General goals for securing long-term flexibility in the MKRF carbon management plan are to:

- ensure acceptable levels of revenue are maintained regardless of changes in market conditions
- ensure that the recommended scenario has the potential for adaptability should the primary market collapse (e.g. shift focus from primary carbon market to secondary timber markets)

3.8.1 Objective 1: Sustain Gallant sawmill activities over time

Indicator: Harvest levels

Target: Maintain harvest levels about 11,000m^3/year

3.8.2 Objective 2: Diversity of species in MKRF inventory

Indicator: Number of different species in log inventory

Target: Maintain four species

3.8.3 Management Strategies

- maintain a balance between carbon and timber objectives
- continue research into new market opportunities, diversification of products with an emphasis on value added product development
- plant a variety of economic species to account for changes in market demand
- continue use and improvement of Loon Lake camp facilities

3.9 Criterion 9: Education and Research

In 1949, MKRF was officially granted their land by the Crown on the condition that education and research are their primary mandates[1]. To uphold this legal constraint, management activities must continue to cater to education and research objectives. Researchers (both local and international) are accommodated in the establishment of their projects, and accommodation for researchers and students is provided if needed.

Currently, more than 100 research projects are active within MKRF, and other activities such as harvesting are carefully planned to avoid interference with any of these projects. It is critical for MKRF to continue to fulfill its research mandate, in order to continue ownership of the land.

General goals for fulfilling the education and research mandate in the MKRF carbon management plan are to:

- continue to permit a wide range of research projects within the forest
- maintain Loon Lake facilities to ensure available accommodation for researchers

3.9.1 Objective 1: Avoid increased constraints on research project types

Indicator: Average number of research projects

Target: Maintain historical average of research projects

3.9.2 Objective 2: Maintain camp and educational facilities

Indicator: Number of educational tours and camp days

Target: Maintain or increase from current levels

4.0 Scenario Modeling

The purpose of this management plan is to explore options for MKRF to generate revenue, utilizing both harvesting and carbon sequestration strategies. Two base case scenarios were developed for 1990 and 2007 to represent "business as usual" baselines[2]. Three additional scenarios were created which aim to increase carbon sequestration in MKRF through improved forest management and conservation techniques. The scenarios were modeled using Forest Planning Studio-Atlas (FPS-Atlas) with carbon stock information generated in the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) to interpret the effects of adjusting current practices to meet carbon and/or timber revenue objectives.

[1] As dictated by the restrictive covenant on the 1949 Crown grant (Powers, 2010).

[2] 1990 is the baseline required by the Voluntary Carbon Standard, whereas 2007 is the baseline required for BC's regulatory market. The baseline for the future North American voluntary market is January 1 of the project enrollment year.

4.1 FPS-Atlas

All of the management scenarios were modeled using FPS-Atlas. FPS-Atlas is a forest- level harvesting model that is designed to schedule harvests according to a range of spatial and temporal objectives (Nelson, 2003). Polygons in the model contain critical attribute information and are vital for the operation of the model .Each polygon in the model was assigned to a stand group with particular carbon stock information. The model is then able to display the total carbon stock of the forest landscape over 240 years according to management assumptions.

4.2 CBM-CFS3

CBM-CFS3 was used to generate carbon stock information and analyze sequestration capabilities of stand structures in MKRF. CBM-CFS3 is an aspatial, stand and landscape-level modeling framework used to simulate the dynamics of all forest carbon (Natural Resources Canada, 2009). The carbon model generates carbon curves for each of the different stand groups used in the FPS-Atlas model. Once the carbon stock information is generated, it is imported to the FPS-Atlas model to generate changes in total carbon stock over time. For the purposes of the scenario modeling a harvesting projection of 240 years was used.

4.3 Carbon Management Scenarios

4.3.1 1990 Base Case

This scenario was developed to reflect 1990 forest management practices. In this scenario harvest levels were set according to a five year historical average from 1988-1992—this average was taken from MKRF's annual harvest levels (Appendix 9), and resulted in a harvest flow of 8,400m^3/year. Conventional harvesting methods were mainly employed using a clearcut silvicultural system and did not incorporate any in-block retention. This particular scenario is not a viable option for MKRF to pursue as it incorporates practices that are no longer relevant to MKRF's management goals—however, this scenario was developed to provide a baseline against which other scenarios can be compared to measure additionality. Additionality is the carbon that is generated by management activities in addition to the business-as-usual scenario (Greig & Bull, 2009).

4.3.2 2007 Base Case

This scenario reflects 2007 forest management practices. Harvest levels were set according to a five-year historical average from 2005-2009 (Appendix 9), and resulted in a harvest flow of 26,000m^3/year. Conventional harvesting methods were mainly employed using a clearcut silvicultural system. In-block retention was utilized as a method of creating wild life tree patches. Commercial thinning operations were incorporated to manage for higher grade timber. Maximum thinning constraints were set at 30% since a lower setting would have resulted in the model not being able to maintain the harvest flow.

4.3.3 No Harvest

This scenario does not permit any timber harvesting activities within MKRF. It focuses solely on revenue generated from carbon sequestration, and the objective of this scenario is to demonstrate the maximum carbon sequestration level that might be obtained.

4.3.4 Extended Rotation

The objective of this scenario was to balance timber harvesting and increased carbon sequestration activities and pursue revenues from both markets. Minimum harvest ages were increased by 30 years, while the harvest level was decreased to 13,000m^3/year. Commercial thinning operations were continued but at a proportion lower than the 2007 Base Case, to better reflect the actual five-year average of 21% thinning relative to the total harvest.

4.3.5 Select Seed

This scenario was developed to maximize timber revenue while increasing carbon sequestration through the 100% usage of genetically improved seed stock[3]. The harvest flow, commercial thinning practices, and other model constraints from this scenario were identical to those of the 2007 Base Case. This allowed for the effect of select seed on carbon sequestration to be better evaluated.

4.3.6 Alternative scenarios

Three other scenarios were also explored, but were not fully developed for this plan due to several limitations and/or lack of significant additionality produced. However, the modeling results for these scenarios can be seen in Appendix 10. These scenarios will not be included in any further analyses.

Table 3 provides a summary and description of base cases and scenarios, including total harvest levels.

Table 3: Summary of the scenarios

Scenario	Description	Total Harvest Level (m^3/yr)
Base Case 1990	• Harvest level maintained at 1990 levels • Model constraints reflect 1990 forest management practices	8,400
Base Case 2007	• Harvest level maintained at 2007 levels • Model constraints reflect 2007 forest management practices • Commercial thinning operations maintained	26,000
No Harvest	• Timber harvesting ceased in MKRF • Manage for maximum carbon sequestration	0
Extended Rotation	• Minimum harvest ages extended by 30 years • Lower harvest levels compared to current practice • Manage for timber and carbon objectives • Decrease in proportion of commercial thinning operations relative to the overall harvest	13,000
Select Seed	• Increase carbon sequestration through 100% usage of genetically improved seed stock • Maintain current practice harvest levels • Continue commercial thinning operations	26,000

[3] Class A orchard seed with the following gains were used: Cw (14.5%), Hw (15.9%), Fd (18.0%). The estimated levels of gain and production for each species were taken from *The Forest Genetics Council of British Columbia Business Plan 2009-2010* (Woods, 2009) and correlate with the elevation levels at MKRF.

4.4 Modeling Assumptions

The assumptions used in the carbon management scenarios are described in Table 4.

Table 4: General assumptions used in modeling the scenarios

General Assumptions used in Modeling		
#	**Model**	**Description**
1	FPS-Atlas, CBM-CFS3	Large-scale disturbances such as forest fires, windthrow and disease/insect infestation do not occur.
2	FPS-Atlas, CBM-CFS3	Yield curves beyond 200 years were assumed to remain constant.
3	FPS-Atlas	Fertilization has been only used for research to date and is therefore negligible.
4	CBM-CFS3	Stands have been mapped based on the leading species only and values do not change for mix species stands.
5	FPS-Atlas	Harvest levels have been adopted from a 5-year average and were assumed to represent future levels.
6	FPS-Atlas, CBM-CFS3	Yield tables that were aggregated to simplify total number of stand groups do not have a significant impact on results of project.
7	FPS-Atlas	Cutblock adjacency was not determined to play a significant role in impacting harvest levels, and was therefore not considered.
8	FPS-Atlas, CBM-CFS3	Select seed use prior to 2007 was negligible and can be ignored.

4.5 Model Constraints

The constraints used in modeling the carbon management scenarios are described in Table 5. See Appendix 11 for a map indicating the operable, low operable, reserves, and riparian buffer areas. Along with the map in Appendix 11, tables are provided showing the area of different site conditions and stand group categories within MKRF. Appendix 12 shows the thinning constraints and zones for the scenarios.

Table 5: Constraints used in modeling the scenarios

Scenario	Model Constraints	Location Applied
1990 Base Case	No harvest	Reserve clique
2007 Base Case	8000m^3/yr max thinning 10% retention 20% retention No harvest	Thinning Zone Operability clique Low operability cliques Reserve clique
Select Seed	8000m^3/yr max thinning 10% retention 20% retention No harvest	Thinning Zone Operability clique Low operability cliques Reserve clique
Extended Rotation	2700m^3/yr max thinning 10% retention 20% retention No harvest	Thinning Zone Operability clique Low operability cliques Reserve clique
No Harvesting	No harvest	Whole forest
All Scenarios	Modeled to period 24 (i.e. 240 years) Harvest priority: oldest stands first	Whole forest THLB

4.6 Modeling and Results of Targets Associated with Criteria and Indicators

The FPS-Atlas model did not allow for modeling of all indicators and targets associated with various criteria. Table 6 shows the indicators and targets that were successfully modeled using FPS-ATLAS.

Table 6: Modelable targets for various criteria and indicators

Criteria	Indicator	Target
Biological Diversity	Significant representation of all three BEC subzones in reserves	Maintain representation
	Significant representation of all seral stages in the forest	Maintain representation
	Area of old growth	Increase, or maintain at current levels
Carbon Storage	Net change in carbon sequestration from SSR's	Increase by minimum 10% above base cases
	Number of carbon credits produced	Increase by minimum 10% from current levels
Economic Benefits from Current Activities	Harvest levels	Maintain harvest levels at minimum 11,000m^3/year
	Total growing stock	Long-term, non-declining even flow
Long-term Flexibility	Number of different species in log inventory	Maintain four species

Scenario comparisons for each modelable indicator and target are discussed below in relation to criteria.

4.6.1 Biological Diversity

The first objective for biological diversity relates to ecosystem diversity (3.1.1).The indicator is significant representation of all three BEC subzones in reserves, and the target is to maintain representation of these subzones. Table 1 provides a description of the BEC subzones within MKRF, and Appendix 13 shows the distribution of these subzones within the reserves. The reserves are maintained for all scenarios, and all subzones are maintained in roughly equal proportions. All scenarios meet this target, as reserves are maintained in perpetuity over 240 years.

The second objective for biological diversity relates to species diversity (3.1.2), and is associated with two indicators. The first indicator is significant representation of all seral stages in the forest, and the target is to maintain representation. Figures 4, 5, 6, 7, and 8 show the seral stages for base cases and scenarios for periods 0, 8, 16, and 24, respectively. With the exception of the No Harvest scenario, all base cases and scenarios meet this target. The No Harvest scenario has an underrepresentation of early and mid seral stages. However, this scenario has the greatest representation of old seral stages.

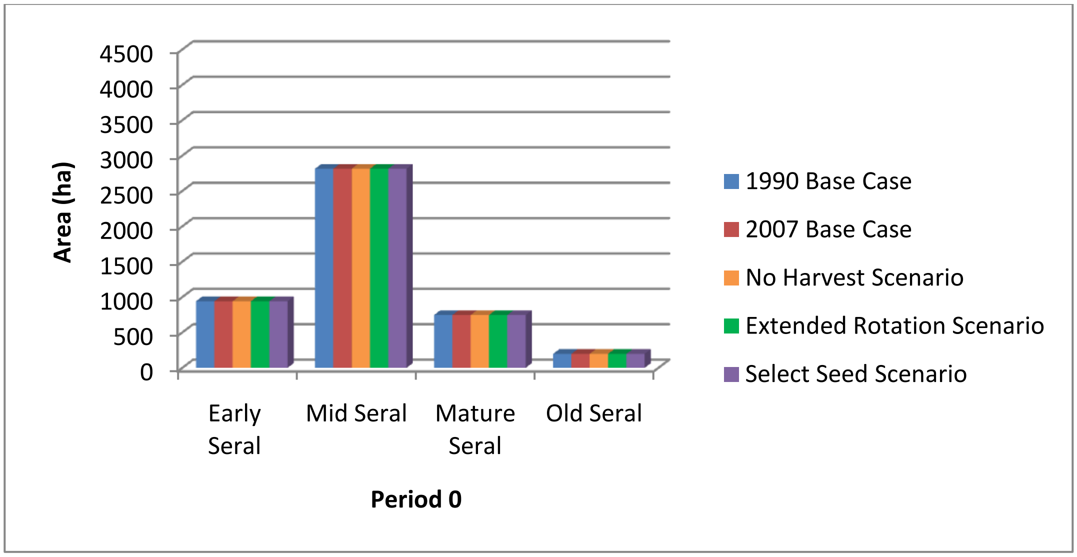


Figure 4: Seral stages (period 0) for base cases and scenarios

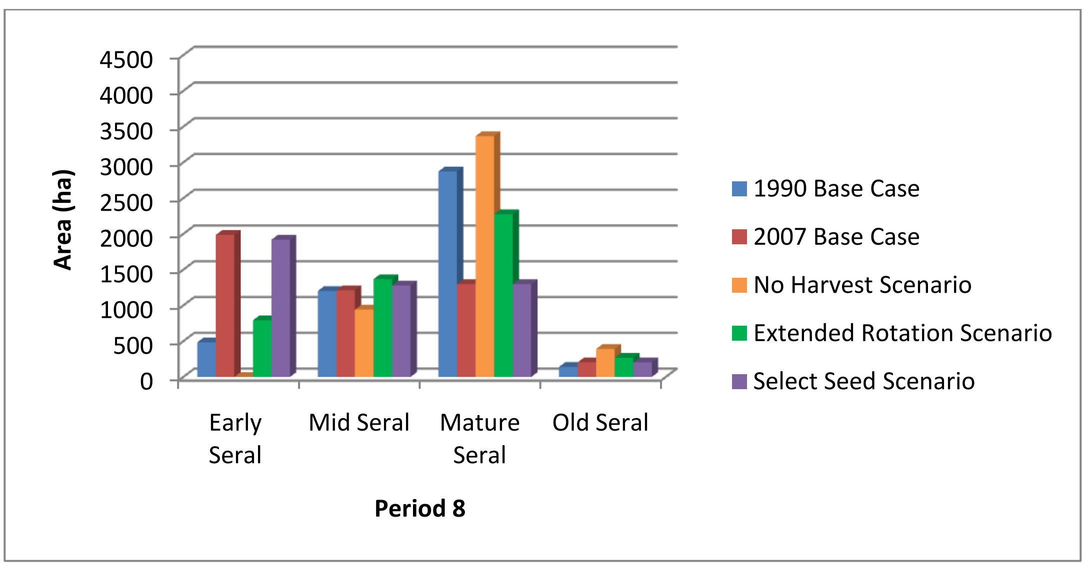


Figure 5: Seral stages (period 8) for base cases and scenarios

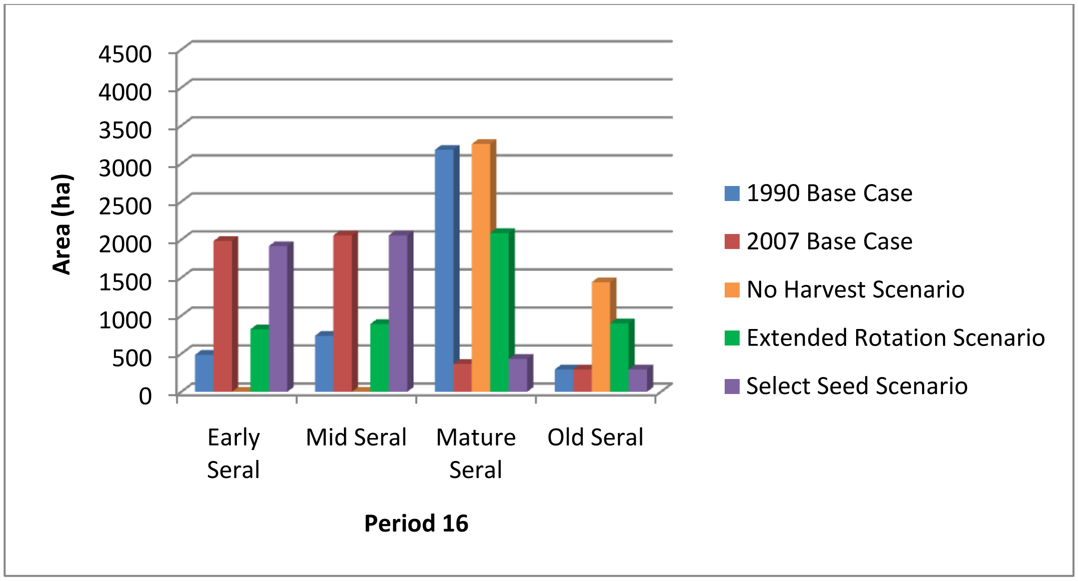


Figure 6: Seral stages (period 16) for base cases and scenarios

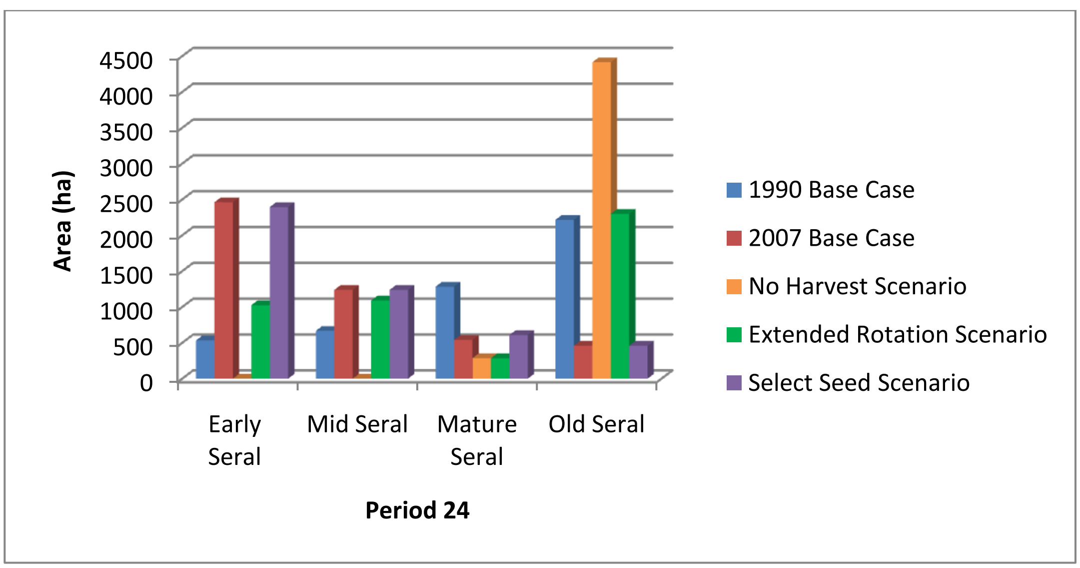


Figure 7: Seral stages (period 24) for base cases and scenarios

The second indicator for this objective is area of old growth, and the target is to increase or maintain this area at current levels. Figure 8 shows the area of old growth for base cases and scenarios for the 240 year period. All base cases and scenarios meet this target, and show an increase in the total area of old growth within the MKRF land base.

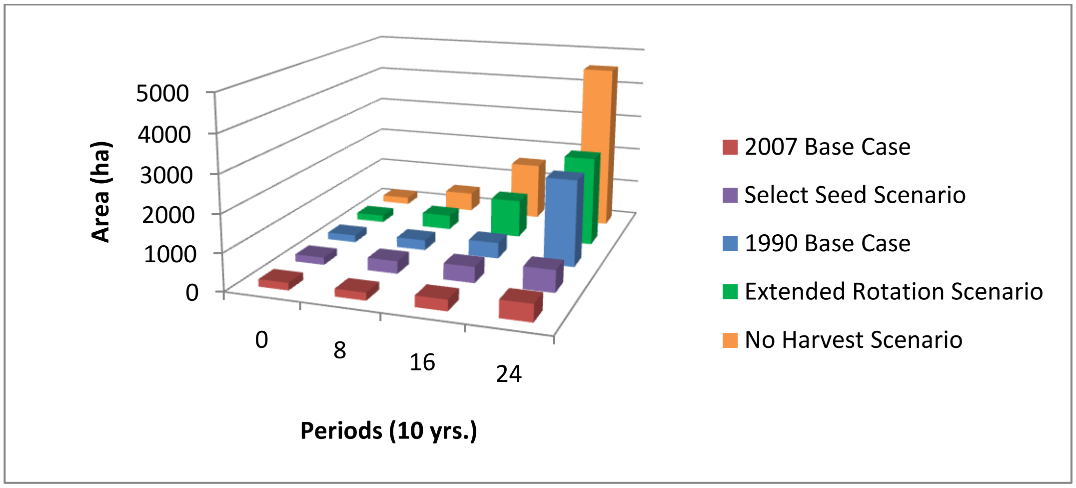


Figure 8: Area of old growth for base cases and scenarios

4.6.2 Carbon storage

Objective 3.2.2 is carbon sequestration, and is associated with two indicators. The first indicator is net change in carbon sequestration from sources, sinks, and reservoirs (SSRs). The target is to increase SSRs by a minimum of 10% above base cases. Figure 9 shows the total ecosystem carbon sequestered from SSRs. All scenarios meet this target since levels of carbon sequestered are above the 2007 Base Case. The No Harvest scenario is the only scenario which exceeds the level of carbon sequestered above the 1990 Base Case.

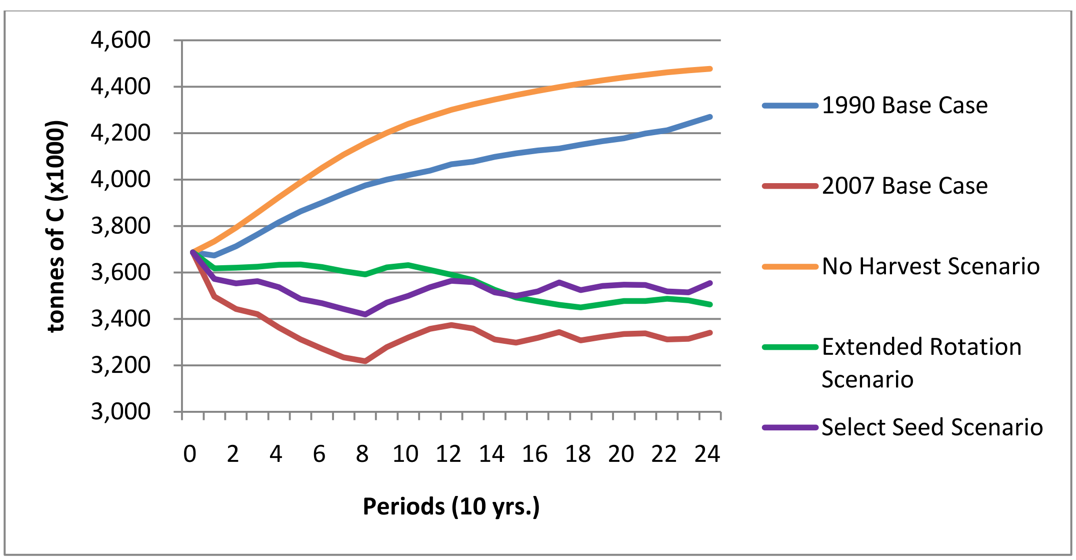


Figure 9: Total ecosystem carbon from sources, sinks and reservoirs for base cases and scenarios

The second indicator for objective 3.2.2 is the number of carbon credits produced, and the target is a 10% minimum increase from current levels. Carbon credits are measured by addition carbon sequestered compared to the base line. Business-as-usual scenarios for our plan are the 1990 and 2007 Base Cases. Figure 10 shows the additionality produced by scenarios compared to the 1990 Base Case. Only the No Harvest scenario produces additionality—approximately 200,000 tonnes—above the Base Case. Figure 11 shows the additionality produced by scenarios compared to the 2007 Base Case—all scenarios meet the target, with the No Harvest scenario producing the greatest additionality. The No Harvest scenario sequesters approximately 1,100,000 tonnes of carbon, while the Extended Rotation and Select Seed[4] scenarios sequester between 150,000 tonnes and 200,000 tonnes in relation to the 2007 Base Case.

[4] Note that Select Seed scenario results are an over-estimation of the carbon stocks. Genetic gains were applied to all managed stands, including those which are currently growing. However, genetic gains would not come into effect until those stands are reforested. The estimated actual genetic gain is 11%, using 100% select seed reforestation.

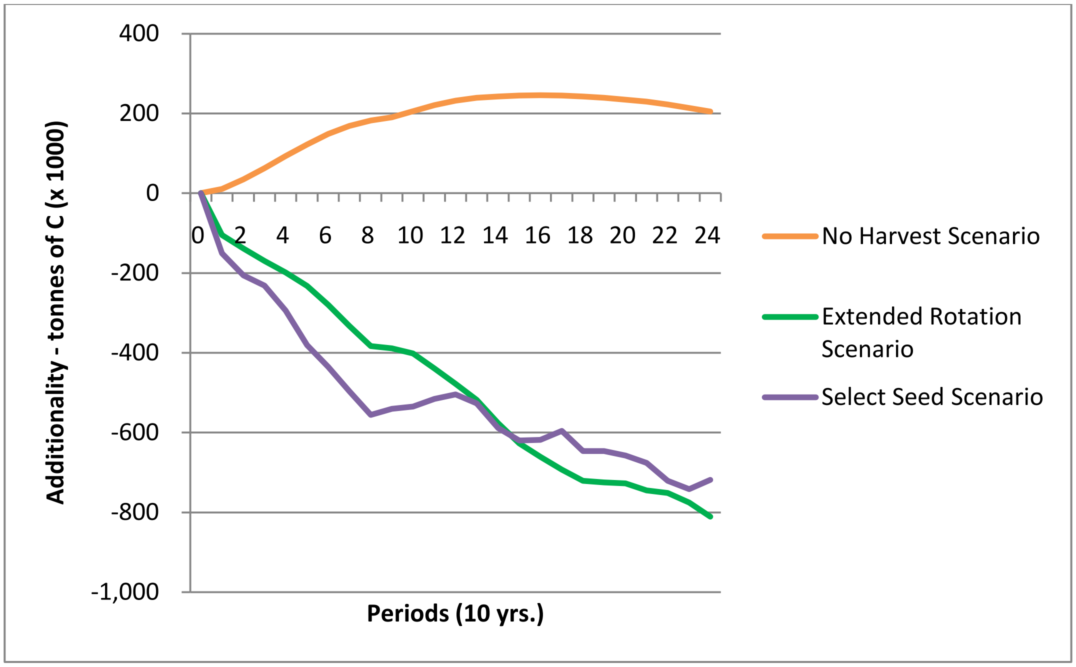


Figure 10: Additionality of scenarios compared to 1990 Base Case

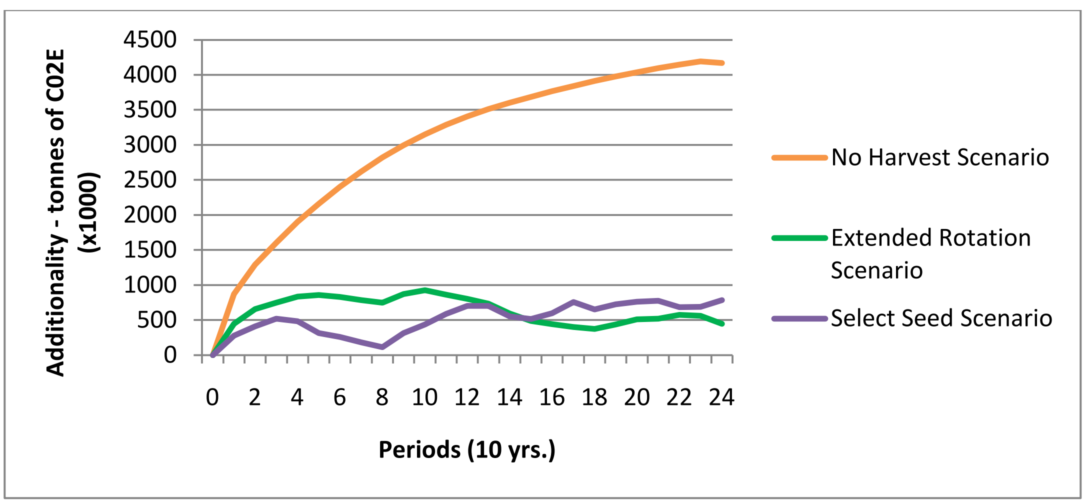


Figure 11: Additionality of scenarios compared to 2007 Base Case

4.6.3 Economic Benefits from Current Activities

To sustain and incur economic benefits from current activities, our plan's objective is to maintain or increase the revenue that is generated by MKRF. Two indicators are identified to meet this objective. The first indicator is timber sales, and the target is to maintain harvest levels at a minimum of 11,000m^3/year. This harvest volume would permit the Gallant sawmill to continue its activities over time and thereby generate revenue through timber sales.

Harvest flow patterns were established for each scenario, as outlined in Table 3. Each scenario was then run through the model to establish harvest volumes, which can be seen in Figure 12. For each scenario, there is no significant deviation from the harvest levels. However, only the 2007 Base Case, and Select Seed and Extended Rotation scenarios meet the target for this indicator. The 1990 Base Case and No Harvest Scenario do not have harvest volumes high enough to sustain harvest levels of 11,000m^3/year.

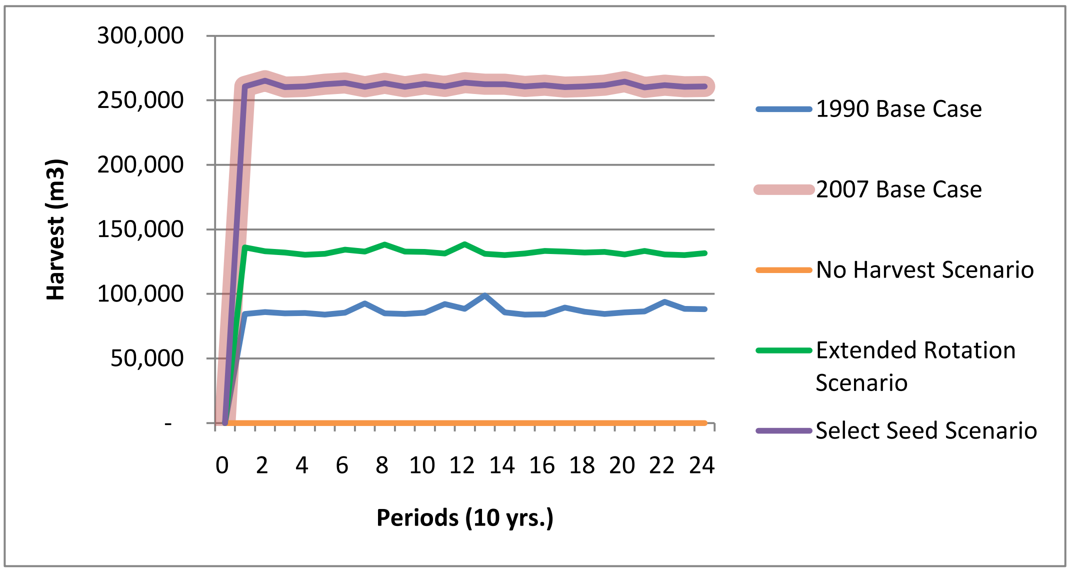


Figure 12: Harvest volumes for base cases and scenarios

The second indicator for this criterion is the total growing stock in MKRF, and the target is a long-term, non-declining even flow to ensure a continuous supply of growing stock. Results for total growing stock for the base cases and scenarios can be seen in Figure 13. All scenarios meet the target in the long-term. As expected, the No Harvest scenario generates the highest total growing stock, and is followed by the 1990 Base Case and the Extended Rotation scenario. If figures 12 and 13 are compared, it can be seen that there is an inverse relationship between harvest volumes and total growing stock. As harvest levels decrease, total growing stock increases.

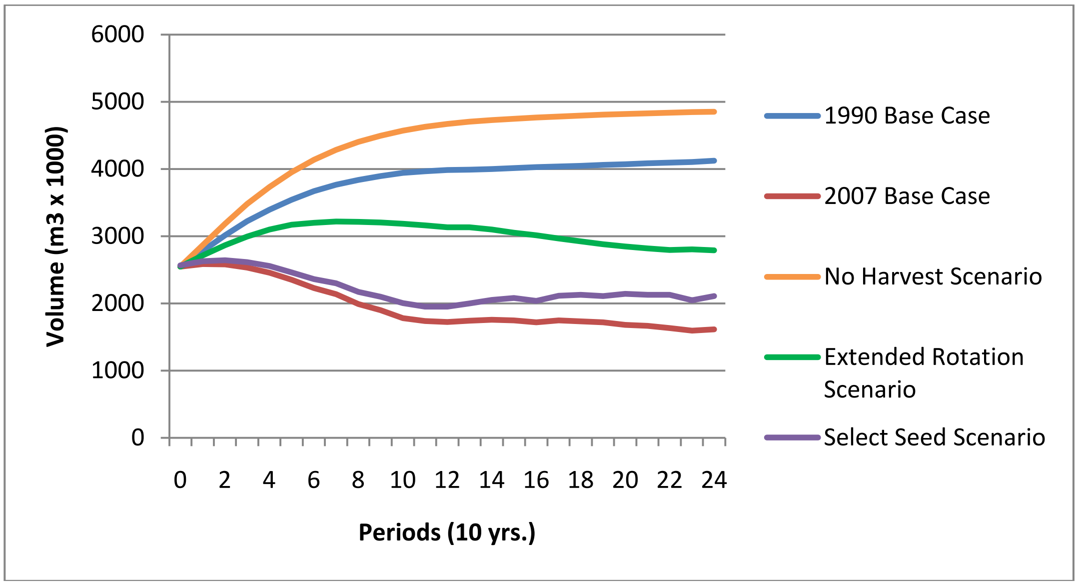


Figure 13: Total growing stock for base cases and scenarios

4.6.4 Long-term Flexibility

To ensure long-term flexibility, a diversity of species in the MKRF inventory will be sustained. The indicator for this objective is the number of different species in the log inventory, and the target is to maintain four. Figures 14, 15, 16, 17, and 18 show the area by leading species for the base cases and scenarios. All base cases and scenarios meet this target. However, the 2007 Base Case and Select Seed scenario result in a substantial decrease in area of Hw as well as alder (Figures 15 and 18).

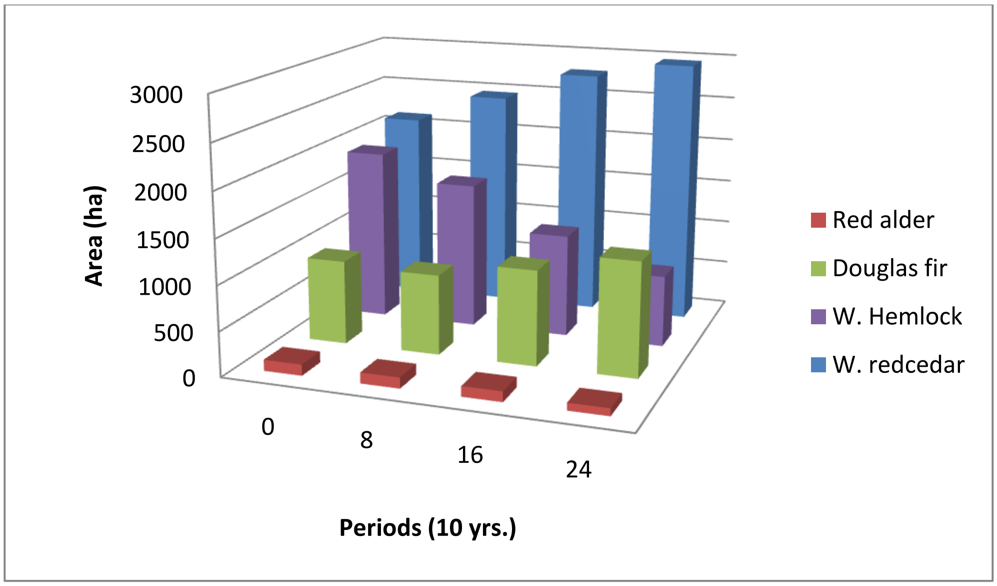


Figure 14: Area by leading species for 1990 Base Case

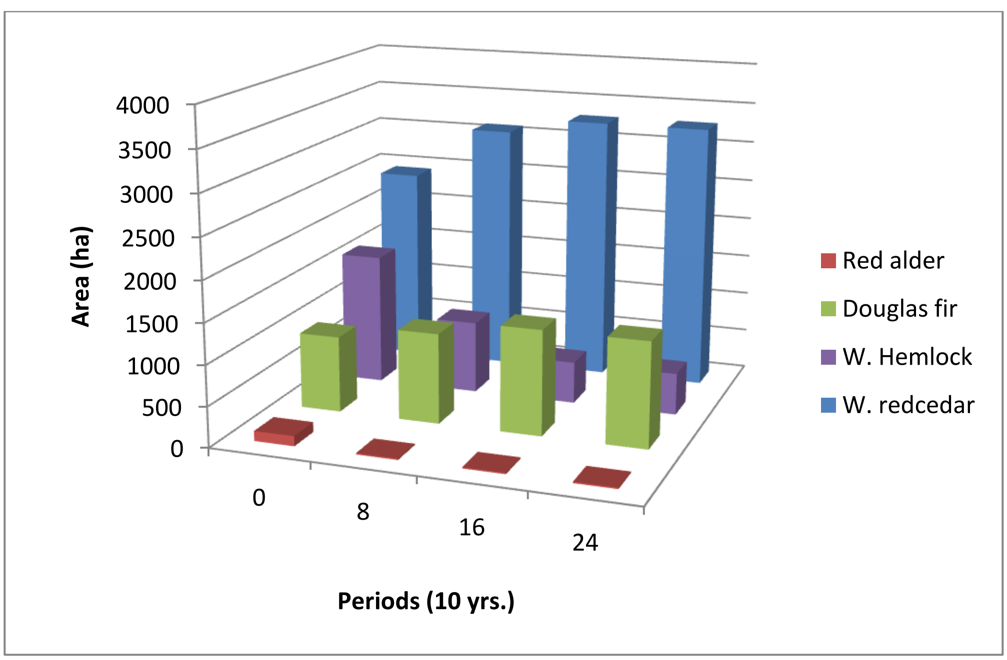


Figure 15: Area by leading species for 2007 Base Case

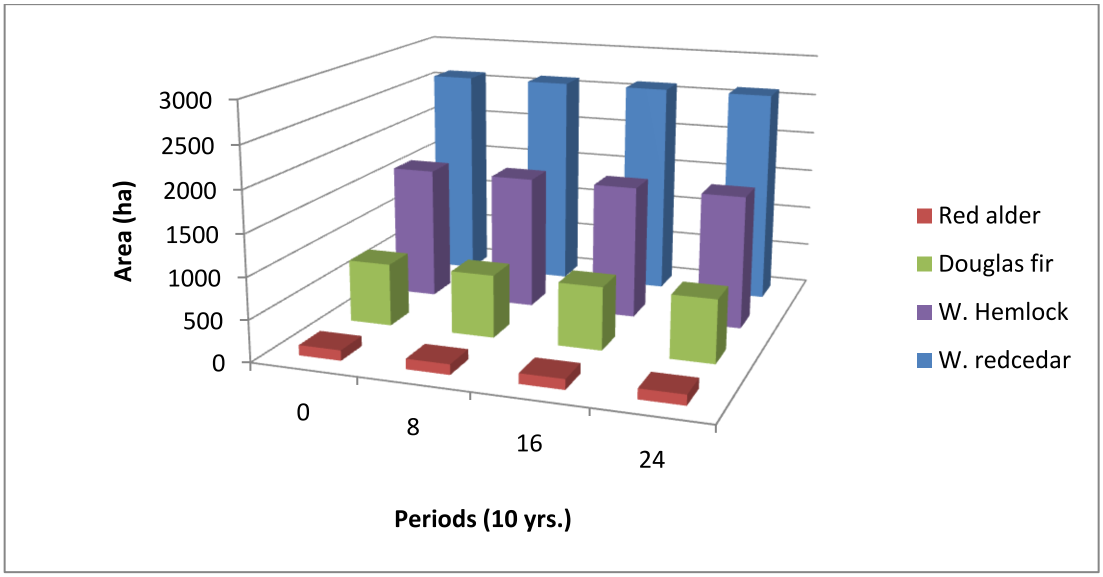


Figure 16: Area by leading species for No Harvest scenario

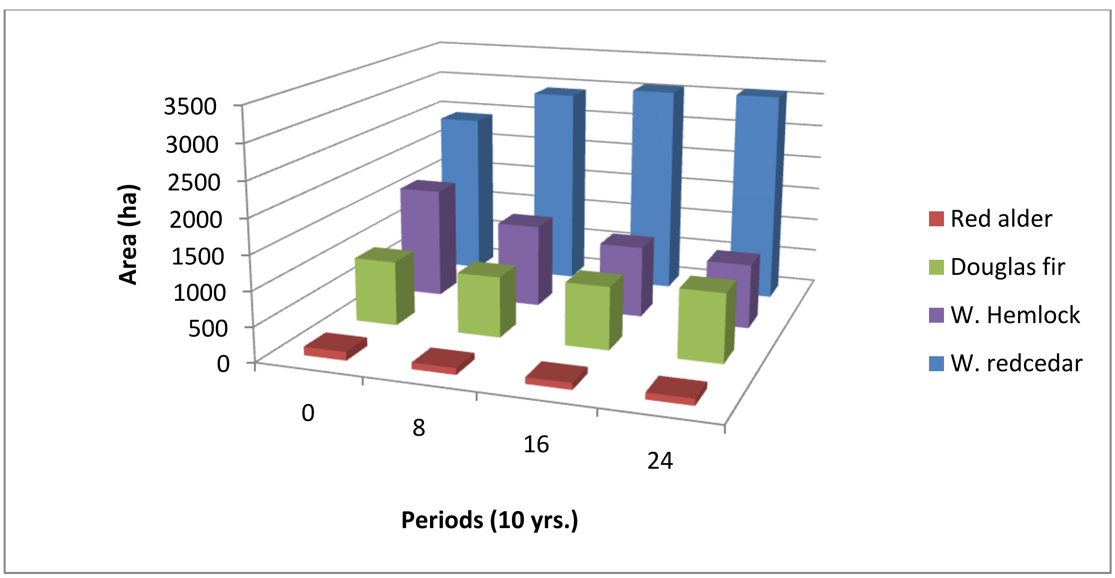


Figure 17: Area by leading species for Extended Rotation scenario

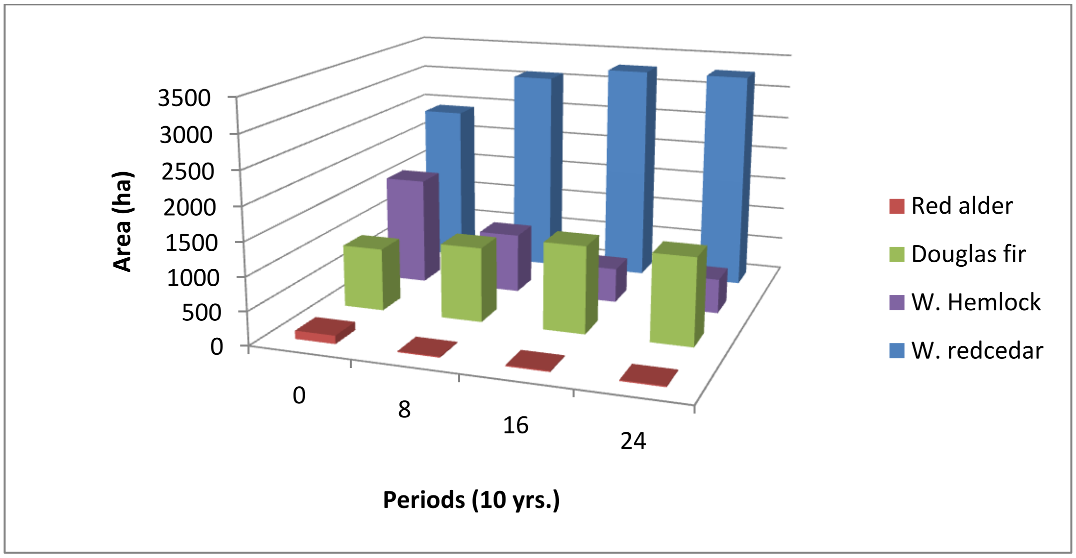


Figure 18: Area by leading species for Select Seed scenario

5.0 Scenario Analysis

The 1990 Base Case was not included in the scenario analysis, as it incorporates management practices that are no longer relevant to MKRF's management goals; the 1990 Base Case will therefore not be considered nor recommended as an option for MKRF to pursue. The remaining scenarios—2007 Base Case, No Harvest, Extended Rotation, and Select Seed—are included in the scenario analysis to determine how each scenario fulfills the established criteria. The ordinal ranking method and multi-criteria analysis presented below will provide the basis for a recommendation.

5.1 Ordinal Ranking

The ordinal ranking method was used to compare the 2007 Base Case and carbon management scenarios in terms of their abilities to meet each of the outlined criterion and their indicators, and to assess the effectiveness of the management strategies regarding these values. To indicate the degree to which each scenario satisfies a particular criterion, each scenario was assigned a ranking number from one to four, in order from worst to best (see Table 7).

Table 7: Ordinal ranking key (degree of target fulfillment)

Worst			Best
1	2	3	4

Ranking of scenarios was based either on the scenario's ability to meet targets based on modeling results of the indicators, or by estimations relying on literature reviews, consultation with interest groups, and/or personal experience.

Assumptions of the ordinal ranking system are as follows:

- Scenarios that are equal in their fulfillment of a particular criterion are assigned the same ranking number
- Increments between ranks are equal

Two criteria—"Responsibilities to First Nations" and "Responsibilities to Local Communities"—were excluded from this analysis, as all scenarios meet the indicator targets equally. Table 8 below shows the ranking of all scenarios (excluding the 1990 Base Case) against relevant criteria.

Table 8: **Ordinal ranking of 2007 Base Case and scenarios against criteria. *Indicates Criteria which are weighed double, based on consultation with our client.**

		2007 Base Case	No Harvest	Extended Rotation	Select Seed
Criteria	Biological Diversity	2	4	3	1
	Carbon Storage	1	4	3	2
	Economic Benefits from Current Activities	3	1	2	4
	Social Benefits	4	1	2	4
	Soil & Water	1	4	3	1
	Long-Term Flexibility*	4	2	8	6
	Education & Research*	8	2	4	6
	Total Score	**24**	**18**	**25**	**24**

Based on the ordinal ranking matrix, a quick comparison of the scenarios can be made according to the total score for each scenario, as listed in Table 8. When the numbers are tallied, the scores are as follows: Extended Rotation has the highest score with 25; Select Seed and the 2007 Base Case ties for second place with 24; and The No Harvest scenario gets fourth place with a score of 18.

The discussion below illustrates how scenarios were ranked according to their fulfillment of the criteria.

5.1.1 Biological Diversity

This criterion concerns ecosystem, species, and genetic diversity.

Ecosystem Diversity: Ecosystem diversity is unaffected by different scenarios, as reserves remain constant and all BEC subzones are represented within the reserves (see Appendix 13).

Species Diversity: Habitat requirements differ according to the species of concern, and species diversity can therefore be influenced by the representation of all seral stages as well as the area of old growth. According to the modeling results, all scenarios except the No Harvest have a significant representation of all seral stages through the next 240 years (Figures 4, 5, 6, and 7). Although the Extended Rotation scenario moves towards a higher representation of the old seral stage, the No Harvest scenario comprises only mature and old seral stages at year 160. However, gap phase dynamics ensure that seral stages are represented throughout the forest in the No Harvest scenario.

Most blue- and red-listed species habitat requirements are for mature/old growth forests (see Appendix 6), and old growth area is therefore valued more highly than seral stage representation. The area of old growth is greatest in the No Harvest scenario, followed by Extended Rotation (Figure 8); the 2007 Base Case and Select Seed scenarios have the least area of old growth.

Genetic Diversity: Genetic diversity can be compromised by the use of orchard seed. The Select Seed scenario—100% usage of orchard seed—will therefore have an effect on the overall genetic diversity of tree species in MKRF. However, all scenarios meet the established target for genetic diversity, as appropriate genetic diversity of orchard seed is regulated through the BC Ministry of Forests and Range Policy Standards (Ministry of Forests and Range, 1998).

A "sub-ordinal ranking" of this criteria can be seen in Appendix 14. Based on the factors that influence biological diversity and the weighted importance of old growth areas, the highest ranked scenario for biological diversity is the No Harvest scenario. The Extended Rotation scenario is ranked second, followed by the 2007 Base Case, and lastly, the Select Seed scenario.

5.1.2 Carbon Storage

MKRF's contribution to the global carbon cycle is a function of sequestration minus emissions. Any activity that influences this balance will affect the total carbon storage.

Carbon Sequestration: A general overview of the overall tonnes of carbon sequestered for each scenario can be seen in Figure 9, which depicts total ecosystem carbon from SSRs. This figure shows that the No Harvest scenario sequesters the greatest amount of total carbon. This scenario is followed by the Extended Rotation scenario, then the Select Seed scenario and finally, the 2007 Base Case scenario.

Carbon Emissions: Emissions associated with operational activities are assumed to correlate with the level of harvest activities. Harvest volumes for each scenario can be seen in Figure 12. Emissions are therefore projected to be lowest for the No Harvest scenario, followed by Extended Rotation. The highest level of emissions will stem from the 2007 Base Case and Select Seed scenarios. As these two scenarios involve similar harvest levels, they are assumed to have approximately the same levels of emissions.

A "sub-ordinal ranking" of this criteria can be seen in Appendix 14. The total amount of carbon sequestered is used as the principal indicator to differentiate between the performances of different scenarios. As a result, the No Harvest scenario is ranked the highest as it sequesters the largest amount of carbon. Extended Rotation, Select Seed, and 2007 Base Case scenarios, respectively, sequester less carbon and are consequently ranked lower.

5.1.3 Economic Benefits from Current Activities

Operations of the Loon Lake camp facilities will be continued with every scenario. The ranking under this criterion is therefore based on the ability of the scenario to meet growing stock targets and the quantity of timber harvested per year. All scenarios meet the growing stock targets by establishing long-term, non-declining even flows (Figure 13). However, the scenarios differ in terms of volume harvested. Figure 12 shows that harvest levels are the highest for the 2007 Base Case and the Select Seed scenarios, both of which have the highest volume of timber extraction per year. However, due to the genetic gain associated with the select seed and the subsequent increase in timber quality, the Select Seed scenario is ranked above the 2007 Base Case. The 2007 Base Case is therefore ranked second, followed by Extended Rotation, and finally, the No Harvest scenario.

5.1.4 Social Benefits

Every scenario allows for continuous recreational usage of MKRF, and management activities will be implemented to maintain and/or expand the current trail network. However, local employment opportunities are expected to have a strong correlation with harvest levels, since most local employment is within the operational activities in MKRF. Harvest levels can be seen in Figure 12. Based on this assumption, the highest ranked scenarios for this criterion are the 2007 Base Case and the Select Seed scenarios. The Extended Rotation and No Harvest scenarios have lower/no harvesting levels and are therefore ranked lower.

5.1.5 Soil & Water

To mitigate effects on soil and water, MKRF strives to implement techniques for careful harvesting whenever possible. MKRF will adhere to rules and regulations concerning riparian habitat protection for all scenarios that include harvesting activities. To evaluate the impacts on soil and water quality, it is assumed that effects on soil and water are directly related—and somewhat proportional—to the total area harvested. Harvest levels can be seen in Figure 12. Therefore, the 2007 Base Case and Select Seed scenarios—which include the highest harvest levels—receive the lowest ranking. Extended Rotation scenario is ranked second highest, and the No Harvest scenario is ranked first.

5.1.6 Long-Term Flexibility

As previously discussed, all scenarios meet the target of maintaining four species in MKRF's inventory.

Two scenarios depend exclusively on one market each: the 2007 Base Case scenario is restricted to the timber market, while the No Harvest scenario is restricted to the carbon market. Both scenarios will be faced with difficulties if their respective markets collapse. However, since long-term contracts are required to enter the carbon market, the No Harvest scenario will be limited if at a later period MKRF seeks to re-enter the timber market due to changing market conditions. On the other hand, since most regulatory carbon contracts (e.g. PCT) can ensure a constant price per tonne of carbon, this scenario may be considered "safer" than scenarios which rely on the volatile timber market.

Nevertheless, the carbon market is an emerging market and is therefore associated with a great deal of uncertainty. As a result, the No Harvest scenario is ranked lowest in terms of long-term flexibility since it relies completely on the emerging carbon market. The 2007 Base Case is ranked second lowest, based on previously discussed concerns. The Extended Rotation and Select Seed scenarios are dependent on both the carbon and the timber market. However, extended rotations are recognized more widely than select seed use by carbon standards as a strategy to increase carbon. Moreover, actual gain in volume realized from select seed use is uncertain. As a result, the Extended Rotation scenario is ranked highest, followed by the Select Seed scenario.

5.1.7 Education & Research

The 2007 Base Case, which represents current management activities, fulfills MKRF's research mandate through the accommodation of researchers and the maintenance of Loon Lake and other educational facilities. The proposed scenarios could potentially place constraints on research project establishment, simply due to the long-term contract requirements of carbon plans. The Select Seed scenario is similar to the 2007 Base Case, but incorporates the use of 100% genetically improved stock for regeneration purposes. Depending on the research activities, this could place some constraints on projects if researchers wish to regenerate with different stock.

The Extended Rotation scenario lowers the harvest level and adds an additional 30 years to the minimum harvest age. Although the decrease in harvest level is not considered to limit research activities, the extended rotation will impede potential projects if, for example, researchers wish to study short rotation harvests.

The No Harvest scenario will greatly obstruct research projects, as the scenario does not permit any harvesting activities.

Based on these justifications, the 2007 Base Case was ranked the highest, followed by the Select Seed, Extended Rotation, and the No harvest scenarios.

5.2 Multi-Criteria Analysis

Although the ordinal ranking matrix provides a general comparison of the scenarios, it does not compare scenarios against each other to fully evaluate which scenario best meets the established criteria. A multi-criteria analysis—based on the values included in the ordinal ranking—can be done to compare proposed scenarios against each other to select the best alternative. This method is a helpful tool in decision-making when dealing with complex problems

Table 9 illustrates how the scenarios are compared to one another. When comparing two scenarios for each criterion, the scenario with the higher score (i.e. ordinal ranking score) receives one vote. The votes for each comparison are then summed up in the "total votes for" column. Based on the total votes, each scenario is finally ranked according to the number of "total votes for."

Table 9: Multi-criteria Analysis

		VOTES AGAINST				MAXIMUM OF THE MINIMUMS	FINAL RANK
		2007 Base Case	**No Harvest**	**Extended Rotation**	**Select Seed**		
VOTES FOR	**2007 Base Case**	X	6	4	3	3	**3**
	No Harvest	3	X	3	3	3	**3**
	Extended Rotation	5	6	X	5	5	**1**
	Select Seed	4	6	4	X	4	**2**

Based on the results of the ordinal ranking (see Table 8) and subsequent multi-criteria analysis (Table 9), it can be concluded that the Extended Rotation scenario is the majority winner. Although this scenario is ranked the highest for only one criteria—long-term flexibility—it is ranked second highest for biological diversity, carbon storage, soil & water, and education and research. This scenario meets MKRF's timber and carbon objectives by keeping harvest levels high enough to sustain the Gallant Enterprises sawmill located in MKRF, as well as producing a large quantity of carbon credits. It is assumed that this scenario will be able to fulfill MKRF's education and research mandate, although some adjustments to the carbon management plan might be necessary to avoid constraints on proposed research projects. The Select Seed scenario receives the second highest number of votes in the multi-criteria analysis, followed by the No Harvest scenario and the 2007 Base Case, which tie for third place.

Based on both the ordinal ranking method and the multi-criteria analysis, the Extended Rotation scenario is superior to all the other scenarios. Taking into consideration both methods of scenario evaluation, the

Select Seed scenario receives second place, closely followed by the 2007 Base Case. The No Harvest scenario comes in at last place.

6.0 Recommendation

This management plan modeled five different scenarios, and compared four of them—excluding the 1990 Base Case as an option—through the ordinal ranking method and a multi-criteria analysis. Based on these methods of analysis, it was determined that Extended Rotation is the recommended scenario. Criteria and indicators compared in the multi-criteria analysis were developed through the use and adaptation of the CCFM's Framework of Criteria and Indicators, and meet sustainable forest management requirements for SFI certification.

Although the multi-criteria analysis is a valuable tool for forest managers in the decision-making process, the "winning" scenario does not necessarily need to be adopted. Other factors can influence management actions, and it is common for forest managers to incorporate strategies from different scenarios in their plans. Moreover, the implementation of any scenario requires continuous monitoring of the indicators and associated targets to ensure that the criteria are fulfilled. On-going changes and improvements to the management plan should be made as values and objectives change.

The economic feasibility of a plan is important since adequate revenue flow is necessary to sustain management activities. In addition to this carbon management plan, a business report was produced to evaluate the financial aspects of each of the four scenarios.

7.0 Leakage and Permanence

To be eligible, a project must be verified to ensure that it adheres to standard requirements. The verification process requires that forest project data is reviewed and assessed by a qualified third-party verifier to ensure that project developers have addressed issues regarding the ways in which carbon is accounted. Some of these issues include leakage, permanence, and risk.

7.1 Leakage

Leakage is the decrease in carbon sequestration or increase in emissions outside the project area boundary as a result of project activities. Internal leakage may occur if a portion of the owner's total land base is in a sequestration project, and emitting activities are moved to another area within the land base. External leakage may occur if market conditions change and carbon losses occur in other areas as a result—for instance, if MKRF reduces their harvest, harvesting activities may increase in other forests to satisfy demand. Leakage is difficult to monitor and can change over time; however, periodic re-evaluations should be undertaken to offset any estimated leakage that may occur as a result of project activities (Forest Carbon Standards Committee, 2009).

Management actions to prevent or minimize internal and external leakage are listed below.

Internal leakage

No net change in activities should take place at MKRF that would increase GHG emissions within the project area boundary (e.g. no net increase in machinery use). Moreover, sustainable forest management and careful site selection at MKRF will help ensure that internal leakage is minimized (Schwarze, *et al.*, 2002). MKRF will further provide documentation to verify that offsets are free of leakage (Lewandrowski, 2008), and will periodically re-assess and update project leakage to ensure compliance to verification standards (Beane, *et al*., 2008).

External leakage

No Harvest and Extended Rotations scenarios may result in external leakage. However, MKRF's share of the market at a national and international level is small due to the scale of its harvesting operations. External leakage for such operations is unlikely to have significant effects on the market, as overall timber prices are not affected by preservation projects—these operations will not likely have an effect on harvest incentives elsewhere in the country (Murray, *et al.*, 2004). External leakage is not anticipated for the scenario involving select seed use, as harvest levels will be maintained from the base case 2007 scenario.

7.2 Permanence

Permanence refers to the stability of carbon stocks within the project zone for the duration of the project. This requirement is met by ensuring that the carbon involved in GHG reduction remains stored for at least 100 years (Climate Action Reserve, 2009).To meet this requirement, non-permanence concerns are addressed by the risk assessment mandated by the carbon standards.

8.0 Risk and Insurance

8.1 Non-Permanence Risk Analysis and Buffer Approach

Risk of non-permanence is the potential of reversibility of sequestered/protected carbon .To address the potential loss of carbon during a project most carbon standards require the creation of buffer reserves of non-tradable carbon credits. These reserves are usually held in a single pooled buffer account.

The determination of the number of buffer credits that a given project must contribute to the associated buffer pool is determined by a risk assessment of the project activity. Although each carbon standard differs in its approach to calculating buffer pool contributions, the following categories are generally used to assess project risk: Financial Risk, Social Risk, Natural Disturbance Potential, and Over-Harvesting potential.

8.2 Risk Assessment for MKRF Management Strategies

As mentioned above, each carbon standard uses its own set of criteria to assess the risk of non-permanence. For the purposes of this report, risk assessment models for the CAR and VCS standards will be used to assess MKRF's risk potentials.

8.2.1 Climate Action Reserve Risk Assessment Model

Although the CAR standard will not be the official standard used by the province of BC to implement carbon sequestration projects, it is assumed that it will be similar to those that will eventually be adopted. Therefore the risk assessment performed under this standard may be similar to the standard that the province will require.

Table 10 summarizes the series of categories used in this standard to assess the risk factors on the project site. Each category contains a risk percentage that is assigned based on standardized information or criteria specific to the project site. The risk percentage that is standard for all projects occurs under the Financial, Management (Over-harvesting) and Social (Policy) categories. The remaining categories are assigned a percentage based on a combination of historical site data and calculated risk analysis. The values used do not represent the true values that would be assessed; however, these values may provide guidance as to what kind of buffer pool contributions may be required by MKRF.

Table 10: Forest project risk types under CAR (Climate Action Reserve, 2009)

Risk Category	Risk Type	Description	Contribution to Total Risk Assessment
Financial	Financial failure leading to bankruptcy	Financial failure leading to bankruptcy and alternative management decisions to generate income resulting in loss of carbon	1.0%
Management	Over-harvesting	Exercising timber value at expense of carbon project	2.0%
	Research	Loss of project carbon to research projects	1.0%
	Conversion to Non-Forest Uses	Future development of infrastructure	1.0%
Social	Social Risks	Governmental policy changes concerning Carbon and/or Forest Management	2.0%
		Change in First Nation Land Usage Principles	1.0%
Natural Disturbances	Wildfire	Loss of carbon from wildfire	8.0%
	Episodic	Loss of carbon from windthrow	1.0%
	Disease	Loss of carbon from insect and/or disease	1.0%
	Catastrophic Events	Snow Ice Flooding	0.5%
		Total Assessed Risk*	**16.8%**

* note Total Assessed Risk is based on the following equation:
Total Assessed Risk = 100%-[(1-Financial %)*(1-Overharvest%)*(1-Research %)*(1-Conversion %)*(1-Social %)*(1-Wildfire %)*(1-Episodic %)*(1-Disease/insect %)*(1-Castastropic Events %)]

For the purposes of this plan, the non-standardized categories were estimated, and do not necessarily reflect the actual percentages that would be applied. As can be seen in Table 10 the greatest risk to the forest is in the wildfire risk type. This is due to the fact that there is a high perceived risk of a fire starting from public use of the forest. This number would be higher if fire mitigation procedures were not already in place at MKRF. The 8 percent fire risk number is estimated using similar results from other carbon projects. It is not necessarily reflective of the actual number that would be used by MKRF to assess fire risk.

Using the risk assessment model provided by the CAR Standard, MKRF would have to maintain an estimated 16.8% of its additionality of carbon sequestered in a buffer pool. In this standard it is possible to reduce the total buffer reserve percentage over time, if it is determined that the overall risk to the project diminishes throughout the project duration. However, for this plan, the risk of non-permanence is assumed to remain constant until the completion of the project, at which time buffer pool credits will be returned to the additionality pool and paid out.

8.2.2 Voluntary Carbon Standard Risk Assessment Model

The VCS also requires the establishment of a buffer pool to balance the risk of non-permanence within a project. This standard uses a ranking system to assess risk. Each risk factor is assigned a rank between "zero" and "high." Each project type is then assigned a risk rating range according to applicable risk factors involved in the project. This can be seen below in Table 11.

Table 11: Guidance on risk factors and ratings for improved forest management projects under VCS (Voluntary Carbon Standard, 2007)

Risk factors	Conventional to Reduced Impact Logging (RIL)	Convert logged to protected forest (LtPF)	Extend rotation age (ERA)	Conversion of low-productive forests to productive forests (LPtPF)
Devastating Fire Potential				
Low to medium fire return interval (> 50 years)	Zero	Low to Medium	Zero to Low	Low
High fire return interval (< 50 years)… …with fire prevention measures such as fuel removal, fire breaks, fire towers, fire fighting equipment	Low	Low to Medium	Low to Medium	Low to Medium
…with NO significant fire prevention measures in place	High	High	High	High
High Timber Value				
Highly valuable species on site, with strong likelihood that the timber value increases over time and…	Zero	Medium	Zero to Low (if extend rotation ≤5 yrs)	Medium
…there is no forest certification …the project is certified by a recognized forest certification company	Zero	N/A	Zero for any extension period	Low
Illegal Logging Potential				
Presence of illegal logging in area (location and intensity in relation to the project area affects actual risk value)… …with forest guards	Zero with no change in harvest intensity*	Low	Zero	Low
…without forest guards	Medium with change in harvest intensity (potentially more timber to harvest illegally)	High	Low	Medium
Unemployment Potential				
Alternative livelihood opportunities for local workforce to mitigate risk of unemployment: Few	Zero to Low -because expect no change in labor needs	Medium to High	Low (extend rotation ≤5 yr or >5 yr), because expect no change in labor needs	Zero to Low -because expect no change in labor needs
Many	Zero	Low	Zero	Zero

After establishing the range, an average risk range for the project is determined. The average risk range for project types can be seen in Table 12. A percentage of risk is then assigned from the total risk range of the project based on suggested risk ranges provided by VCS (Table 12).

Table 12: Risk categories and buffer pool requirement for VCS (Voluntary Carbon Standard, 2007)

Risk Class	Convert logged area to protected forest (No Harvest)	Extended rotation (30 years)
Devastating Fire Potential	Medium	Medium
High Timber Value	Medium	Low
Illegal Logging Potential	Low	Zero
Unemployment Potential	Low	Low
Overall Risk	Medium	Low
Buffer Reserve % Required	**27.5%***	**10%***

*Note that a median number was chosen between the risk range in Table 13.

After establishing the range, an average risk range for the project is determined. The average risk range as well as the overall risk for project types can be seen in Table 12. A percentage of risk is then assigned to the overall risk, using the risk classification range established by VCS. The risk classification range can be seen in Table 13. A median number was chosen for each applicable risk range, and this number stipulates the percentage of buffer reserve required to protect the project owner from risk. During a projection approval process, the actual risk percentage that is assigned from the risk range will be based on the recommendations of two independent certified verifiers.

Table 13: Risk classification ranges for VCS (Voluntary Carbon Standard, 2007)

Risk Class	Conventional to RIL	Convert logged to protected forest	Extend rotation age	Conversion of low-productive forests to productive forests
High	40-60%	40-60%	40-60%	40-60%
Medium	15-40%	15-40%	15-40%	15-40%
Low	5-15%	5-15%	5-15%	5-15%

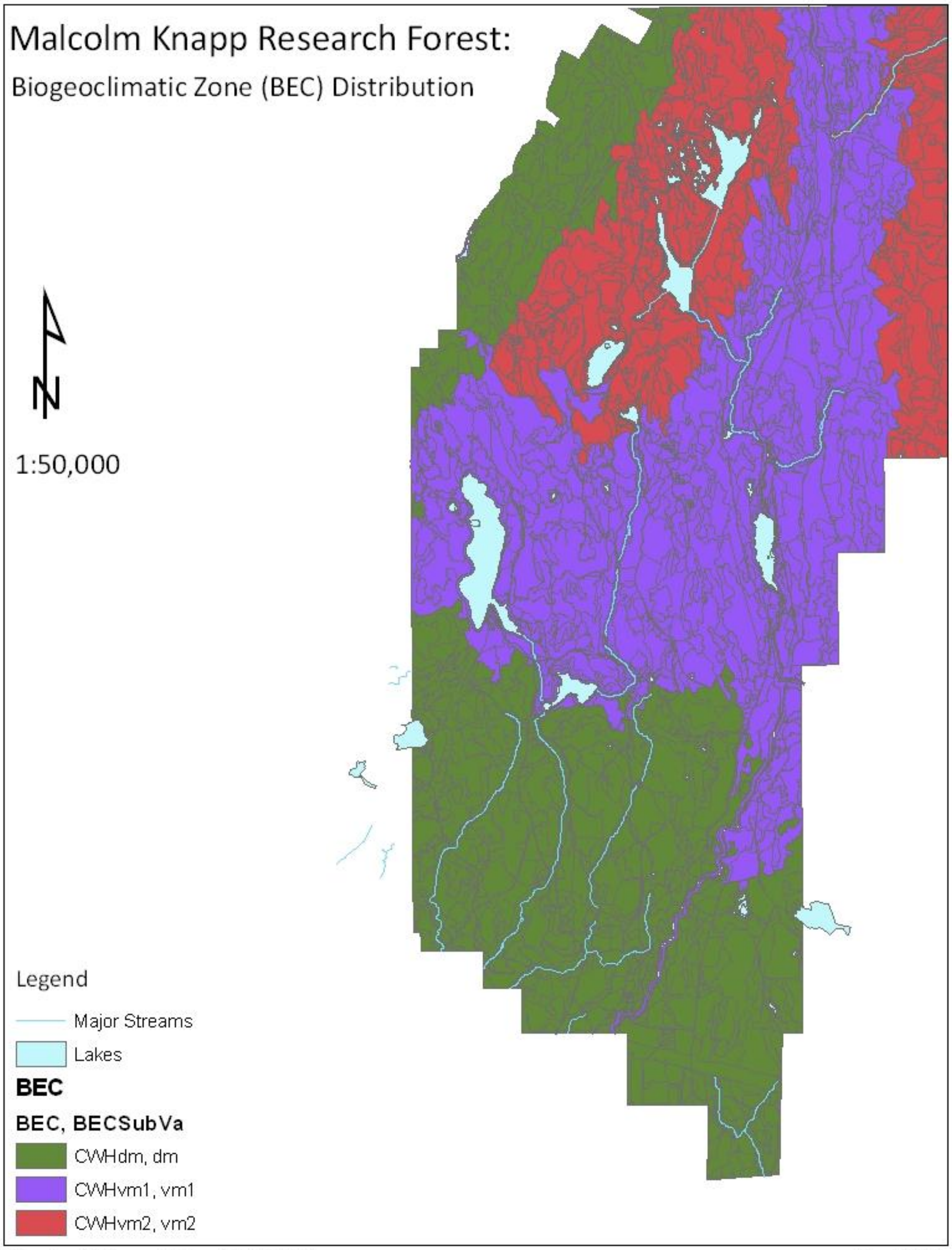
Table 12 shows the final percentage that would be assigned to each project category. Of the two project scenarios, the No Harvesting scenario requires the largest buffer (i.e. 27.5%). This is due to the higher risk ranking that was given to the project. The higher ranking is also due to the increase of timber value over time and the risk that management may decide to try to capture some of this value by harvesting and thereby decreasing total sequestered carbon. According to this risk assessment model, extended rotation would only require a 10% reserve buffer pool (Table 12).

8.3 Insurance

The buffer pool is created to protect against the risk of non-permanence. It does not protect the owner of the project against financial failure due to a sudden loss of carbon due to a large natural disturbance (e.g. through fire or insect infestation). If a project owner wishes to guard against the risk of a catastrophic loss of carbon, some form of external insurance would be required outside of the relevant carbon standard. The owner may wish to connect with a private insurance company to purchase insurance and safeguard against failure of the project—this may be similar to crop insurance that is held by farmers. However, due to the emerging nature of the carbon market, it is difficult to estimate the cost of such an insurance policy. If any project is created in the future, protective insurance is important due to the large amount of forest inventory that is involved in a carbon plan, as well as the long length of carbon contracts.

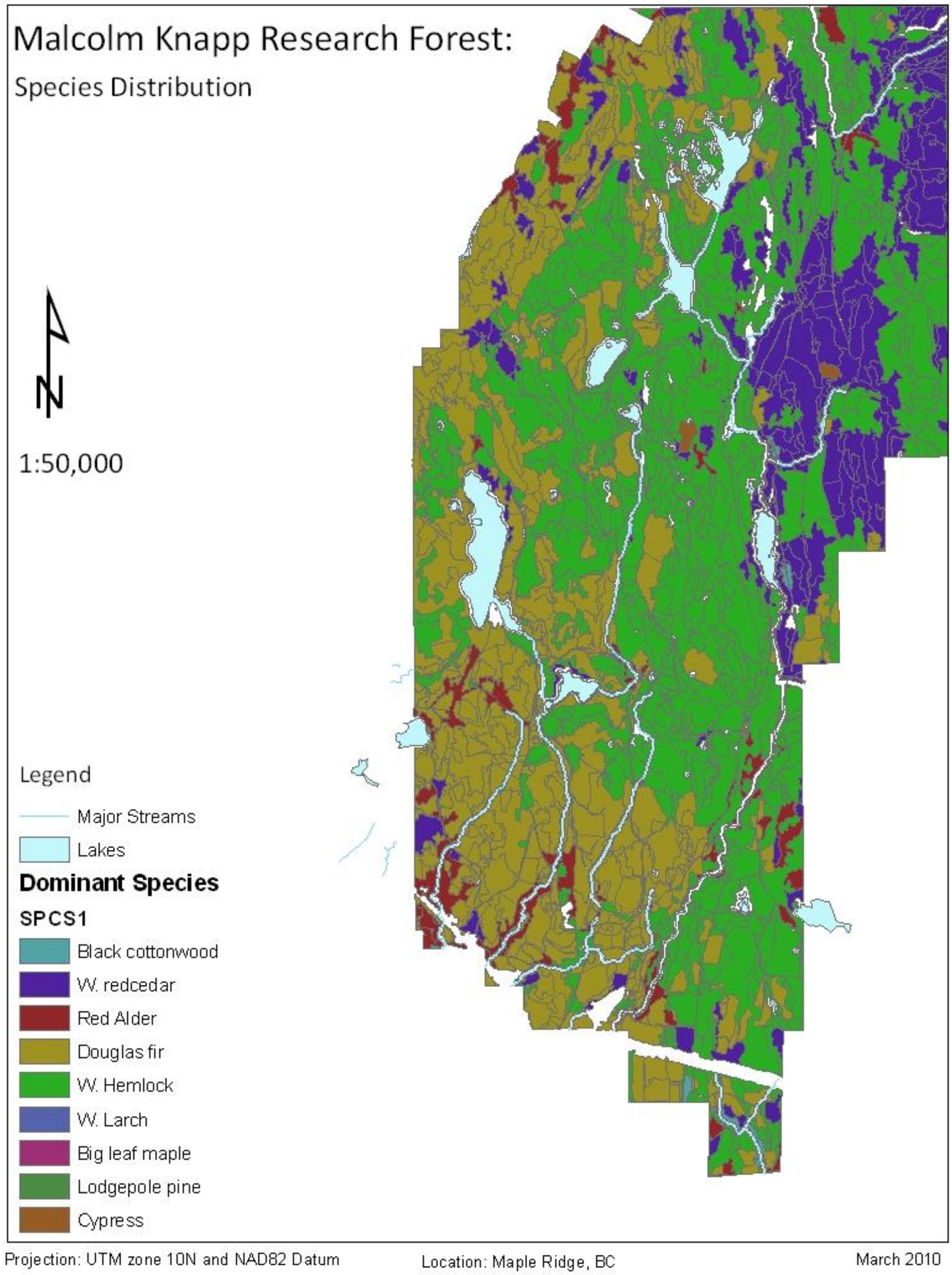
9.0 Appendices

9.1 Appendix 1: Biogeoclimatic Distribution of MKRF

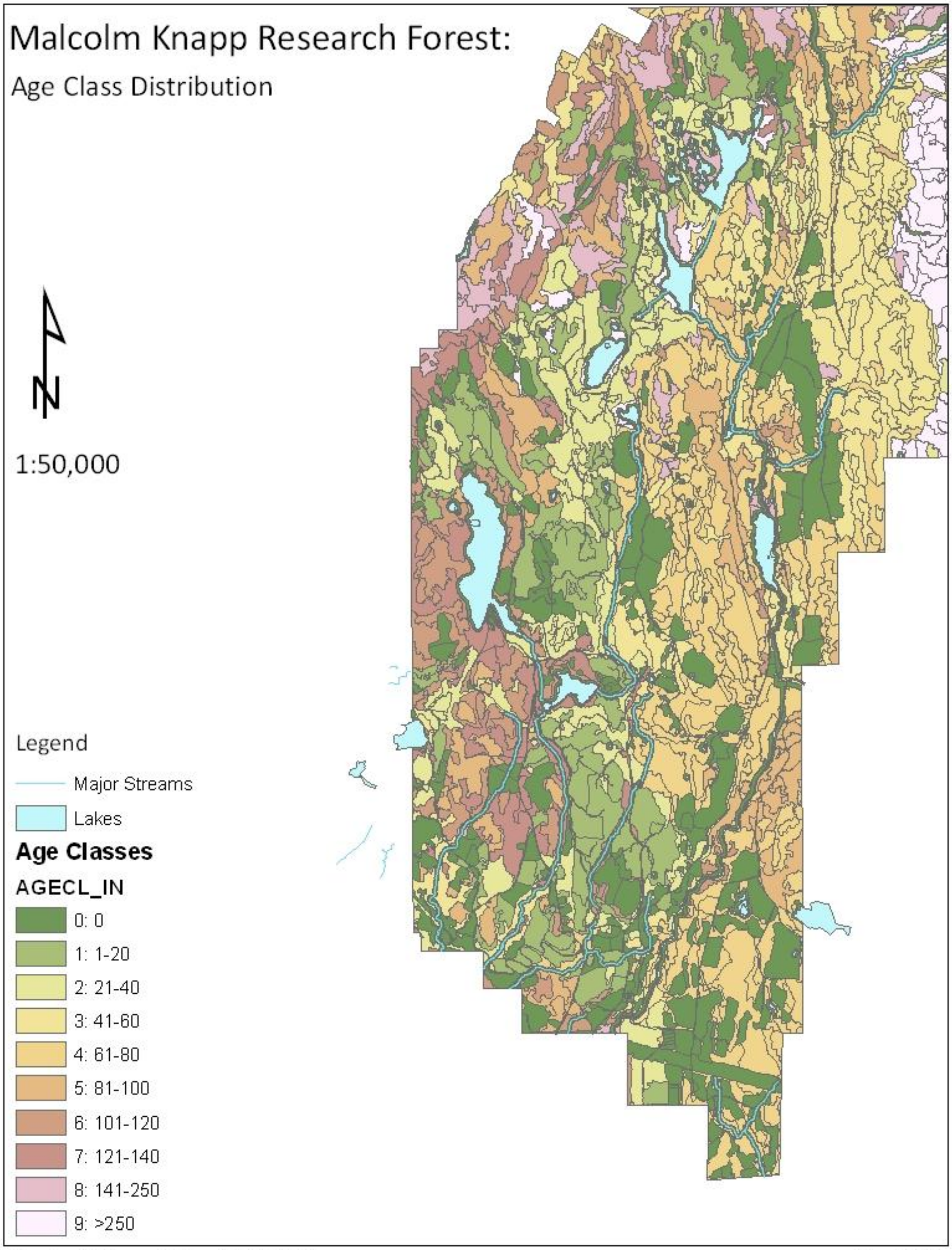


Projection: UTM zone 10N and NAD82 Datum   Location: Maple Ridge, BC   March 2010

9.2 Appendix 2: Tree Species Distribution in MKRF, 2010



9.3 Appendix 3: Age Class Distribution in MKRF, 2010



Projection: UTM zone 10N and NAD82 Datum Location: Maple Ridge, BC March 2010

9.4 Appendix 4: Carbon Markets and Standards

9.4.1 Kyoto Protocol and the Significance of Carbon

Carbon emissions and reduction play significant roles in the mitigation of climate change. Forests have a great potential for sequestering carbon, and forest management practices can therefore affect the global carbon balance. In order to account for these changes, many actions have been taken by international organizations and nations to increase carbon sequestration and reduce GHG emissions. The Kyoto Protocol is an environmental treaty between nations, produced to reduce and stabilize worldwide GHG emissions (United Nations, 1998). Canada and other nations adopted this protocol in 2005. Kyoto requires participating nations to reduce their emissions by at least 5% below 1990 levels (Greig & Bull, 2009). Although Canada failed to reduce its emission goals under the Kyoto Protocol for 2012, Canada announced the introduction of mandatory regulations to reduce emissions by 20% by 2020, and by 60-70% by 2050 (Greig & Bull, 2009)(Environment Canada, 2008). These carbon reductions can be credited as carbon offsets, which can be traded in carbon markets.

9.4.2 Types of Carbon Markets

There are two kinds of international carbon markets—regulatory/mandatory markets and voluntary markets. Regulatory markets follow mechanisms established under Kyoto to reduce emissions; these mechanisms include the Clean Development Mechanism (CDM), Joint Implementation (JI), and Emissions Trading (ET). Emissions Trading allows for carbon offsets to be sold in international markets. Voluntary markets have been created by nations that have not adopted the Kyoto Protocol (e.g. the United States and Australia), and have prescribed similar guidelines to those established by regulatory market. Other nations, such as China, have opted to develop their own carbon forest standards (Greig & Bull, 2009).

Although voluntary markets are currently smaller than regulatory markets, they show a stronger preference for forestry projects (Greig & Bull, 2009). However, both regulatory and voluntary markets require participatory nations or companies to adopt and follow certain standards in order to generate revenue through the sale of their offsets. Participation in both regulatory and voluntary markets has been considered for the MKRF carbon management plan.

9.4.3 Regulatory Markets: Western Climate Initiative and Pacific Carbon Trust

The Western Climate Initiative (WCI) is an independent carbon trading initiative that was developed by several states and provinces in North America to address climate changes issues. BC joined the WCI in 2007, and developed the Pacific Carbon Trust (PCT) to assist the public sector in meeting its carbon neutrality goals. As a forestry-related mitigation initiative and Crown corporation of the Government of BC, the PCT delivers high-quality BC-based carbon offsets through a variety of methods, and will likely include forestry projects that increase terrestrial carbon sequestration through carbon capture and storage (Pacific Carbon Trust, 2010). PCT ensures that offsets sold to clients comply with the *BC Emission Offsets Regulation* (EOR) and meet internationally recognized standards for carbon credit production.

PCT is currently seeking to supply 1,000,000 annual tonnes of offsets to meet the demands of BC companies. Although PCT is seeking to solicit forestry offsets, the Ministry of Forests and Range is still in the process of reviewing the *BC Forest Offset Protocol*; once finalized, the protocol would enable Forestry

Emission Offset Projects to be pre-qualified for supplying GHG offsets to PCT for sale. PCT also recognizes other international quantification protocols and standards that are adapted for BC as long as they comply with EOR. For PCT to supply offsets, projects need to certify that a high quality of standards is met. These standards may have different applications, depending on the location and the bodies that govern the carbon markets (Greig & Bull, 2009).

This presents MKRF with the opportunity to produce forest-based offsets through the initiation of government-approved forestry projects. MKRF may initiate projects that meet the standards established by several organizations in order to enter desirable markets. A portion or the entirety of relevant offsets may be sold to PCT; this does not, however, preclude MKRF from selling offsets to other offset buyers. In order to be eligible, projects registered with the PCT must begin commercial operations after November 29, 2007 (Pacific Carbon Trust, 2010)—2007 is the baseline that is set for projects accepted under PCT. Projects that have been initiated prior to this date are not eligible.

On March 24, 2010, UBC announced its GHG reduction targets to address climate change (University of British Columbia, 2010), and by 2015 aims to reduce its GHG emissions by 33 percent below its 2007 levels. It sets further targets to reduce GHGs by 67 percent below 2007 levels by 2020 and 100 percent by 2050. Although MKRF is operated as a private enterprise, its affiliation with UBC has led to discussions of the possibility of collaboration between the two organizations to offset UBC's emissions through MKRF. No plans are currently in place to formally establish such a relationship; however, UBC anticipates that MKRF offsets will either be sold directly to PCT or listed as "removals" from the University's GHG inventory (Henderson, 2010).

Standards Applicable to Pacific Carbon Trust

CAN/CSA ISO 14064

ISO 14064 is an international standard system that emerged from earlier standards created by three organizations: the World Wildlife Fund (WWF), the Climate, Community and Biodiversity Alliance (CCBA), and the World Resources Institute and World Business Council on Sustainable Development (WRI). ISO 14064 is expected to be used in regulatory GHG emission verification, accreditation and trading systems, and promotes international consensus with regard to climate change (International Organization for Standardization, 2007). ISO 14064 focuses on GHG projects or project-based activities that are designed to reduce GHG emissions or increase GHG removals (Spence, 2009). This standard includes principles for determining project baseline scenarios and for monitoring, qualifying and reporting the performance relative to the baseline scenario (Spence, 2009). In addition, it specifies variable requirements of validation/verification bodies and validators/verifiers in providing assurance against GHG claims from organization (Spence, 2009).

Climate Action Reserve Forest Project Verification Protocol 3.0 (CAR)

Under the California Climate Action Registry, the California Action Reserve Forest Project Verification Protocol Version 3.0 (CAR) has been produced to provide standards for project activities that remove and reduce CO_2 emissions through the increase and/or conservation of forest carbon stocks (Climate Action Reserve, 2009). However, all reports to the California Climate Action Registry are currently being transitioned to the Climate Registry—a non-profit North American collaboration of states, provinces, and territories that verify and report GHGs into a single registry (Climate Registry, 2010). As of March, 2010, each of the states and provinces of the Western Climate Initiative have joined the Climate Registry (Carbon Offset Research & Education, 2010). It is expected that CAR, once finalized, will be adopted by the Climate Registry and therefore be applicable to all WCI states and provinces—including BC—that choose to follow this or similar standards. As a partner of WCI, PCT is therefore likely to supply its clients with offsets that have been created through standards that are recognized by the Climate Registry.

CAR is a national offsets program that develops, quantifies and verifies emissions, and issues carbon offset credits generated from projects that meet its standards. Forest projects that increase and/or conserve forest carbon stocks and are verified by CAR include the following: reforestation projects, avoided conversion projects, and improved forest management projects (Climate Action Reserve, 2009). MKRF may initiate a forest improvement project to be eligible under CAR's established standards; however, CAR does not accept projects which include broadcast fertilization and furthermore requires third party certification under either FSC or SFI (see Appendix **). All projects under CAR, including the project baseline, require third-party verification to assess reported data and information.

9.4.4 Voluntary Markets: Voluntary Carbon Market and Prospective Markets

The Voluntary Carbon Market (VCM) is an international carbon trading market that is used to offset carbon emissions. This market has been growing considerably over the last few years and is expected to become a significant market for carbon offsets trading in the future. This market is accessible to those companies, individuals, and activities that are not subject to mandatory regulations and compliance markets and that are voluntarily seeking to purchase carbon offsets to reduce their GHG emissions (World Wildlife Fund, 2008).

Standards Applicable to Voluntary Markets

CAN/CSA ISO 14064

As previously mentioned, ISO standards are regulated internationally and are expected to be used in providing standards for voluntary and regulatory GHG emission verification, accreditation and trading systems (International Organization for Standardization, 2007). ISO standards are therefore applicable to voluntary markets—MKRF's management strategies align with these standards.

Voluntary Carbon Standard Guidance for Agriculture, Forestry and Other Land Use Projects

The Voluntary Carbon Standard Guidance for Agriculture, Forestry and Other Land Use Projects (VCS) accepts the following project activities to increase carbon stocks: afforestation, reforestation and revegetation, agricultural land management, improved forest management, and reduced emissions from deforestation (Voluntary Carbon Standard, 2007). The standard for improved forest management activities is applicable to MKRF, and may be met through the implementation of the following management strategies: conversion from conventional logging to reduced impact logging, conversion of logged forest to protected forests, extension of rotation age of evenly aged managed forests, and conversion of low-productive forests to productive forests (Voluntary Carbon Standard, 2007). Third-party certification is not presently required in project development to meet this standard. Given the possibility for MKRF to sell its offsets through the VCM, this standard may be used in developing forest projects to increase carbon stocks and produce carbon offsets for sale in the voluntary market.

Standard Applicable to Prospective Voluntary Markets

SCC-ANSI Draft Forest Carbon Standard

Carbon sequestration strategies adopted by MKRF should seek to meet a broad range of standards established by competing markets in order to increase its options in capturing revenues from the sale of offsets. Once finalized, the Draft Forest Carbon Standard prepared by the Standards Council of Canada (SCC) and American National Standards Institute (ANSI) is expected to compete with standards established by the Climate Registry. As a voluntary North American standard, the Draft Forest Carbon Standard seeks to measure, report and verify forest carbon emission reduction projects in Canada and the United States (Forest Carbon Standards Committee, 2009).

The Draft consolidates and revises currently existing and emerging forest carbon protocols to deliver a broadly applicable set of standards and forest carbon accounting rules for American states and Canadian provinces and territories. Forestry projects eligible under this standard include the following: afforestation, reforestation, avoided forest conversion, and improved forest management. Improved forest management projects must seek to protect and/or enhance forests through sustainable forest management treatments, and increase overall forest biomass (Forest Carbon Standards Committee, 2009). Forest carbon sequestration of standing biomass and carbon pools is quantified through sampling and measurement techniques, and the project must be verified according to ISO 14065 standards. The project must also be third-party certified by either CSA or SFI. Currently, the Forest Carbon Standards Committee is undecided on baseline and additionality rules; however, baselines are likely to be established on January 1 of the project enrollment year.

9.5 Appendix 5: SFI Objectives

SFI Objectives used to fulfill sustainable forestry objectives (Sustainable Forestry Initiative, 2010)

Objective	**General Descriptions**
Forest Management Planning	Ensure long-term forest productivity and yield (e.g. activities such as long term resource analysis, document annual harvest trends and periodic updates and inventory system, etc).
Forest Productivity	Ensure forest productivity and carbon storage as well as conservation of forest resources through reforestation, soil conservation, afforestation, etc. (e.g. designating all harvest areas for either natural regeneration or planting, minimizing planting of exotic tree species, etc.)
Protection and Maintenance of Water Resources	Ensure water quality in streams, lakes and other bodies are maintained (e.g. implementing best management practices, designing plans addressing wet-weather events, etc.)
Conservation of Biological Diversity	Ensure the quality and distribution of wildlife habitats are maintained through diversity at stand & landscape levels (e.g. managing native, threatened, endangered species, and locating known sites, etc)
Management of Visual Quality and Recreational Benefits	Ensure the visual impacts are maintained (e.g. managing impacts of harvesting on visual quality, implementing green-up requirements & adjacency rules, etc.)
Protection of Special Sites	Ensure land is managed ecologically, geologically and culturally (e.g. identifying special sites and managing them appropriately)
Efficient Use of Forest Resources	Ensure the use of appropriate harvesting technology (e.g. ground skidder, etc.)
Landowner Outreach	Ensure that landowners are provided with adequate information for reforestation after harvest, for best management practices, etc.
Use of Qualified Resource & Qualified Logging Professionals	Ensure that landowners are encouraged to use services of forest management and harvesting professionals (e.g. use of certified logging professionals, etc.)
Adhere to Best Management Practices	Ensure that best management practices are being used to protect water quality (e.g. defining and implementing policies to ensure activities don't compromise sustainable principles)
Promote Conservation of Biological Diversity, Hotspots, High Biodiversity Wilderness Areas	Ensure that fiber sourcing programs support principles of sustainable forestry (e.g. applying programs with direct suppliers to promote principles of sustainable forestry, etc.)

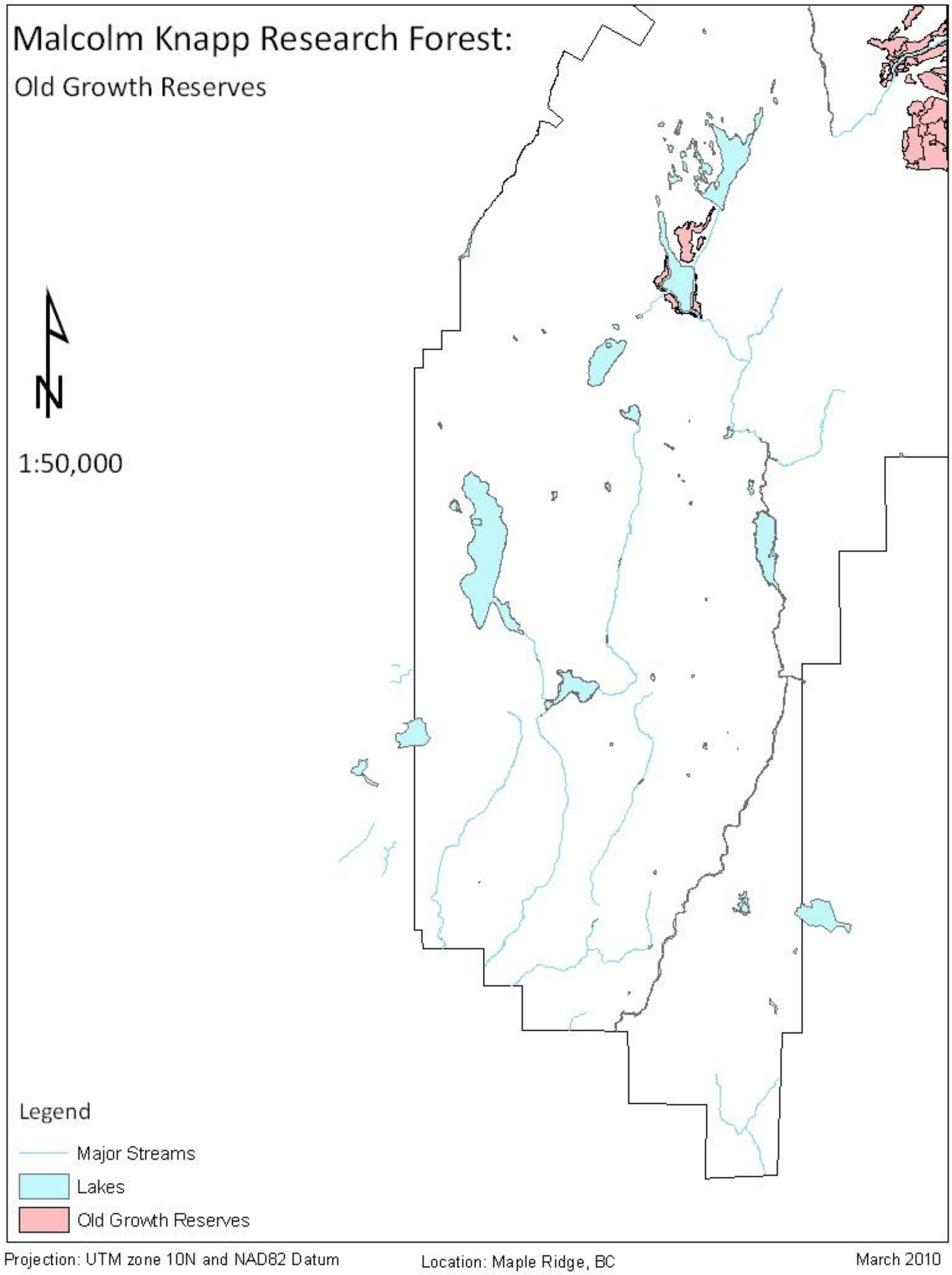
Avoid Controversial Sources	Ensure that illegal logging is prohibited (e.g. avoiding the use of controversial sources, and encouraging socially source practices, etc.)
Legal and Regulatory Compliance	Ensure there is a legal and regulatory compliance with applicable federal, provincial, state and local laws and regulations (e.g. taking steps to comply with forestry, social environmental laws and regulations, etc.)
Support Forestry Research, Science, and Technology	Ensure that individuals/cooperatively provide support/funding for forest research, health, productivity (e.g. research on genetically engineered trees adhere to applicable protocols & regulations, etc.)
Training and Education	Ensure that personnel and contractors have sufficient training (e.g. establish criteria for recognition of logger certification programs, etc.)
Community Involvement	Ensure that there is support and promotion for efforts that different groups put in to apply principles of sustainable forest management (e.g. holding periodic tours, seminars, etc.)
Public Land Management Responsibilities	Ensure the participation in developing of public land planning and management process while conferring with affected indigenous peoples
Communications and Public Reporting	Ensure to prepare a summary audit report after successful completion of a certification
Management Review and Continual Improvement	Ensure to promote continual improvement; monitor, measure, report performances through time

9.6 Appendix 6: Identified Species at Risk

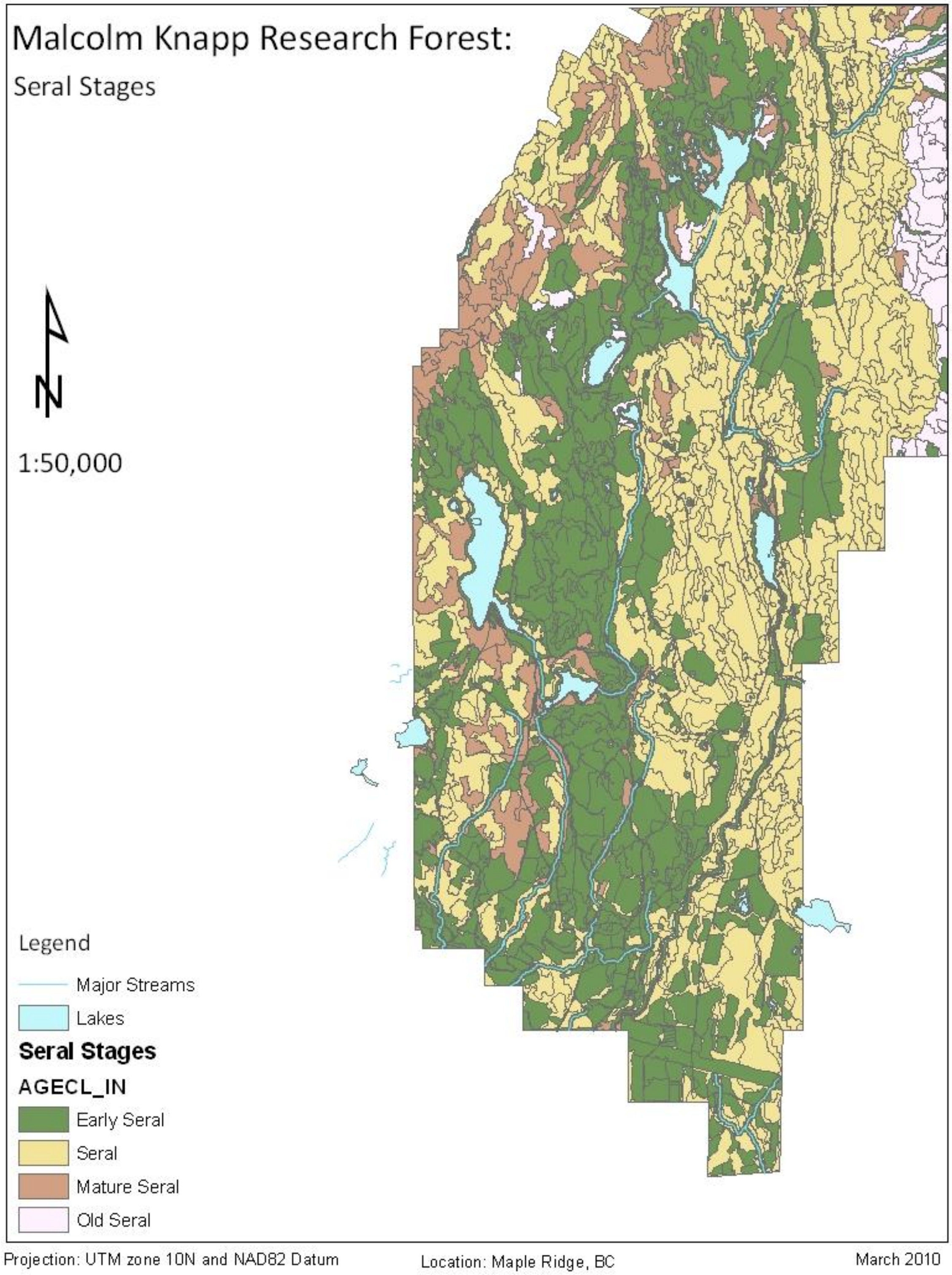
Identified BC species at risk, sourced from *Species at Risk & Local Government* (Pearson & Healey, 2010) unless otherwise indicated.

Common Name	Scientific Name	Listed Status	Habitat Requirements	ID'd
Pacific Water Shrew	*Sorex bendirii*	Red	• Most individuals are found within 25 m of streams in mature coniferous or mixed forests • Riparian areas	Yes
Northern Goshawk	*Martes pennanti*	Red	• Mature and old forests, closed canopies (≥50%), and relatively large diameter trees • Goshawks select nest trees with structural attributes that will support their relatively large stick nests (ca. 1-m diameter) and these often include trees with deformities and sometimes snags)	Yes
Johnson's hairstreak	*Callophrys johnsoni*	Red	• Old Growth (Opler, Lotts, & Naberhaus, 2010)	n/a
Grappletail	*Octogomphus specularis*	Red	• Streams and Riparian areas along lakes; larvae require riffle,-pool section and adults perch along stream edge	n/a
Fisher	*Martes pennanti*	Blue	• Old and large diameter trees are critical habitat features for fisher in managed landscapes that can be impacted by forest harvesting operations	Yes
Tailed frog	*Ascaphus truei*	Blue	• 6: mature forest (100–140 years) • 7: old forest (>140 years)	Yes
Red-legged frog	*Rana aurora*	Blue	• Mature deciduous riparian forests with abundant woody debris. • Aquatic areas	Yes
Herons and Bitterns	*Ardea herodias*	Blue	• 5: young forest • 6: mature forest • 7: old forest • Riparian areas	Yes
Dolly Varden	*Salvelinus malma*	Blue	• Large rivers • Riparian areas	n/a
Autumn meadowhawk	*Sympetrum vicinum*	Blue	• It lives in ponds, slow flowing streams and lakes with dense stands of emergent plants. • Adults perch in riparian bushes. Females deposit eggs in moss or vegetation very close to the water, and they will not hatch until submerged.	n/a
Beaverpond baskettail	*Epitheca canis*	Blue	• Bushy riparian areas of lakes and small ponds	n/a
Coastal wood fern	Dryopteris arguta	Blue	• It is most abundant on south facing slopes in open coastal forest under Douglas fir, Garry oak or arbutus trees, but also occurs on coastal cliffs if sufficient shade is present.	Yes
Menzies' burnet	Sanguisorba menziesii	Blue	• It has been found in coastal bogs on the Olympic peninsula in moist soil. It is associated with sedges (*Carex* spp.).	Yes
Bigleaf sedge	Carex amplifolia	Blue	• Swamps and bogs	Yes

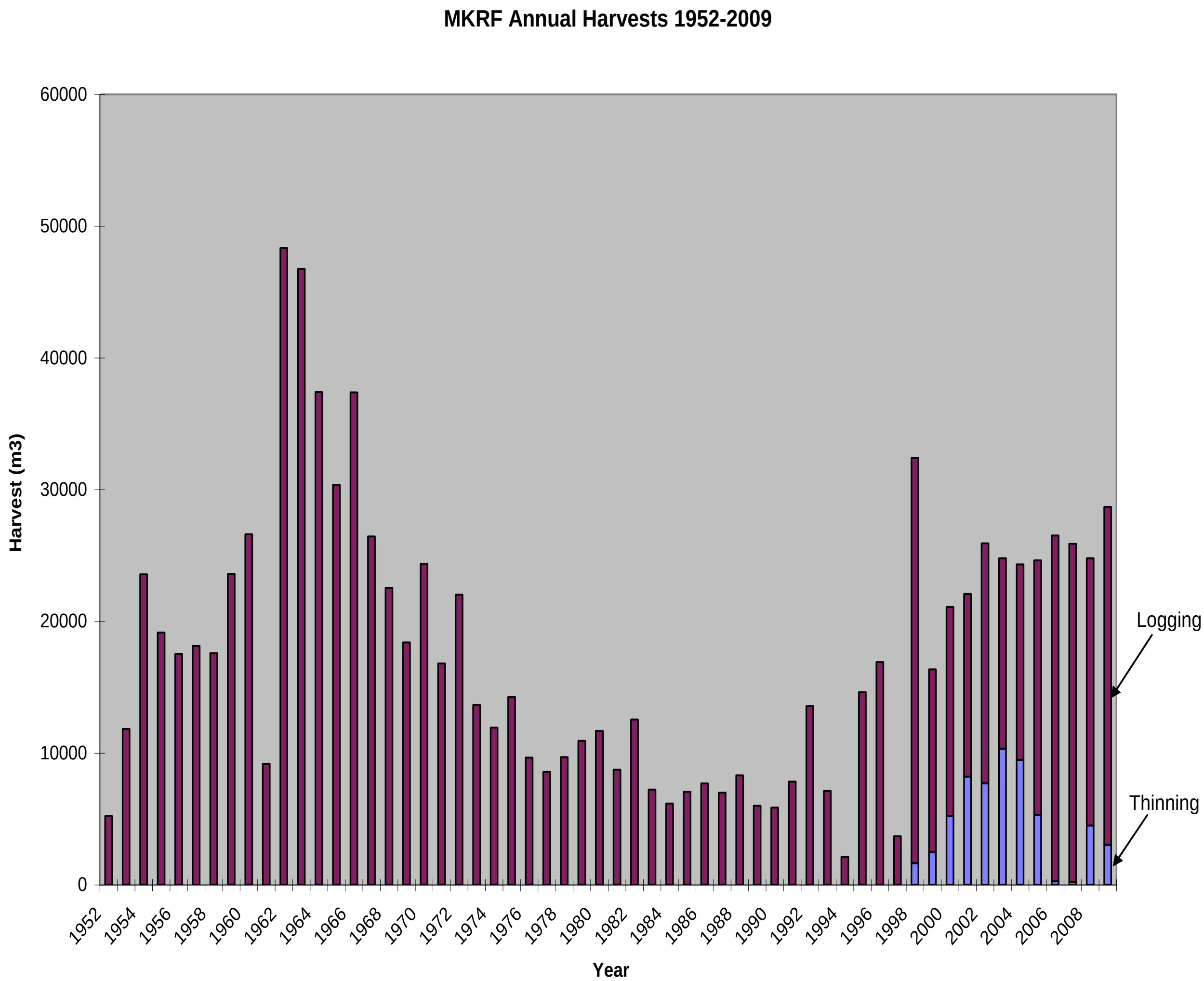
9.7 Appendix 7: Old Growth Reserves, 2010



9.8 Appendix 8: Seral Stages in MKRF, 2010



9.9 Appendix 9: Annual harvest levels for MKRF between 1952-2009 (Lawson, Financing the Research Forests, 2010)

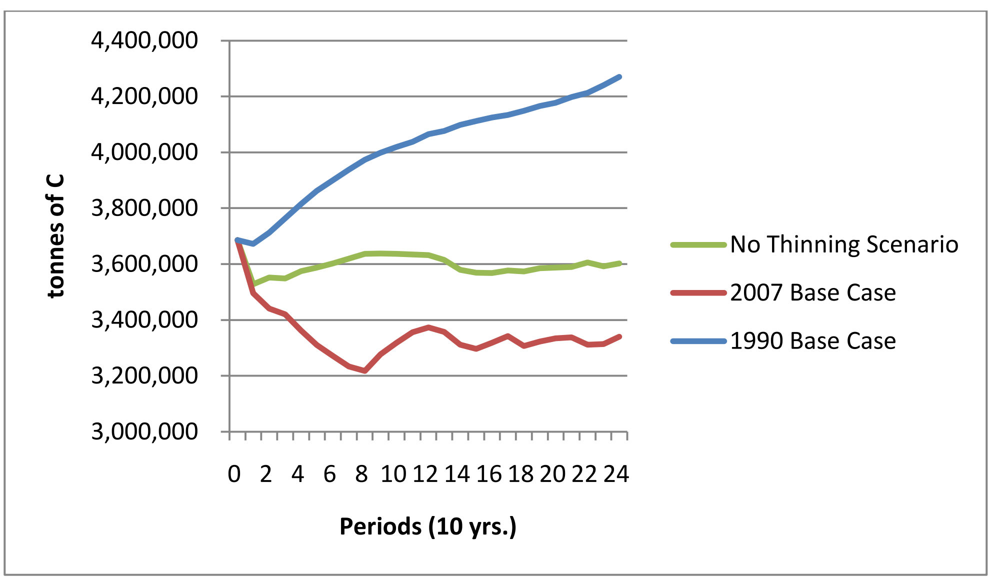


9.10 Appendix 10: Alternative scenarios

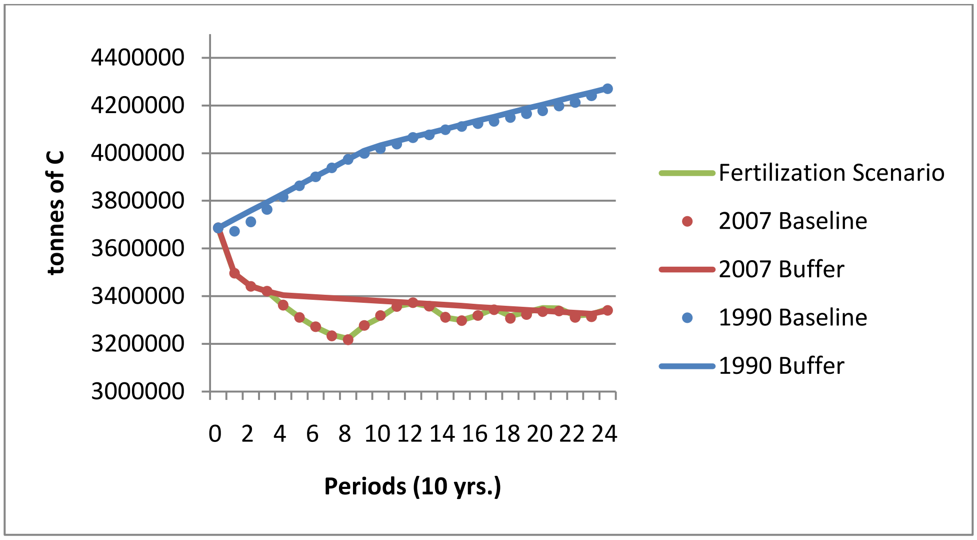
In addition to the alternative scenarios described in the report, three other alternative scenarios were explored. The alternative scenarios explored include the following: No Thinning, Fertilization, and Red Alder Plantations. These scenarios were not further analyzed due to the reasons mentioned in the table below.

Alternative scenarios considered:

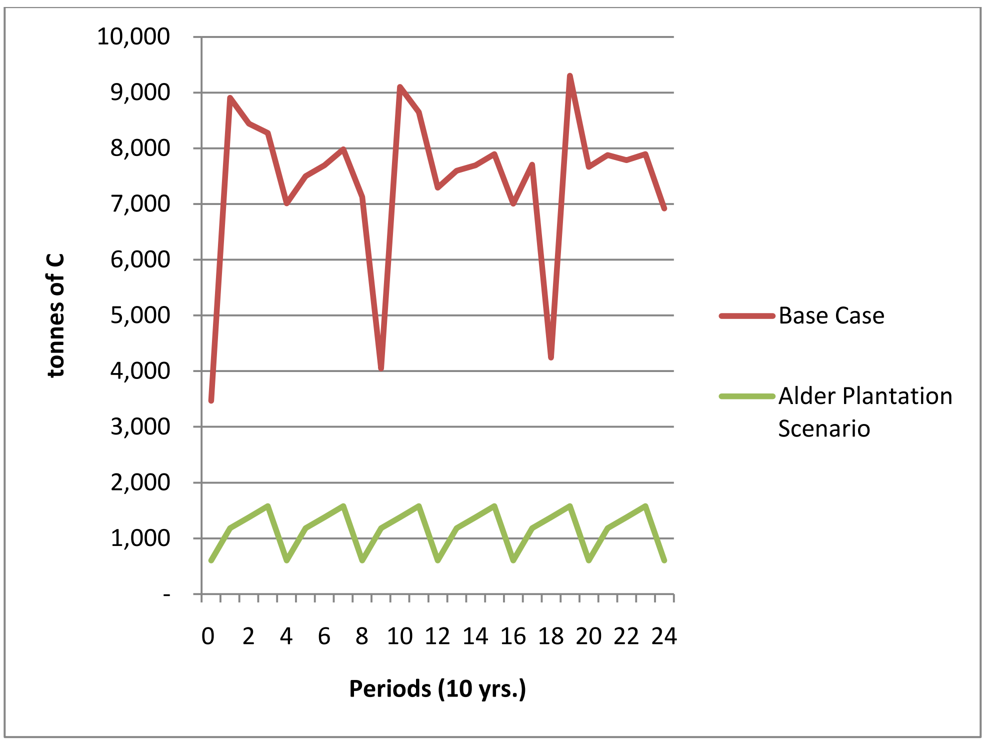
Other Alternative Scenarios	Description	Reason for lack of further consideration
No Thinning	Cease all thinning operations	• Has a significant impact in carbon sequestration capabilities but not currently endorsed by any carbon standard associations (see No Thinning scenario below)
Fertilization	Apply fertilizer to poor site index sites in the operable and low operable areas	• Due to small scale and relativity small gain in yield no significant increase in carbon sequestration capabilities was found (see Fertilization scenario below) • Expensive to implement • Cost benefit unclear
Red Alder Plantations	Convert select super site index areas to alder plantations	• Red Alder was found to have a similar carbon sequestration capabilities as Douglas Fir/Cedar stand (see Red Alder Plantation scenario below) • No financial gain and possible decrease in timber revenue



No Thinning scenario

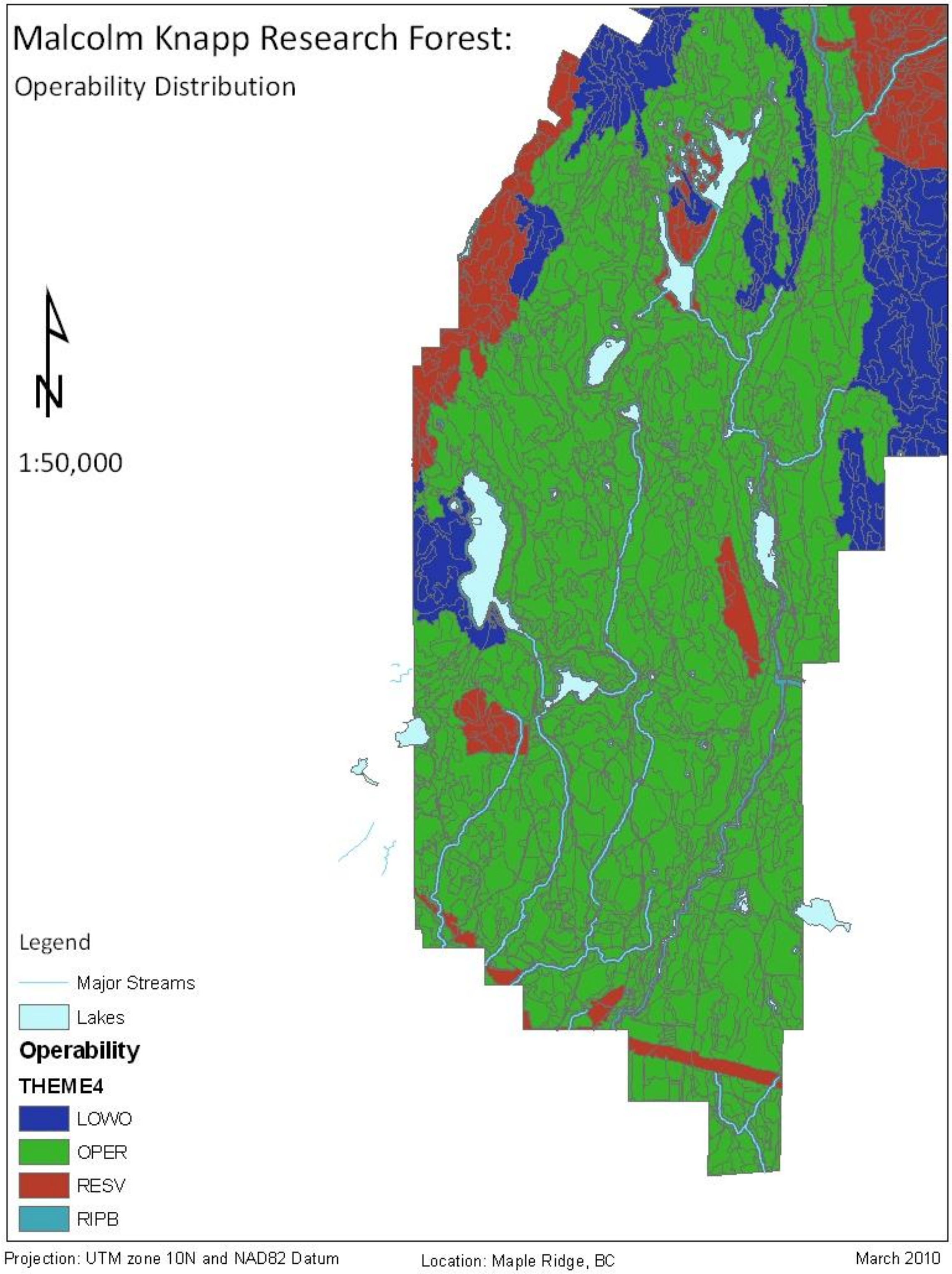


Fertilization scenario



Red Alder Plantation scenario

9.11 Appendix 11: Operability Cliques in MKRF (low operable areas, operable areas, reserves)



Site index classes and area distribution per operability zone (Moreira-Munoz, 2008)

Operability zone	Site Class	SI class value	SI class range	Area (ha)
Operable	P	18	≤ 20	537.95
	M	24	[21 – 26]	1,230.73
	G	30	[27 – 32]	1,188.32
	S	36	≥ 33	613.23
Low Operability	P	18	≤ 20	312.19
	M	24	[21 – 26]	234.30
	G	30	[27 – 32]	80.12
Reserve	P	18	≤ 20	201.72
	M	24	[21 – 26]	131.92
	G	30	[27 – 32]	69.51
	S	36	≥ 33	23.16
Total				4,623.15

Area per operability zone (Moreira-Munoz, 2008)

Operability zone	ID	Area (ha)
Operable	OPER	3,570.23
Low Operability	LOWO	626.61
Operable + Low Oper		4,196.84
Reserve	RESV	426.31
Total		4,623.15

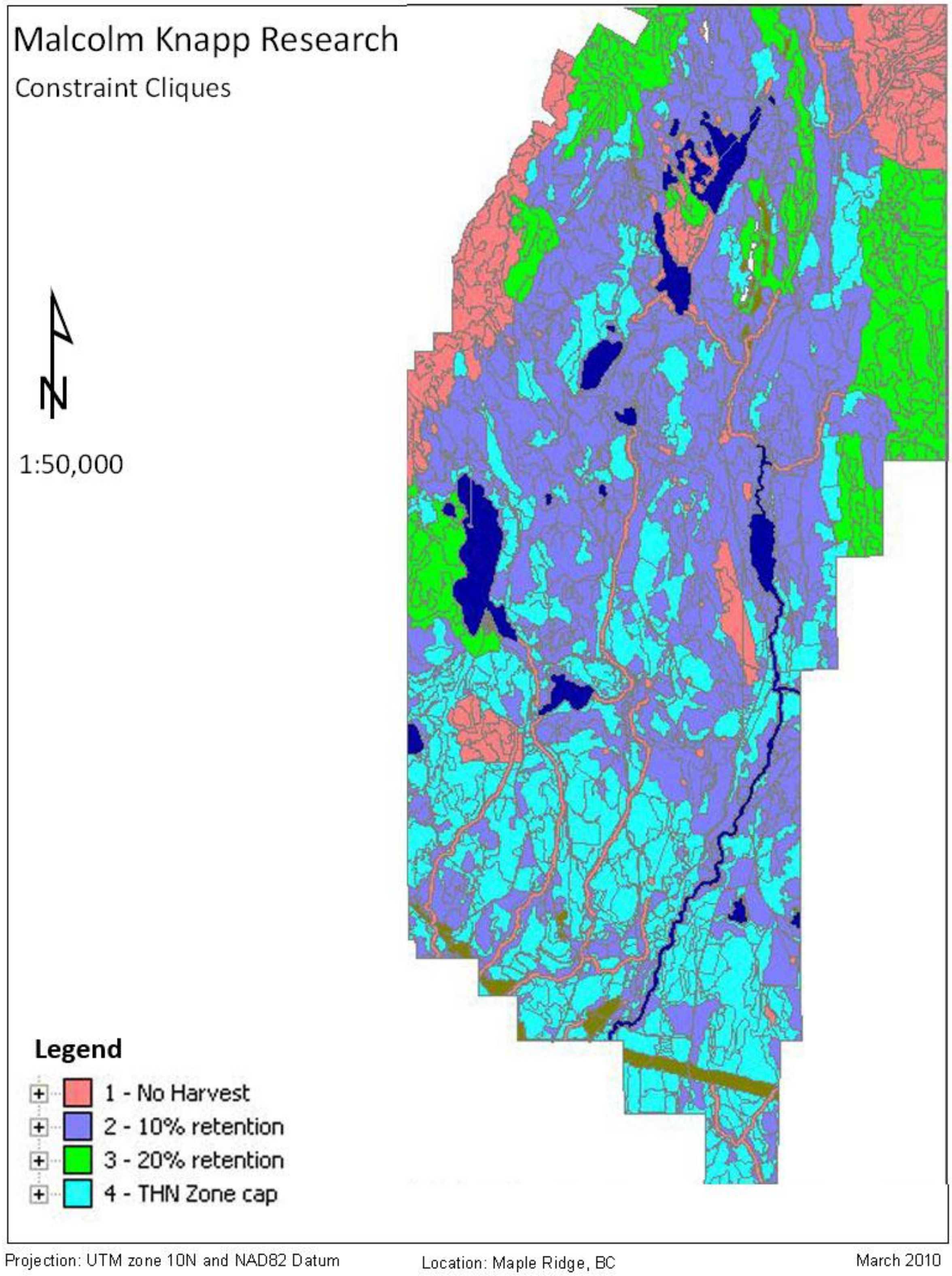
Area by stand condition (based on first harvests in 1950) (Moreira-Munoz, 2008)

Stand condition	ID	Area (ha)
Natural (Age > 59)	NAT	3,163.70
Managed (Age ≤ 59)	MAN	1,459.45
Total		4,623.15

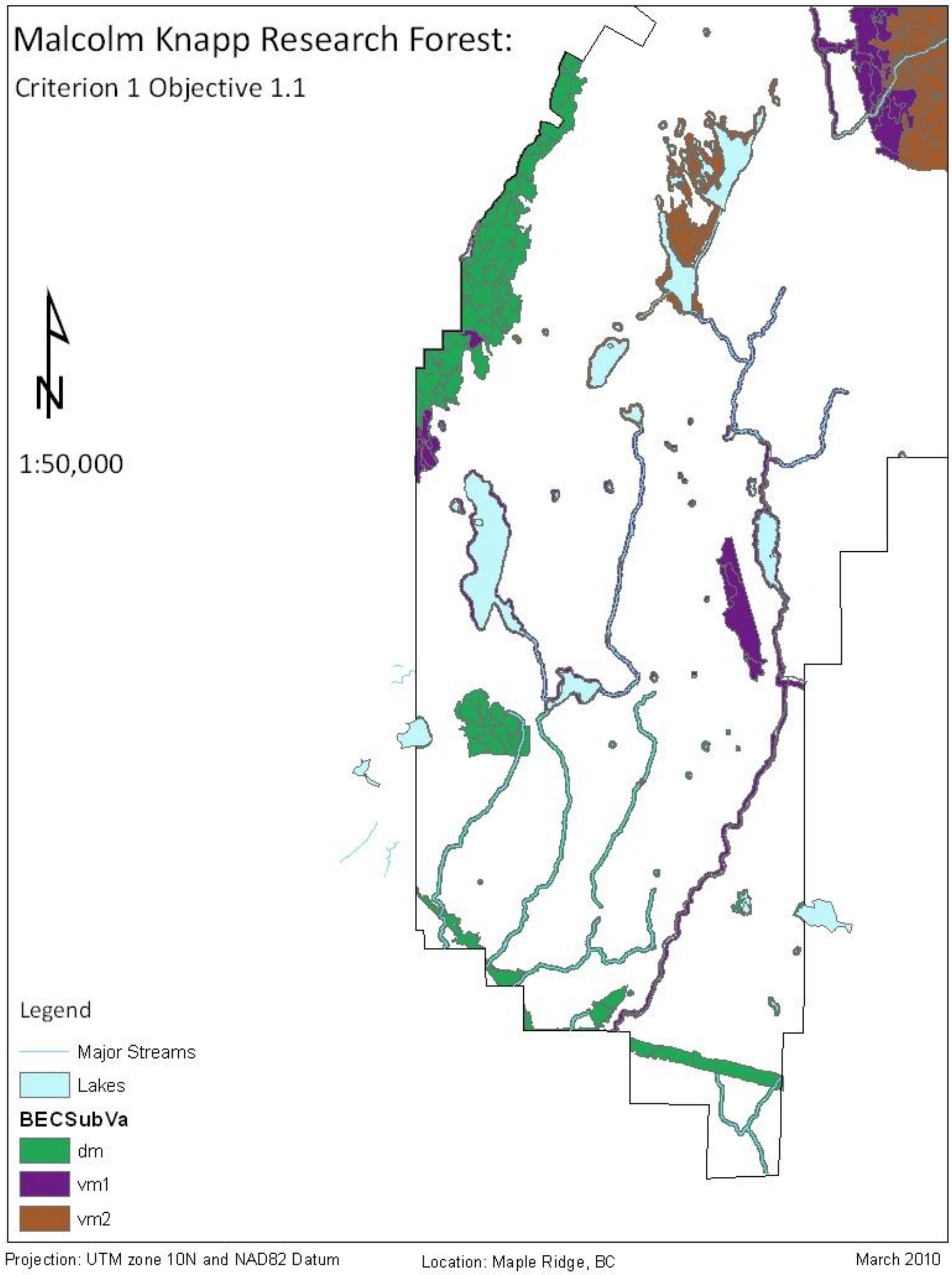
Area distribution by operability zone and stand condition (Moreira-Munoz, 2008).

Clique	ID	Area (ha)
OPER	NAT	2,157.69
	MAN	1,412.54
LOWO	NAT	604.80
	MAN	21.81
RESV	NAT	401.21
	MAN	25.10
Total		4,623.15

9.12 Appendix 12: Thinning constraints and zones for scenarios



9.13 Appendix 13: Representation of all three BEC subzones in reserves



9.14 Appendix 14: Sub-ordinal ranking of indicators

Sub-ordinal ranking of "Biological Diversity"

Criteria: Biological Diversity	Indicator	Scenario			
		2007 Base case	**No Harvest**	**Extended Rotation**	**Select Seed**
	Representation of all seral stages in the forest	4	1	2	4
	Area of old growth*	2	8	6	2
	Genetic diversity of reforested stock	2	4	3	1
	Total Score	**8**	**13**	**12**	**7**

*: This indicator is weighted double as the majority of blue and red-listed species have old growth habitat requirements (See Appendix 6)

Sub-ordinal ranking of "Carbon Storage"

Criteria: Carbon	Indicator	Scenario			
		2007 Base Case	**No Harvest**	**Extended Rotation**	**Select Seed**
	Emissions from MKRF and related operations	1	4	3	1
	Total carbon sequestered in ecosystem*	2	8	6	4
	Total Score	**3**	**12**	**9**	**5**

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