Culturally Important Plants, Climate Change and Monitoring in the Morice LRMP

Prepared by
Fenger, M. and A. Inselberg
(Mike Fenger and Associates Ltd.)
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Prepared For
Ministry of Agriculture and Lands
Integrated Land Management Bureau
Leigh-Ann Fenwick
Smithers

Executive Summary

This report is prepared for the Biodiversity Technical Working Group of the Morice LRMP. This report deals with a) culturally important plants, and b) tracking climate and plant response. More specifically the report addresses two problems. The first is how to monitor and assess whether the LRMP objectives are being met with regard cultural plants and the second problem is monitoring to detect changes in global climate and the influence on ecosystems and plants in the LRMP area.

The first section of this report is a review of climate change and what may be occurring in the Morice LRMP in the next few decades. There are quantitative data to support a scenario of continued rising mean annual temperature and evidence to support a scenario of longer wetter growing season in this area. We propose more time be spent on review and analysis of currently available climate data from stations in the LRMP. We propose (in section 5) establishing a baseline of vegetation plots and initiating a long-term monitoring project to monitor change in vegetation through time, in order to guide management of values in the LRMP in the context of climate change. Local quantitative data is considered a good foundation for adapting practices and plans when there are uncertainties in the magnitude and speed of climate change.

The second section of the report reviews current provincial monitoring initiatives that supply vegetation or climate information directly to the LRMP. There are three climate monitoring programs collecting data in the LRMP 1) Environment Canada stations, 2) Fire Weather Stations and 3) Snow Pack monitoring sites). Their locations are shown and years of data for these stations are summarized. There are two potential sources of vegetation monitoring information in the LRMP area both maintained by the Ministry of Forests and Range these are; 1) Permanent Sample Plots (102 plots) on which forest growth and yield estimates are based and 2) vegetation research plots (estimated at 400 plots) that were used for classification of sites in the Biogeoclimatic Ecosystem Classification (BEC) system. There are two sources of vegetation inventory that support plan monitoring these are Vegetation Resources Inventory and Ecosystem Mapping (TEM/PEM).

We also review 2 provincial monitoring initiatives that use and analyze data in the LRMP. The Timber Supply Review (TSR) monitors change in vegetation and periodically forecasts timber, and the Forest and Range Evaluation Program is beginning to monitor and evaluate the results of forest practices. LRMP monitoring could benefit with coordination of effort with TSR data assembly. Timber supply determinations (rate of cut) are a stress to resource objectives and so timing of reporting on monitoring results can inform sustainability and lead to changes in plans which inform timber supply decisions. We propose the LRMP monitoring and reporting be linked to TSR cycle to facilitate adaptive management.

Two local monitoring initiatives the Babine Trust and the Sustainable Forest Management Plan (SFMP) were reviewed for their potential to support LRMP monitoring efforts and approaches. The monitoring framework we propose has been more widely applied than the Babine Trust framework, but both use elements of risk assessment. The SFMP coordinates a number of initiatives on behalf of licensees and coordination in areas such inventory improvements are of mutual benefit.

The third section in the report proposes a monitoring framework based on a process described in a technical report (MoE 2000), and applied extensively throughout the province (Utzig and Holt 2002; Holt 2004). This approach uses six steps, which are explained in general, and then specifically applied to the objectives in the LRMP for culturally important botanical plants. The process includes a review of factors which put stress on a resource value and that may contribute to a failure to maintain the value. Risk is measured using a comparison between a natural

baseline and current condition. Forecasting can be done to assess the trend and expected future condition and whether risk is increasing or decreasing. Once risk and trend are clarified, risk reduction strategies become clearer and the adaptation of plans, inventories, assumptions and practices most likely to reduce risk can be planned and implemented.

The framework is applied to important cultural plants already identified in the LRMP and a number of specific recommendations for implementation are made. We classified the list of culturally important plants (Table 11 in the LRMP) to determine how many were strongly linked to early and late successional stages and which ones were linked to sites in general moisture classes. A few species are strongly linked to old growth (Epiphytic lichens) and a few were strongly linked to early seral stages (fireweed and clover) but most occur in all seral stages when present on a site. We also classified plants to soil moisture preferences to help the monitoring framework for climate change (section 5) of the report. We conclude that to establish a natural baseline from which to measure change it will be necessary to rely on VRI and assumptions of abundance differences in plants in early, mid, mature and old seral stages.

Improvements to the culturally important plants natural baseline can be made using LRMP Table 11 and sites series mapping (PEM/TEM) but only once this inventory is quality assured and includes non-forested ecosystems. Additional sites series plant abundance would need to be added to Table 11 as it does not include mesic sites and some other extensive site series in the LRMP. We recommend that more cultural plant information be collected from First Nations especially for the northern portion of the LRMP.

The final section of the report provides a framework for monitoring vegetation response to climate change. Long-term funding for periodic future data collection five, 10, 15, 20 etc. years into the future will be required in order to periodically sample, analyze vegetation and climate, interpret and report findings. We recommend vegetation baseline plots be established as soon as practical and that existing plots be given preference as these afford an opportunity to back cast in time and assess whether a trend is already quantifiable. It is recommended that vegetation sampling capture the diversity of ecosystems and include the following strata: 1) non forested ecosystems, 2) rare and endangered ecosystems, 3) forested ecosystems with sampling to include a) xeric, b) mesic and c) hygric sites and replicates in a) early and b) late seral forest for each of major BEC variants in the LRMP area. Sites in close proximity to existing Fire Weather Index stations and other Environment Canada maintained climate stations should be given priority when possible.

Climate change has complicated management of forests and sustainability of multiple values. The globe is seeing species extinction rates at levels not seen since the age of the dinosaurs, and that practically we will need to coordinate development and conservation around a strategy focused on getting as many species as possible through the bottleneck (Peart et al. 2007), in order to retain maximal levels of biological diversity. It is predicted that massive human induced loss of biological diversity over the next century (Wilson, 1993). Given the relatively natural state of the Morice LRMP area, there is increased opportunity rise to the conservation challenge than in many in other areas.

The major recommendations are presented below. There are minor recommendations throughout the text.

Recommendation 1 We recommend a project to review and analyze existing climate data be undertaken. The project will confirm whether there is a warmer wetter trend under way that can be documented from locally available climate records such as Environment

Canada, Ministry of Forests Fire weather and snow pillow station data. This project could create the baseline from which future climate change can also be measured.

Recommendation 2 That vegetation monitoring be initiated in the LRMP, following but not limited to the elements we have provide such as use of existing vegetation plots and the strata for sampling outlined in Section 5.

Recommendation 3 The MOFR schedule for measurement of the Permanet Sample Plots (PSPs) in the Morice be clarified to the LRMP monitoring group and that existing understory vegetation data quality be assessed for it's potential as baseline data to quantify trend through back casting. That the LRMP committee explores inclusion of vegetation data measurement be added to address vegetation trends. That the data-sharing agreements between appropriate agencies be clarified to ensure these data are available to the LRMP group.

Recommendation 4 That a review of BEC plots be undertaken to determine which plots may be suitable for remeasurement, the seral condition of plots, which plots are within conservation reserves such as Old Growth Management Areas (OGMAs), parks and non harvest zones and ease of access and sampling.

Recommendation 5 PEM/TEM sites series mapping be completed. That quality assurance projects for PEM/TEM are supported and that non forested sites series be included in mapping.

Recommendation 6 Establish whether FREP intends to monitor effectiveness in the Morice LRMP. If FN consultation is planned then integrate the need for Traditional Knowledge with FREP. The northern portion of the LRMP in particular lacks information on use of plants and practices such as burning.

Recommendation 7 Support a project to improve understanding of traditional knowledge (TK) for the northern portion of the LRMP area.

Recommendation 8 Loss of natural ecosystems be quantified (area in hectares) for private land, land cleared for agricultural, linear development, and reservoirs and expected trend identified is possible for future land conversion. The areas converted are recommended for inclusion when assessing cultural plant baseline and current risk as they were part of the historic available land base**.**

Recommendation 9 In the longer term refine LRMP table 11 (as begun in Appendix C) so that site series can be used to define plant baselines in combination with disturbance return intervals and seral stages. In the short term set natural baseline using natural disturbance return intervals for seral stages only.

Recommendation 10. Propose a project to improve understanding of traditional knowledge (TK) linked to epiphytic lichens. Sample lichens for identification to improve baseline and seek insight in TK on use and collection areas for the entire LRMP.

Acknowledgements.

We thank the following people for help in compilation of information for this report. Allen Banner for his advice on monitoring plants and the list of BEC plots. Bob MacDonald for his advice on the state of Growth and Yield and permanent sample plots. Sybille Haeussler for advice on potential monitoring approaches in general. Lisa Levesque for her insights into projects monitoring First Nations cultural values under the Forest and Range Evaluation Program. Craig Nitschke for sharing his in-print articles. Jim Pojar for sharing his insights on climate change in northern BC. Trevor Goward for sharing his insights on lichens as good indicators for monitoring climate change. Nancy Turner for her interest in this project and connecting us with Leslie Johnson who also provided insight and experience in this area. Rachel Holt provided general input particularly on the development of a risk approach. She also reviewed and edited the document.

Thanks also to the staff of ILMB, particularly Leigh Ann Fenwick for her role as contract monitor and for guidance on behalf of the LRMP committees, to Ryan Holmes for his GIS support and to Brian Fuhr for the concept of First Nations as potential monitors linked to cultural plants.

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1. Introduction

This report is prepared for the Integrated Land Management Bureau, the Biodiversity Technical Working Group. This project builds from a report that assessed candidate old growth management areas and recommended retention to conservation targets consistent within the direction provided by the LRMP. This earlier report entitled, "Field Assessment of Old Growth Management Areas –Morice LRMP" was prepared for the Biodiversity Technical Working Group and presented to the working group on December 18th 2007 (Fenger, Holt, Inselberg, and Wheatley 2007).

The climate section in Fenger et al. 2007 concluded that larger old growth management areas were less vulnerable to the anticipated changes in climate in comparison to smaller candidate areas. Since size and interior habitat were weighted more heavily when ranking candidates, it is hypothesized that the recommended candidates would have increased resiliency to climate change than other potential candidates. Smaller Candidate Old Growth Management Areas (COGMAs) adjacent to wetland/lake/floodplain riparian habitats were also typically ranked high as the presence of soil moisture was also considered to provide greater resilience to climate change. Smaller xeric (dry) and mesic (well drained sites) are hypothesized as most likely to respond rapidly to climate change. This report does not alter this earlier advice.

The objectives of this report are to provide solutions to two problems. The first problem is how to monitor and determine whether the Morice LRMP is meeting its objective of "no net loss" of culturally important botanical plants. The second problem is how to monitor for climate change as it affects culturally important plants and many other LRMP values, such conservation of biological diversity.

The report begins with a section on climate change which reviews the evidence for climate change with reference to the LRMP area. This is followed by a section on the links between plants and climate and potential local implications. This is followed by a review of provincial and local monitoring with references to sources of data (climate stations, vegetation plots, inventory etc.) and what can be taken from existing monitoring programs and applied to the two problems. We then propose a risk-based monitoring framework which follows a generic approach suitable to LRMP values. The proposed framework is then applied to the LRMP objectives using the three culturally important botanical plant indicators identified in the LRMP. Sufficient detail is provided for data analysis but no data analysis is done. The final section of the report provides the elements of a site-level monitoring program which is our proposed solution to the second problem of monitoring vegetation response to climate change. Figure 1 shows the area of the Morice LRMP.

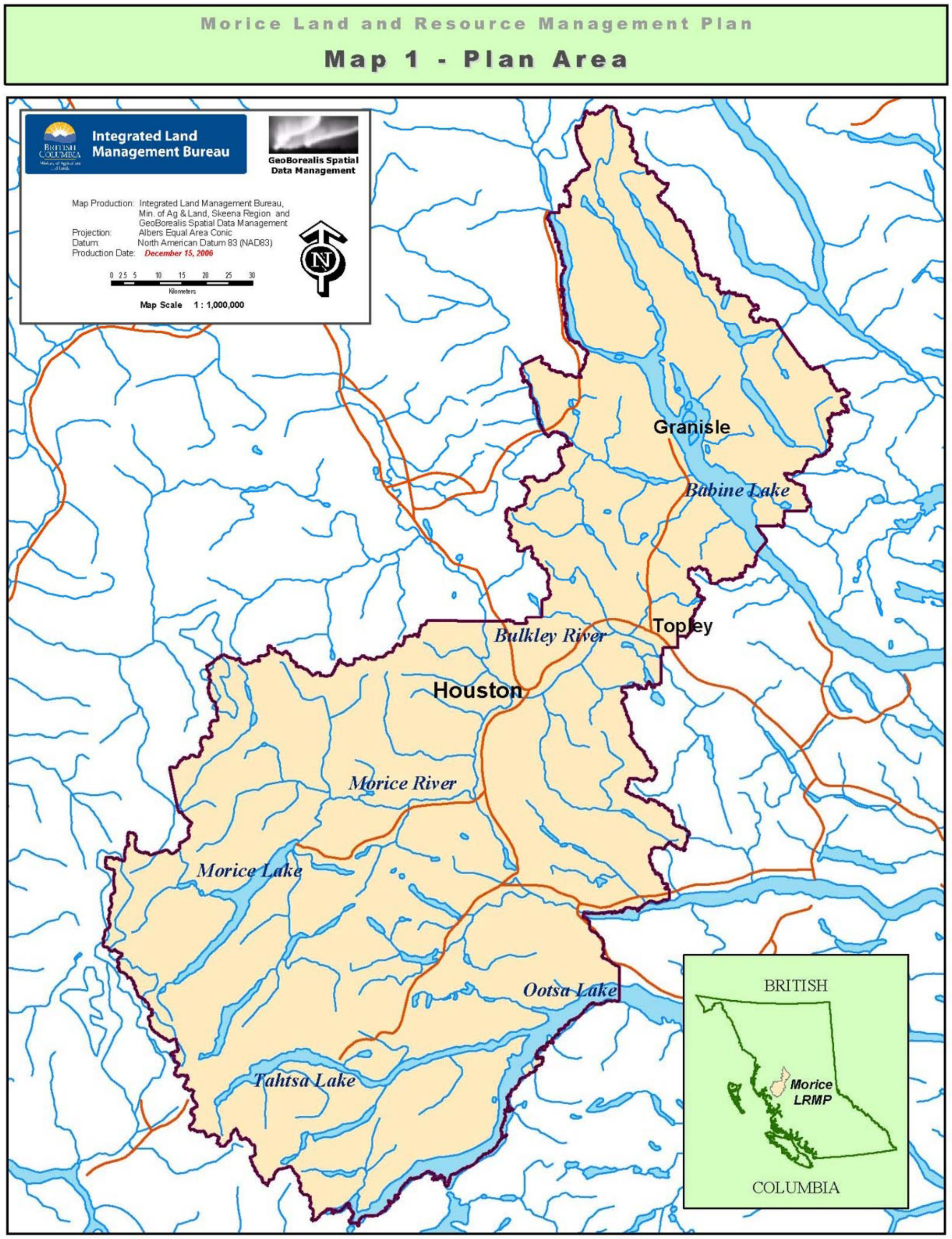

Figure 1. Map of the Morice LRMP area.

2. Climate change

2.1 Evidence of climate change and the Morice LRMP

The State of Environment Report 2002[1] indicates that we have already experienced a 1.1 degree Celsius temperature increase over the last 100 years in the central interior where the Morice LRMP area is located, with to-date largely unquantified impacts. North of the LRMP in the western portion of the Canadian boreal forest region an increase of 4.0°C has occurred between 1955 and 2005 (Vincent, et al.

[1] http://www.env.gov.bc.ca/soerpt/997climate/temperatureglance.html

2005). An article on northern grasslands indicates that grasslands are smaller and have higher shrub cover, because moister conditions have reduced summer fires and have encouraged tree and shrub growth (Haussler 2006)

In the climate modelling community there is more confidence in temperature forecasts than in moisture trends, simply because temperate is a continuous variable. In BC it is postulated that the drier SBS zones will become drier and tend towards IDF and that the wetter SBS variants will tend towards Interior Cedar Hemlock. Where the wetter warmer and drier warmer transition will occur in the interior of the province is less certain. (Del Meidinger pers. comm.). Central BC would appear to have slightly wetter winters and slightly drier summers based on the Canadian Climate Scenarios Network[2] and summarized in Table 1.

Table 1. Climate change scenarios for British Columbia for the 2020s, 2050s and 2080s from 7 models and for 8 emission scenarios.

Data summary shows changes from 1961–90 climate as a change in mean temperature or a percentage change in total precipitation. The range of the data represents the differences in the emission scenarios and in the climate models. (From Spittlehouse 2007)

Southern BC

	2020		2050		2080	
	Temp. °C	PPT %	Temp. °C	PPT %	Temp. °C	PPT %
Winter	0 to 2	-5 to +15	1.5 to 3.5	0 to +20	2 to 7	0 to 25
Summer	0.5 to 2	-30 to +5	1.5 to 4	-35 to 0	2.5 to 7.5	-50 to 0

Central BC

	2020		2050		2080	
	Temp. °C	PPT %	Temp. °C	PPT %	Temp. °C	PPT %
Winter	0 to 2	-5 to +15	1.5 to 4	0 to +30	2.5 to 6	+5 to +40
Summer	0.5 to 1.5	-10 to +5	1.8 to 3.5	-20 to 0	2.5 to 6.5	-20 to +5

Northern BC

	2020		2050		2080	
	Temp. °C	PPT %	Temp. °C	PPT %	Temp. °C	PPT %
Winter	0 to 2.5	0 to 20	1.5 to 5.5	0 to +25	2.5 to 9	0 to +45
Summer	0.5 to 1.5	-10 to +10	1.5 to 3.5	-10 to +15	2 to 6	-15 to +25

Knowing that temperatures are increasing and knowing the climate parameters of our current BEC zones, computer models have been used to forecast a range of potential future climate envelopes of our current BEC zones, with one considered most likely shown in Figure 2 (Hamann and Wang 2006). Figure 2 is included here for discussion purposes and is one possible outcome based on temperature. All climate models indicate migration of warmer temperatures towards the poles and a migration of the semi-arid zones northward from the equator.

Based on temperature forecasts alone the forests of Morice LRMP are trending towards climates similar to those that support the Interior Douglas fir zone (Hamman and Wang 2006). The forecast in Fig. 2 shows the warmer zone expanding northward in the rain shadow of the Coast Mountains. IDF-like climate exists for lower elevation forests in the LRMP over the next 10 to 15 years and by 2055 this IDF-like climate would be equivalent in area to the current SBS zone. Above this IDF-like zone the warming will provide conditions similar to today's Interior Cedar Hemlock zone in what is now the ESSF zone. By 2085 the model predicts the IDF-like climate to expand into the current ESSF which will then be entirely absent from the Morice LRMP, and that ICH temperature-like zone will occupy the area that is

[2] http://www.ccsn.ca/index-e.html

currently ESSF and a portion of Alpine tundra zone. The remaining Alpine zone will be smaller and non-existent in some areas.

There are other factors which also affect broad climate - for example, the Pacific Decadal Oscillation[3] is a term used to describe the changes in the north Pacific sea surface temperature which change slowly and influence precipitation. Between 1947 to 1976 the PDO was in a cool mode and then since 1976 it became dominantly positive (warm mode). These decadal fluctuations will make understanding data on climate trends more difficult to establish.

The amount of climate data available from within and adjacent to the LRMP area is summarized in Section 3. Based on review of climate station data there is sufficient historic data available to better understand the actual trends that have occurred for this area. Appendix X shows the location of climate stations, types of information, the quality and years of available data.

Recommendation 1 That a project to review and analyze existing climate data be undertaken. The project will confirm whether there is warmer wetter trend under way that can be documented from locally available climate records. This project could create the baseline from which future climate change can also be measured.

2.2 Plants and climate

This section is in the report because plants reflect climate and because the definition of ecosystems (which are integral to implementation of LRMP objectives – e.g. BEC zones, subzones etc) are defined by climate. The Subboreal Spruce (SBS) and Engelmann Spruce Subapline fir (ESSF) for example are named after tree species considered to represent climatic climax ecosystem conditions. This means trees which will be present on well drained (mesic sites) in the absence of stand initiating disturbance events or what trees are in old growth forests. Old growth forests on well drained soils therefore reflect the regional climate in the biogeoclimatic classification system.

The vegetation plots for BEC system sorted information into sites series based on sampling of older climax forests only. We also know that the old forests in the Morice were established when temperatures were (at least) 1.1 degrees C colder than today, and that older stands (> than 250 years) were established under even cooler climate situations. Since the BEC climate envelopes are predicted to shift quite dramatically, the degree to which vegetation responds is important for meeting the objectives of the LRMP and to all aspects forest management - from tree species selection for reforestation to conservation - because measures are based on the provincial BEC. Climate stations are collecting data but there is no monitoring of vegetation that can be used to correlate a response to climate change. Section 3 reviews the vegetation plots in the LRMP that may provide some historic data points for vegetation. As well as the MOFR research Branch BEC plots there are the Permanent Sample Plots maintained for measuring growth and yield.

Recommendation 2 That vegetation monitoring be initiated in the LRMP, following but not limited to the elements we have provide such as use of existing vegetation plots and the strata for sampling outlined in Section 5.

[3] http://jisao.washington.edu/pdo/

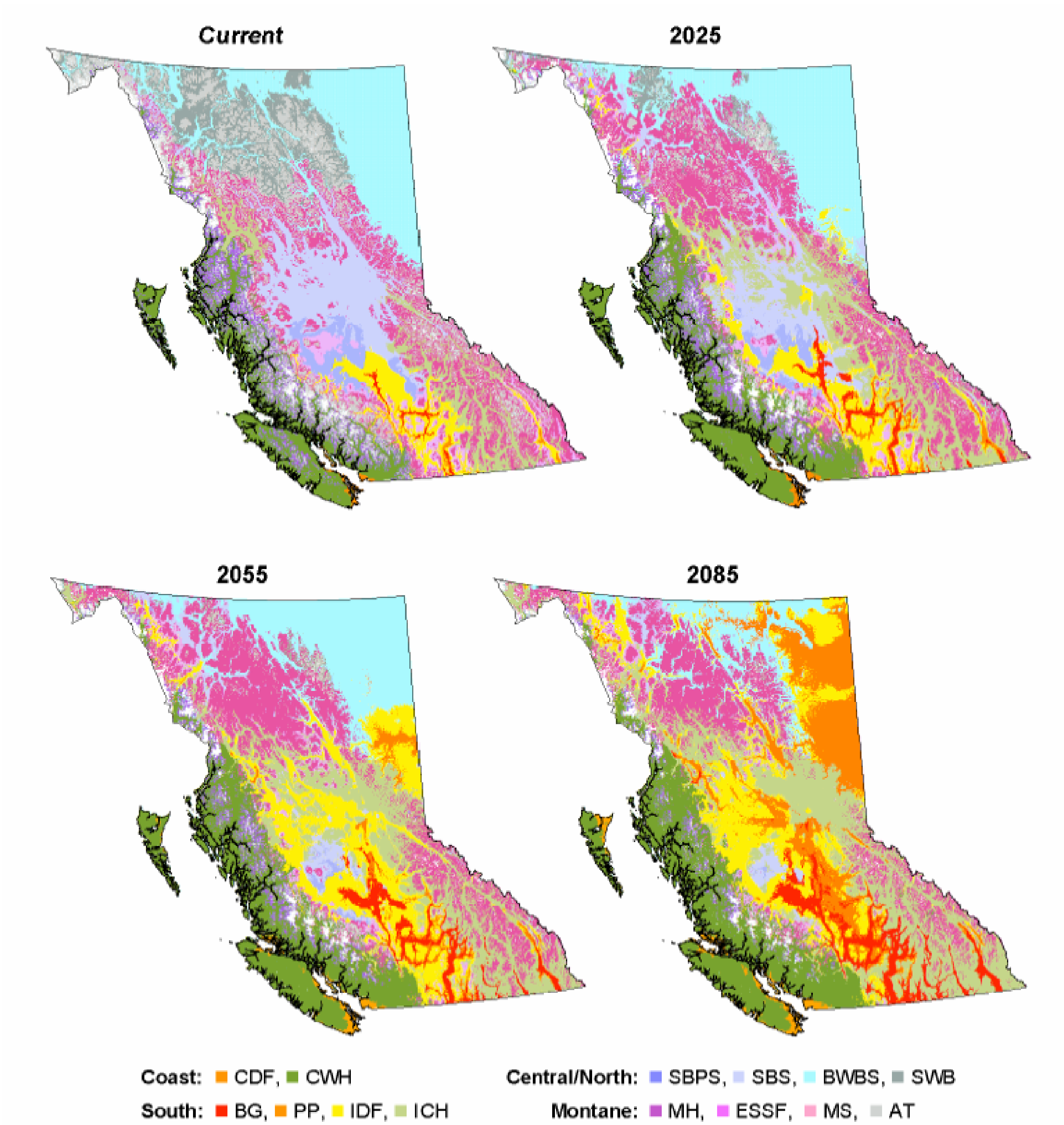

FIG. 2. Shift of the climatic envelope of ecological zones based on the ensemble simulation CGCM1gax for the normal periods 2011–2040 (2025), 2041–2070 (2055), and 2071–2100 (2085). The ecological zones are: CDF, Coastal Douglas-fir; CWH, Coastal Western Hemlock; BG, Bunchgrass; PP, Ponderosa Pine; IDF, Interior Douglas-fir; ICH, Interior Cedar–Hemlock; SBPS, Sub-boreal Pine and Spruce; SBS, Sub-boreal Spruce; BWBS, Boreal White and Back Spruce; MH, Mountain Hemlock; ESSF, Engelmann Spruce–Subapline Fir; MS, Montane Spruce; SWB, Spruce–Willow–Birch; AT, Alpine Tundra.

Figure 2. Shift of ecological zones and climate change. (From Hamman and Wang 2006).

2.3 Potential Implications of climate change to ecology in the Morice LRMP

How to interpret the "flying BEC zones" forecast is unclear with regard to change in the distribution of plants in general, and culturally important plants in particular.

It does seem likely that the familiar plant associations may not migrate in step with the climate changes and may be a disintegration of plant communities as we know them. This is predicted as some plants as well as other elements of biological communities have different ecological niche widths as well as differing dispersal aptitudes. It is therefore likely that under climate change some plants will change their abundance and be distributed differently. Those with a narrow ecological niche on a restricted site type and which also have poor dispersal are expected to be at higher risk even when there may be suitable sites elsewhere they may no be able to colonize.

The warming trends already witnessed are predicted to continue but the rate of change is uncertain. An increase of 1 C° will shift the climate envelopes for BEC zones a predicted 300 m up in elevation and 150 km north. If there is an increase of 2 to 5 C° in 70 to 100 years this would mean a shift between 600 to 1500 m in elevation and a shift of between 300 to750 km in distance in latitude. This ecological zone shift is estimated to be at a rate of 40 km per decade which is faster than the many plants can disperse (Peart et al[4]. 2007). This means plants with poor dispersal and fairly restricted ecological niches can be expected to decrease in abundance and range.

There are some general hypotheses that can be made about how plants on different sites may respond to climate change: Plant species on drier rapidly drained soils (xeric sites) are adapted to survival during severe moisture deficits. Species such as terrestrial lichen-pine sites can be expected to shrink in a warmer wetter climate as there will new species colonizing these sites and out competing the lichens. Tree line will rise causing the alpine zone and alpine meadows habitat to shrink. In general, wetter forested sites and seepage receiving sites are expected to shift most slowly because their composition is determined/ limited primarily by moisture, rather than general climate.

Changes in climate influence natural disturbance agents such as wildfire, insects and disease pathogens severity and frequency. Whatever the specific changes will be, it seems likely that climate change will be reflected in a change in natural disturbances at multiple scales over the landscape. For example, though the early evidence points to wetter summers, increased fire risk should not be dismissed as the concomitant increase in mean temperature may result in increased fire hazard.

In summary - climate change has added a new level of complexity and complication to land management, forestry, conservation and pursuit of multiple values and good and services from the same land base. The globe is seeing species extinction rates at levels not seen since the age of the dinosaurs, and it has been suggested that practically we will need to focus conservation and coordinate development around a strategy focused on getting as many species as possible through the bottleneck, in order to retain maximal levels of biological diversity (Wilson 1993). We are in an age of predicted massive human induced loss of biological diversity over the next century (Wilson 1993). Given the relatively natural state of the Morice LRMP area there is likely increased opportunity here than many other areas on the globe to successful adapt to the conservation challenge.

3. Monitoring

3.1 Monitoring Concepts, Definitions and Programs

Monitoring is the "process of checking, observing, and measuring outcomes for key variables, or specific ecological phenomena against a predefined quantitative objective or standard".[5] Monitoring is the only way of assessing whether we are selecting the most effective practices or meeting the expected targets or

[4] http://cpawsbc.org/pdfs/Climate_Change_CPAWS-BC.pdf

[5] Mulder, B.S., B.R. Noon, T.A. Spies, M.G. Raphael, C.J. Palmer, A.R. Olsen, G.H. Reeves and H.H. Welsh. 1999. The strategy and design of the effectiveness monitoring program for the northwest forest plan. USDA Forest Service, Pacific Northwest Station. PNW-GTR-437.

goals. Monitoring also is important in refining thresholds and should be used to reveal needs for adjustment. There are a number of different types of monitoring, and it is important to be very clear about which is undertaken, prior to design or action [6].

Five types of monitoring are outlined below:

Compliance Monitoring. Does it meet the legal requirements?

This is considered relatively straight forwards type of monitoring with a yes/no type outcome. This requires understanding of the law and legal interpretations and evidence but there is a clearly established threshold between legally compliant or not. Compliance monitoring is the purview of Compliance and Enforcement (C&E) Program[7] within Ministry of Forests and Range over forest and range practices and tenure conditions.

Implementation Monitoring. Did you do what was stated?

This is also considered relatively straight forward. Requires understanding of plan or strategy, clearly defined tasks, sufficient resources and a time table. Chapter 6 in the LRMP provides direction on plan implementation monitoring.

Effectiveness Monitoring. Are the desired outcomes being met?

This is a challenging type of monitoring as it requires deciding whether or not a resource goal was met as expected. To be undertaken, effectiveness monitoring requires a clear goal to be stated and an understanding of the level of uncertainty and risk that are acceptable related to working in dynamic ecosystems where outcomes are cannot be precisely predetermined. It typically is also difficult to undertake effectiveness monitoring for ecological values because it requires long-term commitment and high statistical power in areas that are often naturally highly uncertain.

Validation Monitoring. Is the hypothesis correct?

This is also very challenging as it involves showing causal relationships between some management action(s) and an environmental response. Much of our forest and environmental management is based on assumptions about relationships between factors in the environment, which are often not validated through evidence. This applies whether forecasting for timber or non-timber as forecasts are based on assumptions linked to data.

Baseline Monitoring. What is present naturally and what is the risk level associated with the desired future condition?

While the Forest and Range Evaluation Program (FREP) web site[8] provides more detailed definitions of the above 4 types monitoring it does not mention natural baseline monitoring. The term baseline monitoring is used by the World Wildlife Fund and the American Prairie Foundation[9] when monitoring biodiversity as a means by which to report progress toward habitat/species protection or restoration goals. Their projects establish baseline conditions and then monitor changes to indicators of ecosystem function to inform management decision-making. It requires that the system being measured has not already undergone significant change from some level of 'natural' or 'unimpacted' condition. Baseline monitoring is therefore an important aspect of both effectiveness and validation monitoring.

3.2 Monitoring Overview

In this section we review provincial and local monitoring programs that may provide relevant information or context to the cultural plants / broader biodiversity monitoring needs in the LRMP area. We include climate and vegetation inventory as forms of monitoring.

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[6] Lindenmayer and Franklin 2002[6] also provide definitions types of monitoring and a good overview of monitoring design. Discussion on assessing effectiveness of management can also be found at Biodiversity and Forest Management web site maintained by the Conservation Biology at UBC http://www.forestbiodiversityinbc.ca/manage_steps_assess.asp.

[7] http://www.for.gov.bc.ca/rni/Enforcement/Index.htm

[8] http://www.for.gov.bc.ca/hfp/frep/about/types.htm.

[9] http://www.americanprairie.org/biodiversityBaseline.html

3.2.1 Vegetation monitoring

Vegetation monitoring can be done at a variety of scales for plot/stand scale, landscape, and regional and provincial scales. At the stand level scale there are two potential data sources that could be used to provide both a back cast and forecast for vegetation monitoring data in the Morice LRMP area. These two data sets are maintained by Ministry of Forests Research Branch and Land and the Integrated Land Management Bureau in the Land and Resource Data Warehouse (LRDW).

***Permanent Sample Plots* (PSP)** were established to measure forest yield and are periodically monitored by the Growth and Yield program Ministry of Forests. The LRMP area has 104 inventory growth and yield permanent sample plots of which 101 are active samples[10]. The 23 PSP established in the 1970s have growth and yield information but no understory plant species listed so using these to back cast for a vegetation trend is not realistic. (Bob Mac Donald MOFR pers. comm.). PSP inventory now includes understory species data collection, so there is the potential to analyze plant information and assess future trends based on periodic remeasurement of PSP sites. PSPs are protected from harvest and road building and provide some security as long term monitoring sites. Current vegetation sampling is only done to classify plots to site series. Remeasurement of vegetation for changes should be fully explored rather and the adequacy of the vegetation data assessed.

The locations of the Active Permanent samples plots are shown in Fix Z and Z.

Recommendation 3. That the MOFR schedule for remeasurement of the PSP in the Morice be clarified to the LRMP monitoring group and that existing understory vegetation data quality be assessed for it's potential as baseline data to quantify trend through back casting. That the LRMP committee explores inclusion of vegetation data remeasurement be added to PSPs to address vegetation trends. That the data-sharing agreements between appropriate agencies be clarified to ensure these data are available to the LRMP group.

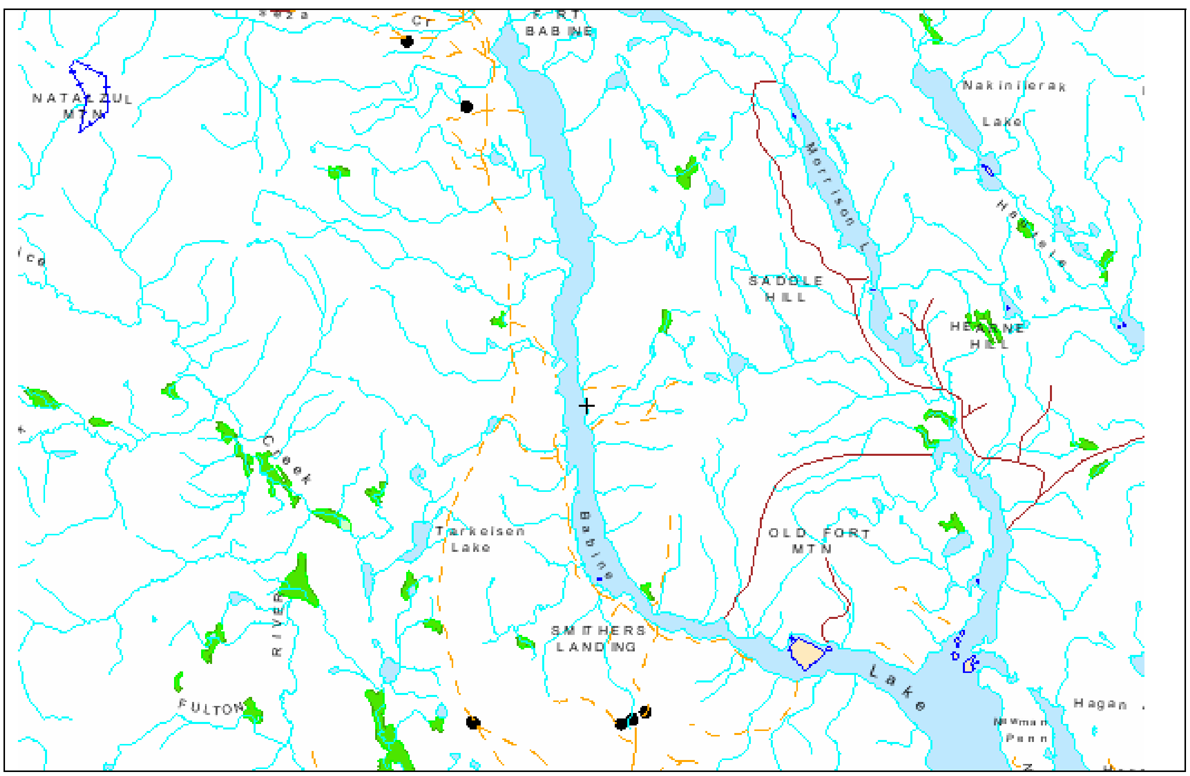
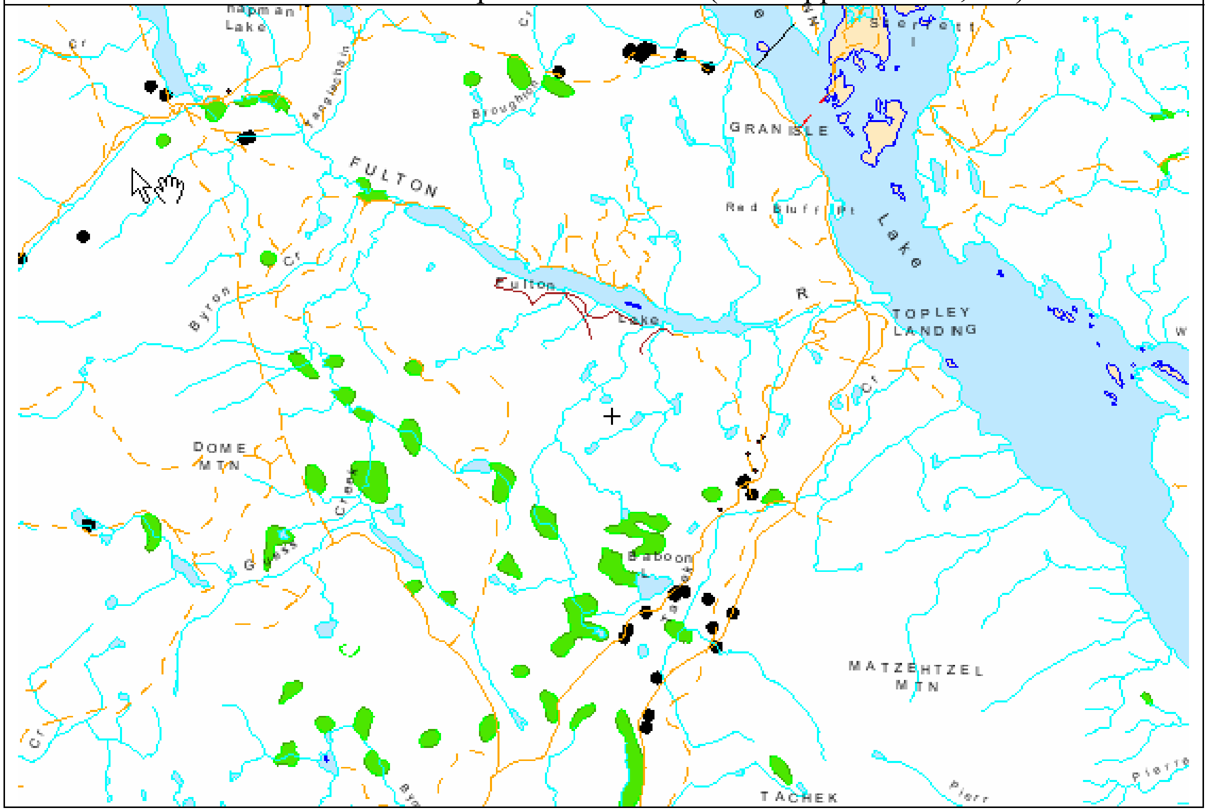


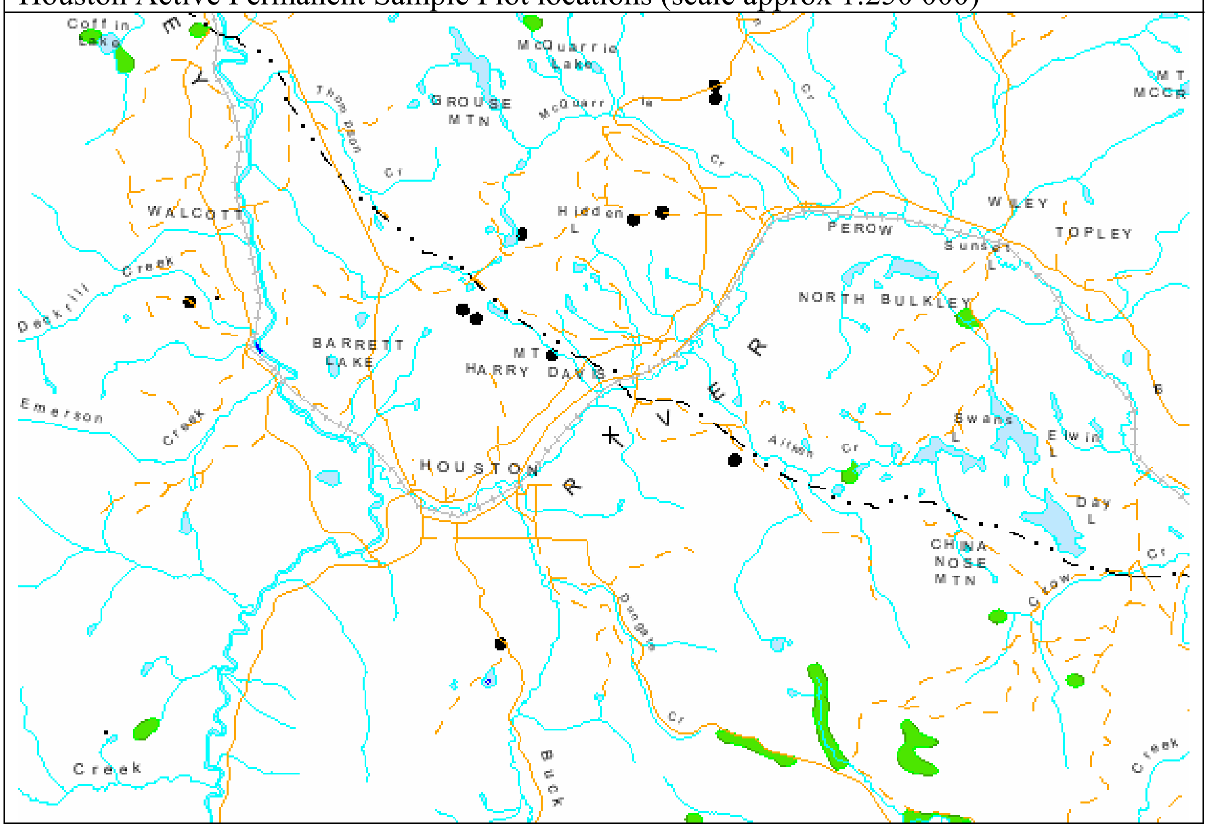
Figure 3. Location of some active PSPs in the Morice area.

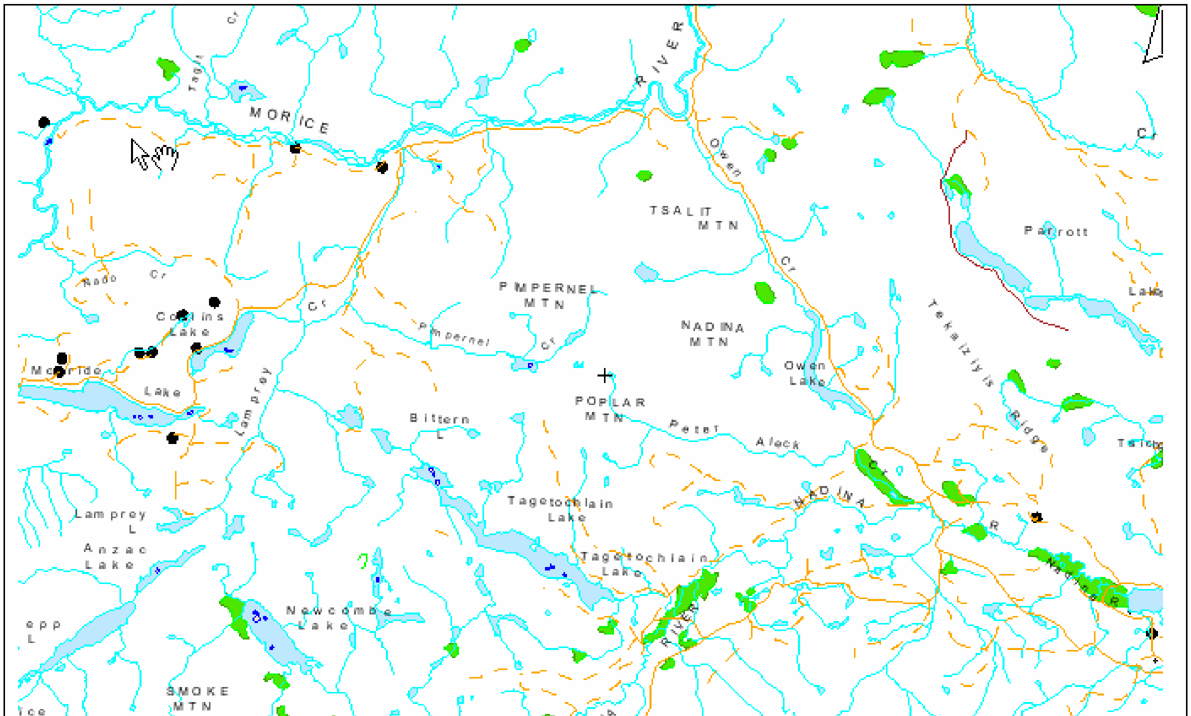
[10] http://www.for.gov.bc.ca/hts/vri/ip/index.html

Fulton Lake Active Permanent Sample Plot locations (scale approx 1:250,000)

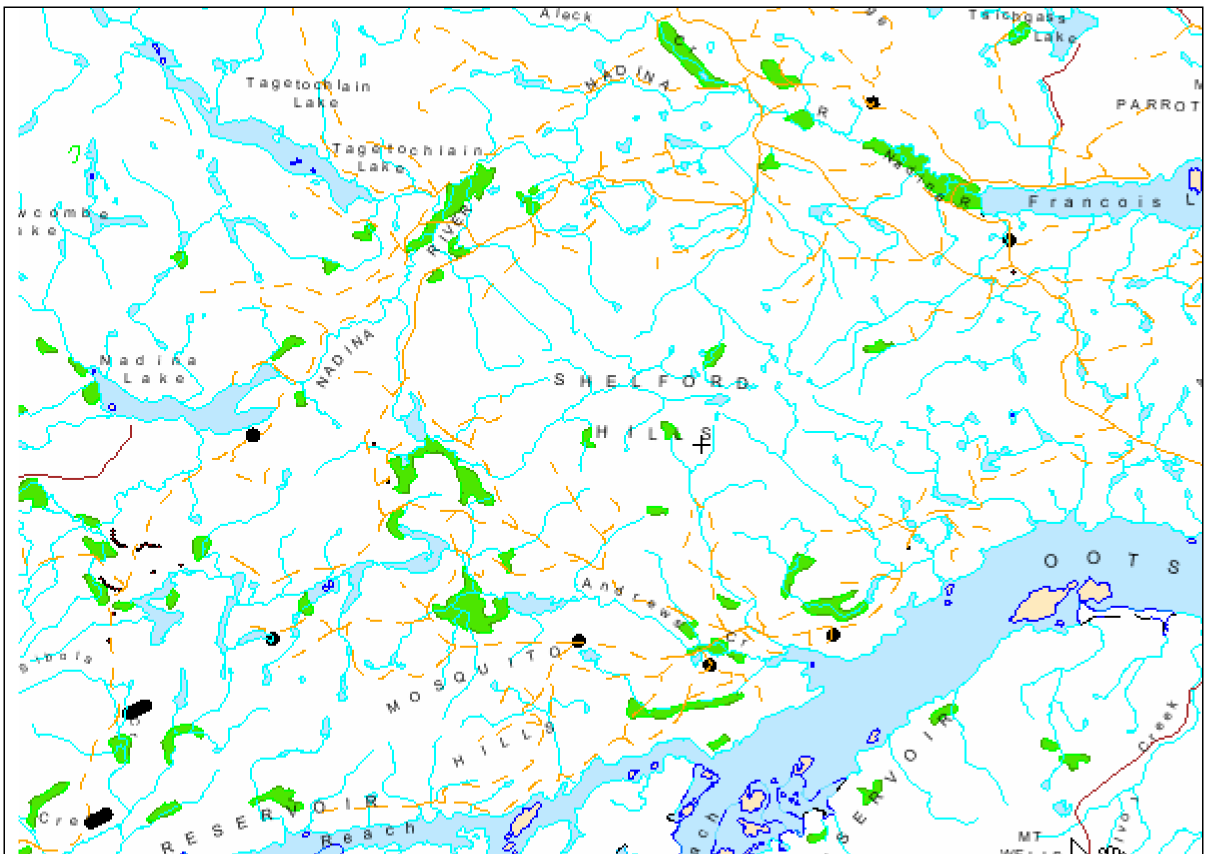


Houston Active Permanent Sample Plot locations (scale approx 1:250 000)





Morice Drainage Active Permanent Sample Plot locations (scale approx 1:250,000)



Southern Portion of LRMP Active Permanent Sample Plot locations (scale approx 1:250,000)

Biogeoclimatic Ecosystem Classification (BEC) plots

The second set of existing sample plots are the Biogeoclimatic Ecosystem Classification established Ecological plots sampled in the 1990s and used to classify subzones and sites series (Banner et al 1993). These plots may still be present if they were not logged or have not been subject to a catastrophic natural disturbance. Where they remain intact they potentially provide data on which to back cast and see if a trend can be quantified. In the event that plots have been logged or burned, they may provide opportunity to address differences in plant abundance linked to changes in seral stage. Cultural plant abundance is an LRMP objective and the best data on this is from the BEC plots.

Ministry of Forest Research Branch lists 461 plots for the Nadina Forest District some of which are in the area of the LRMP. Where site conditions were sufficiently uniform, sample plots described a 20 x 20 m area. Plants listed in these plots were used in vegetation analysis and not for biodiversity monitoring purposes. The exact location of BEC plots will be more problematic than PSP as these plots were not established for remeasurement. The number of plots in the MOFR data base may overstate the actual number in the LRMP area. The data based provided includes SBPS zone plots and this zone does not occur in the LRMP area.

Table 2. BEC sample list. (Allen Banner pers. comm.)

Project: BEC Master / SU: Nadina

Plot Number	Zone	Subzone	Site Series	Accuracy	Latitude	Longitude	Elevation
0000453	SBPS	mc	01		53.20416641	-125.6083298	990
0001053	SBPS	mc			53.18611145	-125.5986099	920
0001453	SBPS	mc	02		53.20416641	-125.5833359	950
0001653	SBPS	mc	01		53.24166489	-125.5916672	940
0001853	SBPS	mc	02		53.22638702	-125.5694427	970
0003352	SBS	dk			53.39166641	-125.625	860

The sample plots outlined above (Table 2) focus at the stand level and provide detailed plot level information. A higher level of information is provided by Vegetation Resource Inventory (VRI); the VRI for the Morice is the same as existing Forest Cover and has apparently not yet been updated[11].

Recommendation 4. That a review of BEC plots be undertaken to determine which plots may be suitable for remeasurement, the seral condition of plots, which plots are within conservation reserves such as OGMAs, parks and non harvest zones and ease of access and sampling.

***Vegetation Resources Inventory* (VRI)[12]:** These provide landscape level information that can be used to inform on LRMP implementation monitoring. VRI information is basic LRMP implementation. Forest stand ages are for example used to assess whether seral stage objectives in the LRMP are met. Significant effort is placed on maintaining and up-dating VRI due to links to Forest Stewardship Plans and Timber Supply Reviews.

***Predictive Ecosystem Maps* (PEM) and Terrestrial Ecosystem Maps (TEM)[13]:** These maps provide an inventory of sites series location and condition which can be linked to plant abundance. The most recent PEM maps did not pass quality control assurances and so cannot be used to construct cultural plant distribution and abundance estimates at this time. Better quality sites series maps will improve monitoring for cultural plants.

Recommendation 5. PEM/TEM sites series mapping be completed. That quality assurance for PEM be achieved and that non forested sites series be mapped.

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[11] http://www.for.gov.bc.ca/hts/Maps_Inventory/Maps_June_2006/VRI/TSA_VRI_KEY%20MAP_2006_06.pdf
[12] http://www.for.gov.bc.ca/hts/vri/
[13] http://www.env.gov.bc.ca/ecology/tem/

Airphoto and satellite imagery: These can also be used to document vegetation changes and to back cast where time series are available. In the longer term distinct changes such as tree line may be successfully documented with imagery.

3.2.2 Climate Monitoring

There are three sources of climate information for this LRMP area. Monitoring stations are being maintained or have been maintained by 1) Environment Canada Network for British Columbia, 2) Fire Weather stations maintained by BC Ministry of Forests Protection Branch and 3) Snowpack and Water Supply Outlook for British Columbia maintained by the Water Stewardship Division of BC Ministry of Environment.

1) Environment Canada Climate Network for British Columbia[14]

Environment Canada show active and inactive climate stations as well as active and inactive hydrologic stations on their website. This information has been extracted and summarized for the Morice LRMP and surrounding areas (Table 3). The location of the stations is shown in Figure 4.

There is a single active climate station (HOUSTON (#1073615)) in the LRMP area. It operated from 1957 to 1963 and again from 1988 to 1999. It is unclear whether there is data from 1999 to 2008 which has not been entered or if the active designation was to 1999. There is data available from 11 inactive stations in the LRMP. The longest running was the BABINE LAKE HALIFAX BAY (#1070572) station which operated from 1912 to 1936 in which 18 years are shown as having complete records for all twelve months.

The data collected varies by stations and may includes temperature, precipitation, rate of precipitation, wind speed, soil temperature, evapotranspiration, Sunshine, radiation, ozone, precipitation as snow. The frequency of the observations can be hourly or in terms of observation/day.

Table 3. Climate stations providing relevant data for the LRMP area.

Climate Stations	Start	End	Years in operation	Years with complete monthly
Active in the LRMP				
1. HOUSTON (#1073615)	1957	1963	6	6
HOUSTON (#1073615)	1988	1999	11	9
Inactive stations in the LRMP				
1. MORICE RIVER HOUSTON (#1075200)	1955	1958	4	1
2. MORICE RIVER FDR (#1075199)	1961	1962	2	-
3. COLLINS LAKE (#1071785)	1958	1958	1	-
4. NANIKA RIVER HATCHERY (#1085373)	1961	1966	6	3
5. HOUSTON MCBRIDE LAKE (#108CFAF)	1970	1971	2	1
6. NADINA RIVER (#1085281)	1981	1988	8	6
7. NADINA RIVER (#1085279)	-	-	Not avail.	Not Avail
8. FULTON LAKE (#1073040)	1960	1961	2	1
9. BABINE LAKE HALIFAX BAY (#1070572)	1972	1973	2	-
10. BABINE LAKE HALIFAX BAY (#1070572)	1912	1936	25	18
11. HOUSTON GOOSLY LAKE (#1073616)	1970	1970	1	-
Active Adjacent to LRMP				
1. BABINE LAKE PINKUT CREEK (#1070573)	1969	1999	30 +?	28 + ?
2. BURNS LAKE CAMPBELL SCIENTIFIC (#1091174)	1990	1999	10 + ?	5+?
3. SMITHERS A (#1077500)	1942	2000	58 + ?	55 + ?
4. EQUITY SILVER (#1072692)	1981	1999	18 + ?	13 + ?
Inactive Adjacent stations				

14 http://scitech.pyr.ec.gc.ca/ClimHydro/climate_explanation_e.asp

1. SMITHERS CDA (#1077505)	1938	1968	51	50
2. TELKWA (#1078070)	1922	1968	47	45
3. TELKWA COAL MINE RD (#1078072)	1986	1984	4	2
4. BURNS LAKE (#1091169)	1969	1990	22	21
5. QUICK (#1076638)	1983	1995	12	10
6. NORA LEE NORTH (#1085615)	1979	1983	3	0

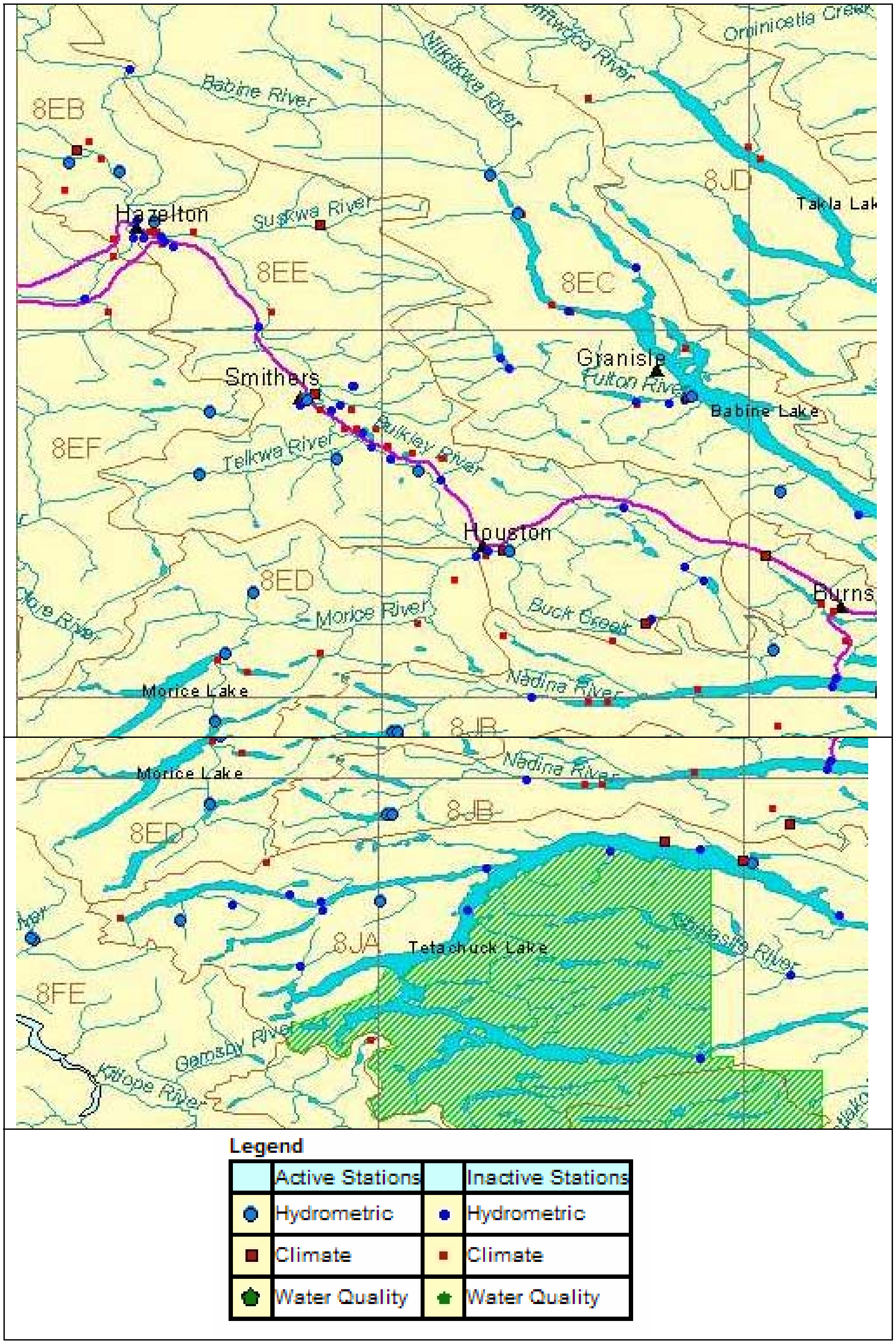

Figure 4. Environment Canada climate and hydrographic monitoring locations.

2) Fire weather stations

The Ministry of Forests and Range, Protection Branch[15] operates approximately 215 hourly weather stations, in British Columbia. These hourly weather observations, supplemented by data from other agency stations, also listed, are used to support fire weather forecasting and the Canadian Forest Fire Danger Rating System (CFFDRS). Table 4 shows the station in or adjacent to the LRMP area. There is a limitation to this data in that it is collected only from April to October; however a review of the data may reveal changes during the growing season and would be valuable.

The computer-based CFFDRS is the primary fire management decision aid in Canada. With it, fire managers can assess the potential for ignition, spread and burning intensity. This information is used for making fire prevention, preparedness and suppression decisions, as well as other general fire management decisions.

Temperature, relative humidity and precipitation, wind speed and wind direction are recorded by the fully automated stations. This data is transmitted to Protection headquarters every hour from April through October but less frequently and from fewer stations during the winter months. Data from other agencies' weather stations are also utilized and transferred electronically to Protection headquarters. Maps are generated of temperature, relative humidity, precipitation and wind speed and available the online.

Summary Fire weather stations maintained by Ministry of Forests and years of data collection. The locations of the stations are shown in Figure 5.

[15] http://bcwildfire.ca/Weather/Maps/danger_rating.htm

Table 4. Fire weather stations in the LRMP area.

Active Fire weather stations and station ref # in the LRMP	Elevation meters	Start date	Years of data Presumes data is retained
1. North Babine (173)	951	1986	21
2. Upper Fulton (169)	900	1986	21
3. McBride Lake (180)	815	1990	17
4. Nadina (179)	954	1985	22
5. Houston (Dungate) (162)	608	1974	33
6. Peden (178)	747	1984	23
Fire weather station adjacent to the LRMP			
7. Pine Creek (938)	1320	2006	2
8. Gankwa (182)	855	1993	14
9. Smithers (157)	522	1970	37
10. Burns Lake (181)	830	1993	14
11. Augier Lake (167)	900	1983	24
12. Grassy Plains (161)	944	1970	37

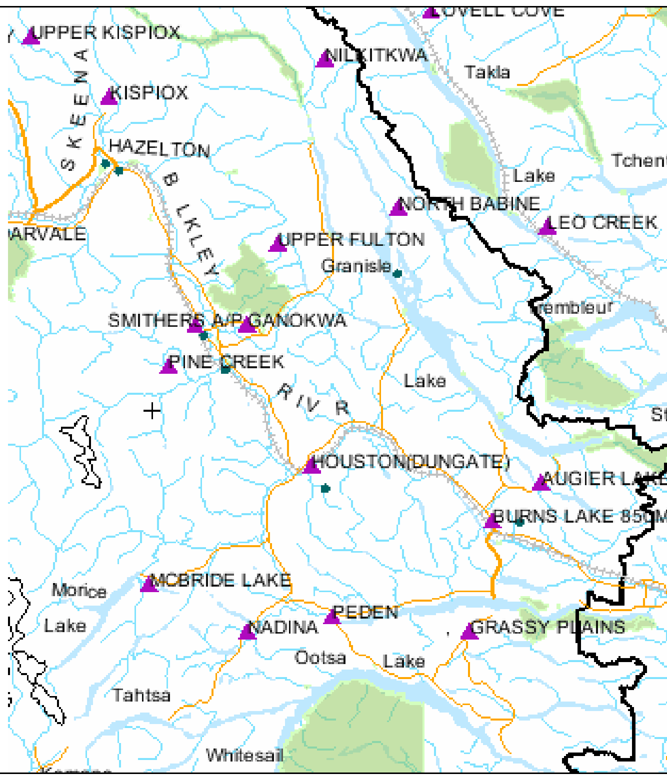

Figure 5. Locations of fire weather stations.

3. Snow pack and Water Supply Outlook Monitoring

The Ministry of Environment River Forecast Centre[16] records snow pack information as part of flood predictions. The data is collected through an automated snow pillow station. Prior to these stations there were manual snow measurements. The snow pack information is shown in Table 5. The locations of the snow stations are shown in Figure 6 and 7. River Forecast Centre. Automated Snow Pillow Historic Snow Survey Data is available from the following stations http://aardvark.gov.bc.ca/apps/mss/stationlist.do

Table 5. Snow pack information stations from Forecast Centre.

Stations in or adjacent to LRMP	Elevation (m)	start	end	Years in operation
4B06 TACHEK CREEK	1133	1968	2007	39 +
4B01 KIDPRICE LAKE	1415	1952	2007	55 +
4B03 (Inactive) HUDSON BAY MTN	1520	1965	1977	13
4B03A HUDSON BAY MTN	1452	1972	2008	36 +
4B04 CHAPMAN LAKE	1485	1965	2007	42 +
4B05 (Inactive) SMITHERS	500	1967	1968	2
4B12 (Inactive) GRANDUC MINE	790	1974	1999	34
4B14 EQUITY MINE	1434	1977	2007	39 +
4B15 LU LAKE	1296	1977	2007	39 +
4B07 MCKENDRICK CREEK	1048	1968	2007	40 +
4B08 MOUNT CRONIN	1491	1969	2007	39 +
1A16 BURNS LAKE	820	1970	2008	37
1B02 TAHTSA LAKE	1319	1952	2007	56
1B04 (Inactive) WHITESAIL LAKE	1330	1953	1953	1

[16] http://bcwildfire.ca/Weather/Maps/danger_rating.htm

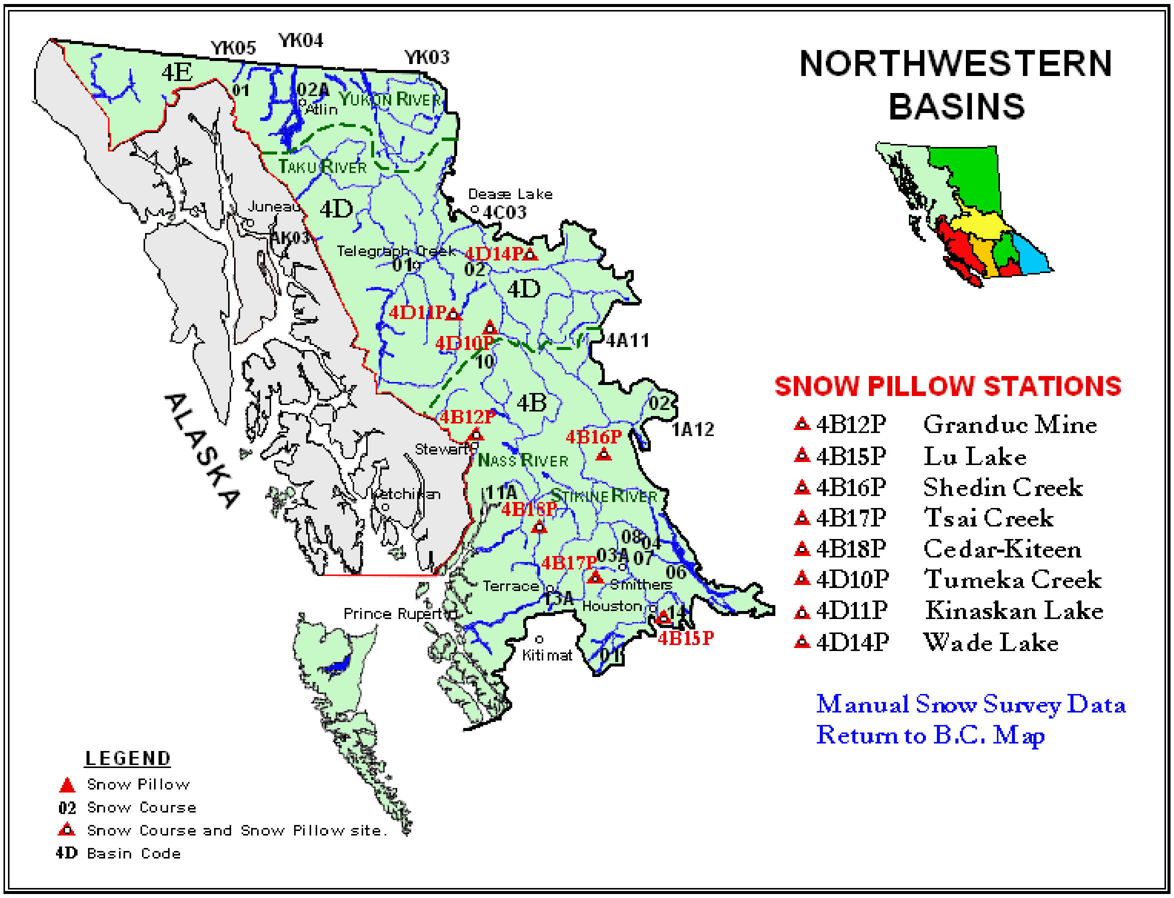

Figure 6. Northern Snowpack and water stewardship monitoring locations.

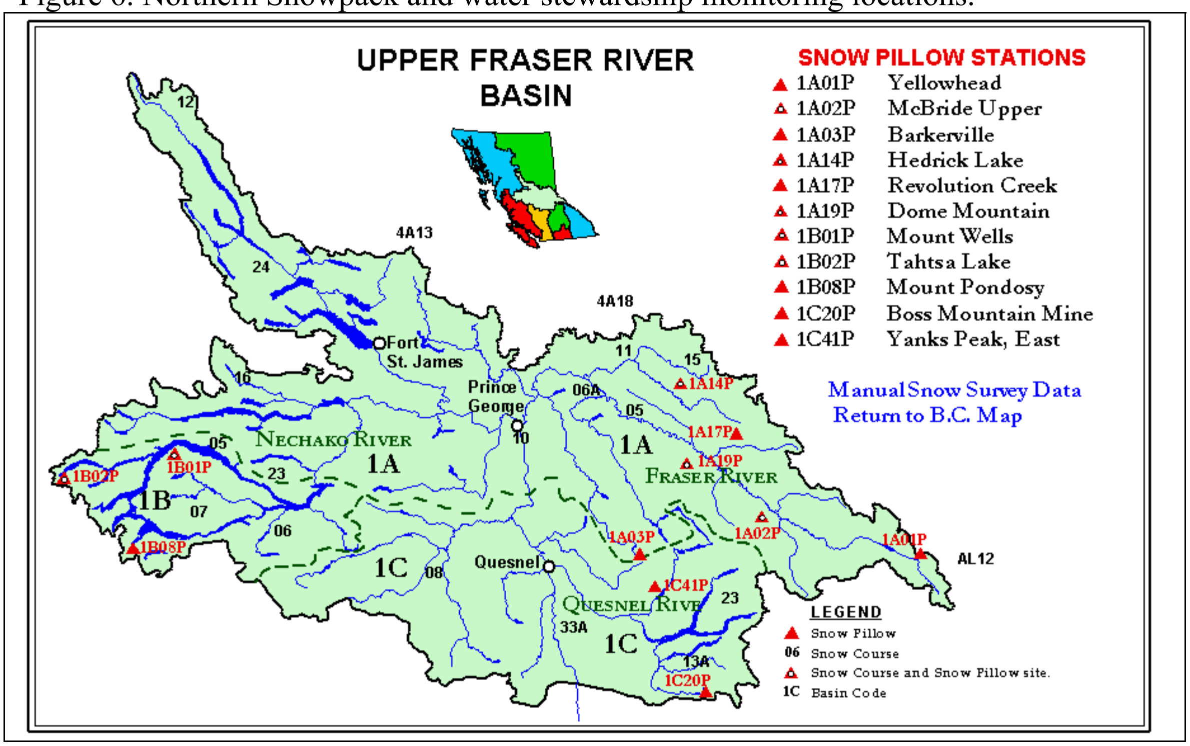

Figure 7. Southern Snowpack and water stewardship monitoring locations.

3.2.3 Forest and Range Evaluation Program (FREP)

The FREP[17] is a provincial monitoring program with a focus on evaluation of the 11 resources[18] identified in the Forest and Range Practices Act[19]. These values include some cultural heritage values, landscape and stand level biodiversity also present in the LRMP.

The FREP objectives of resource stewardship monitoring are to provide a mechanism for continuous improvement of forest stewardship through the assessment of on-the-ground forest practices as they relate to approved Forest Stewardship Plan results and strategies and FRPA resource value objectives.

Projects and monitoring protocols have been developed for some indicators such as stand level biodiversity (wildlife trees) but landscape level biodiversity monitoring remains under development.

Cultural Heritage Resource projects are current focused on process and communications and described in the following section.

The types and scale of monitoring are shown in Figure 8. There is overlap between FREP and LRMP monitoring at the district level[20].

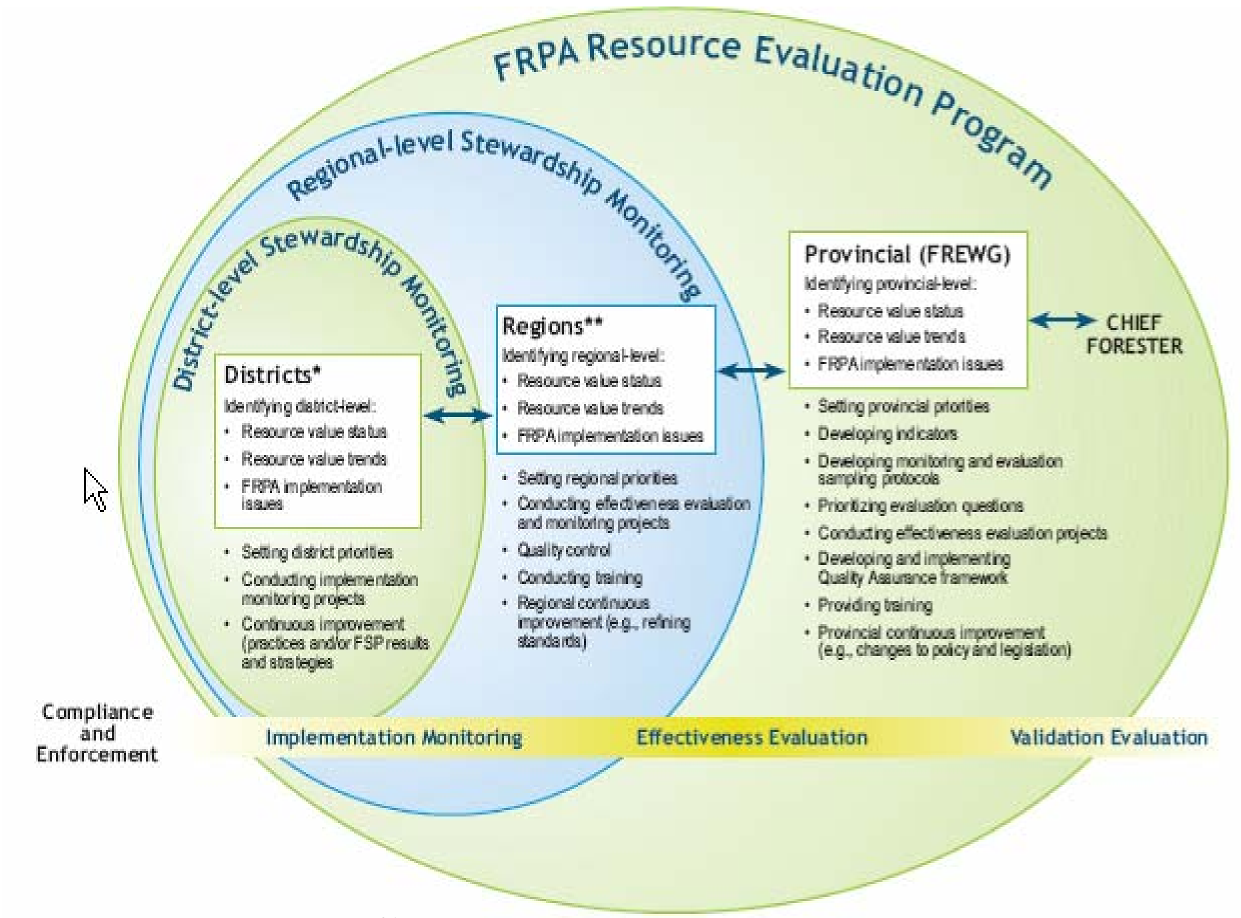

Figure 8. The FREP Program[21].

The FREP does not define natural baseline line monitoring. In the context of the Morice LRMP, a natural baseline is needed inform whether the plan is meeting its objectives. FREP also does not address cumulative impacts of other resource stresses and so remains focused on the 11 values identified in

[17] http://www.for.gov.bc.ca/hfp/frep/
[18] http://www.for.gov.bc.ca/hfp/frep/indicators/table.htm
[19] Biodiversity; Cultural Heritage Resources; Fish/Riparian; Forage & Associated Plant Communities; Recreation Resources; Resource Features; Soils; Timber; Visual Quality; Water; Wildlife
[20] The FREP regional contact for Nadina Forest District is Agathe Bernard (250) 692-2200.
[21] http://www.for.gov.bc.ca/hfp/frep/site_files/discussion/FREP_Discussion_Paper_Activities_at_the_Regional_and_District_Level.pdf

legislation and whether proposed results and strategies in Forest Stewardship plans are effective for sustaining the legislated objectives for that value. Biodiversity landscape and stand level results and strategies are constrained in that they can not unduly reduce the supply of timber from British Columbia's forests. Cultural Heritage objectives intend to conserve, or, if necessary, protect traditional use by an aboriginal people that is of continuing importance to that people and is not limited by the 'must not unduly reduce timber supply' clause that applies to other non-timber values. Currently FREP is evaluating effectiveness in relation to cultural values, by focusing initially on the effectiveness of the FN consultation process (Levesque, 2008).

FREP is potentially relevant to LRMP monitoring as it is designed to report on effectiveness of forestry strategies in meeting objectives. The monitoring implementation of the LRMP requires accounting for forest practices and also accounting of the LRMP objectives together. If forest practices on their own are ineffective they could cause a failure for an LRMP objective. If LRMP implementation is ineffective it could cause objectives to not be met. Joint weaknesses may also result in objectives not being met. Accounting between the two programs is needed for adaptation to be effective. In the event that the forest practices are deemed ineffective the LRMP can be amended and the solution provided through higher level plan direction.

Recommendation 6. Establish whether FREP intends to monitor effectiveness in the Morice LRMP. If FN consultation is planned then integrate the need for Traditional Knowledge with FREP. The northern portion of the LRMP in particular lacks information on use of plants and practices such as burning.

3.2.4 Timber Supply Review (TSR)

The timber supply review is considered a monitoring program to the extent that it is a periodic assessment of a single indicator. The TSR also has a time line set in legislation which means there is a level of rigor and predictability attached to this process. Since TSR is dependent on VRI and will use PEM when available it is a driving force in maintaining these inventories. In terms of LRMP level monitoring data assembly and reporting there are benefits to coordinating with this process. TSR reflects current land use plans and forest practices and therefore conforms to LRMP direction and forest practices when determining which areas are available to harvest. The TSR however assumes that the LRMP objectives and forest practices are effective and that area designated to support non-timber are in proper functioning condition. The monitoring committee may benefit by selecting a reporting schedule for the plan to coincide with the next expected TSR in 2013. This is not to suggest delaying implementation but is a recommendation for a periodic evaluation on the effectiveness of the LRMP. The advantage of coordination TSR process is that savings are likely available in data package assembly which for TSR is usually completed a year in advance of harvest determination date. The data package for timber however is not sufficient for all the values in the LRMP. It is recommended that LRMP monitoring be coordinated with TSR because then the findings of the LRMP monitoring could be used where necessary to adapt the LRMP plans and practices where deemed ineffective. Should forecasting of risk be undertaken the TSR base case would be a means to predict risk when it can be linked to future seral stages.

The Schedule of TSR has just been completed for the Morice as of Feb 1 2008 the AAC is 2,165,000 cubic metres. This cut level remains in effect until 2013 at which time it can be recalculated or the recalculation postponed. The new AAC is an increase of 10 % over the previous AAC 2002 of 1 961 117 cubic meters in response to mountain pine beetle salvage.

3.2.5 Babine Watershed Trust

We reviewed the Babine Watershed Trust as it is a local monitoring initiative with a monitoring framework that guides projects and work plans. The Babine watershed is adjacent to the Morice LRMP area. There are six government approved Land use plans with various objectives and management strategies for the Babine Watershed: Bulkley LRMP, Kispiox LRMP, Babine Landscape Unit Plan (LUP), Nilkitkwa LUP, West Babine Sustainable Resource Management Plan (SRMP), and Babine River Corridor Park Management Direction Statement (MDS). The purpose of the Trust is to assess the implementation of land-use plan strategies and the effectiveness of those strategies in meeting key land-use plan objectives. The area of interest to the Trust does not include the Morice LRMP though Babine Lake and tributaries are in the Babine watershed.

Price and Daust 2005 developed a Monitoring Framework for the Babine Watershed[22]. The Babine Trust framework was developed in response to a monitoring gap analysis conducted previously (Daust and Price 2004). Their framework distinguishes between implementation and effectiveness monitoring and focuses mostly on effectiveness monitoring. The framework reviews indicators from land use plans and assesses their strengths and weakness in terms of monitoring, cost, benefit and learning. Indicators are also given a current and future risk and uncertainty rating as a guide to which may be of higher utility for monitoring. Effective monitoring priorities are based on the need to improve understanding of risk and understanding of consequences. Results of various projects are provided to monitoring trust members in an adaptive management loop to improve learning. This framework was considered thorough and uses a similar approach to what we are proposing in that it addresses risk and uncertainty. The complexity of climate change on land use planning and practices was not explicitly mentioned.

Some of the problems the Babine Trust aims to solve such as funding and monitoring priorities are also facing the Morice LRMP monitoring group. There are differing responsibilities between agencies and industry with regards to who is responsible for this non-legislated obligation. ILMB has responsibility for Strategic Land Use Plans and the Ministry of Forests and Ministry of Environment have responsibilities for forest and range practices over the same ecosystems within the context of the LRMP direction. In an adaptive management framework as is mentioned by agencies and industry it is beneficial to integrate monitoring and present data so that agency/industry responsibilities are clear and where there is an onus to adapt.

3.2.6 Sustainable Forestry Management Plans (SFMP)

As part of the Morice Innovative Forest Practices Agreement, five forest licensees undertake coordinated TSA level monitoring under the Morice Sustainable Forest Management Plan[23]. The SFMP is not a legally binding plan but consolidates information for a number of different strategic planning initiatives and so serves the purposes for different organizations. These strategic planning initiatives include IFPA Forestry Plans, LRMP, Forest Stewardship Plans, Forest Investment Plans, certification initiatives and Beetle Management Plans. The purpose of the SFMP is to coordinate these into a single adaptive management framework for operational planning and implementation. There are 58 monitored indicators and thresholds related to LRMP objectives. Each indicator is shown so that the relative responsibility of each licensee is known and this eases Licenses tasks when preparing Forest Stewardship Plans that meet LRMP objectives. VRI and PEM inventory form a significant mutually shared area of interest between government and industry. With regard to culturally important plants it is unclear on whom the onus rests to establish the natural baseline in the LRMP area.

There is no baseline specific to cultural plants in the SFMP however the Morice IFPA SFMP states under section, 2.3.8 Non-timber Forest Products that "non-timber Forest Products (NTFP) use on the TSA is neither documented not inventoried, however, this use is known to occur on the TSA in varying capacities ranging from non-commercial personal use of NTFP, to small commercial operations, NTFP uses on the Morice TSA include such activities as wild mushroom harvesting, berry picking and country food harvest. (Page 17).

[22] http://www.babinetrust.ca/.
[23] http://www.moricelakes-ifpa.com/publications/documents/MoriceSFMPlan_V3.1%20(033107).pdf

4. A Monitoring Framework

4.1 Generic monitoring framework

Sustaining environmental values depends on the understanding the condition of the environment at a variety of scales, understanding trends and have a framework in place to ensure management adapts as needed.

We recommend a monitoring framework that assesses risk to cultural plants through a number of steps that provide information on the condition of the resource, in relation to the various stressors. The generic framework used here is based on that outlined in an MOE 2000 technical publication [24].

The environmental risk assessment (ERA) approach is suited to use of expert opinion (data poor) or quantitative analysis of baselines, current condition and future expected condition (data rich). It highlights the identification of risk thresholds within an adaptive management process.

Within ERA a baseline must be identified, against which to compare what was expected of an indicator under the range of natural conditions against the current and if possible future condition. In general, it is assumed that risk to the value is proportional to the degree of deviation from natural condition: the further away the higher the risk. ERA should also account for cumulative impacts from a number of sources as an aid to understanding stressors and current condition. As in the Price and Daust (2006) monitoring framework there is a need to understand risk to different components and then place effort where there is greatest risk and most likelihood of a response. The generic approach is shown in Figures 9 and 10. Monitoring is included in ERA in a number of different areas – in defining the natural baseline (if it doesn't exist already), and in testing hypotheses about how indicators are expected to respond to stressors.

Environmental thresholds are generally not well documented but considering potential thresholds is essential for effective management of ecological (and social) resources. One approach for prioritizing monitoring action is to identify indicators with poor current condition, or indicators whose forecast trends suggest they will be at high risk into the future. In the case of cultural plants with the LRMP, indicators plus desired future condition is stated. Risk thresholds/classes and assessment of the current risks to indicators however are not discussed in the LRMP. Understanding risk and stress on values is considered fundamental to understanding how to sustain values under the plan.

Risk assessment is a basis for understanding potential impacts, but does not assess the *acceptability* of impacts. Decision-makers must choose a desired or acceptable level of risk. Uncertainty in inventory, assessment assumptions and thresholds can be better understood through iterative assessment (sensitivity analysis) to improve understanding and confidence in risk levels.

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[24] Ministry of Environment Lands and Parks (MELP) 2000 describe this in a report entitled *Environmental Risk Assessment (ERA): An Approach for Assessing and Reporting Environmental Conditions*. This publication can be found at the Strategic Land and Policy Legislation web page[24]

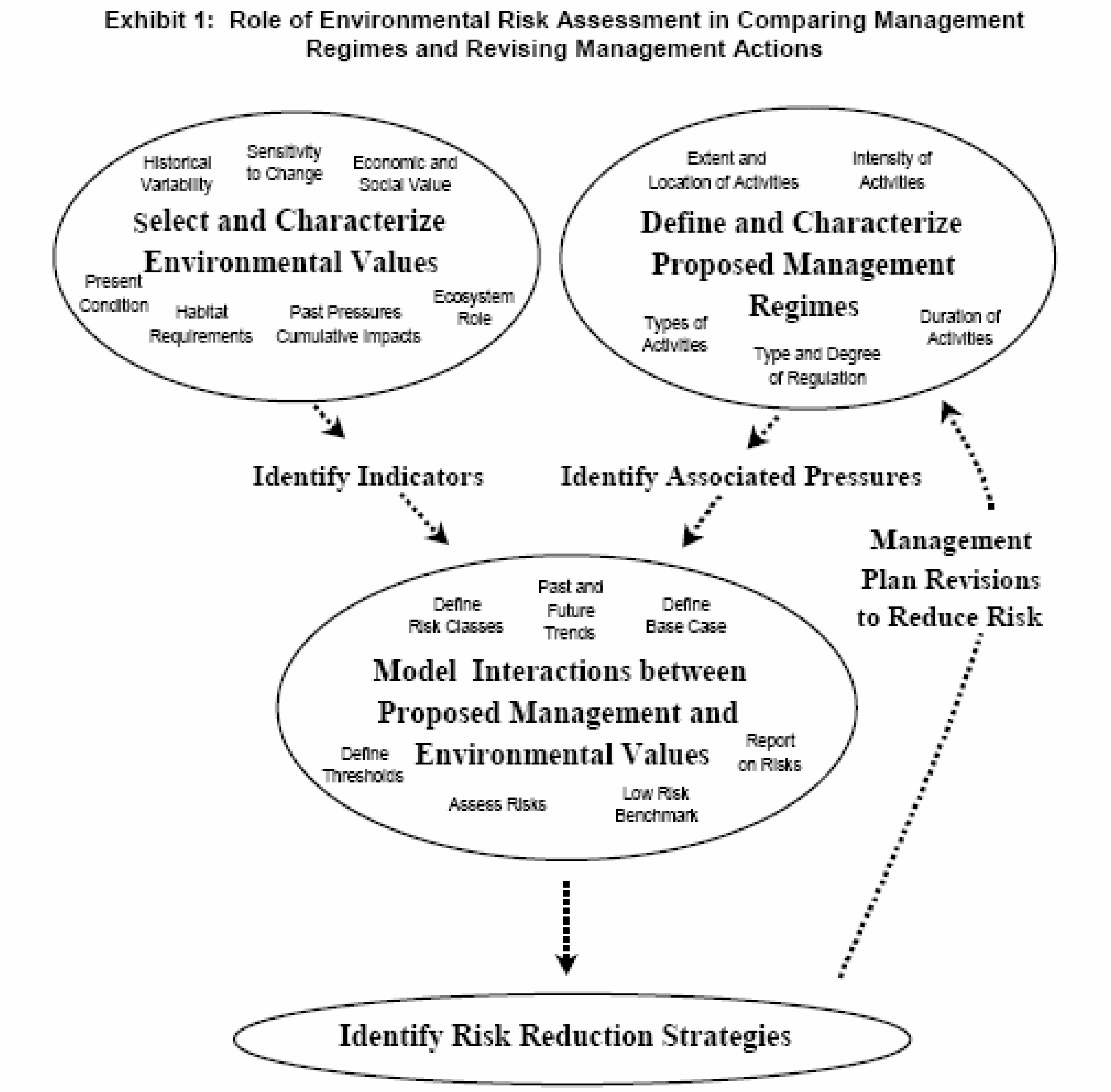

Figure 9. Environmental Risk Assessment (from MOE 2000).

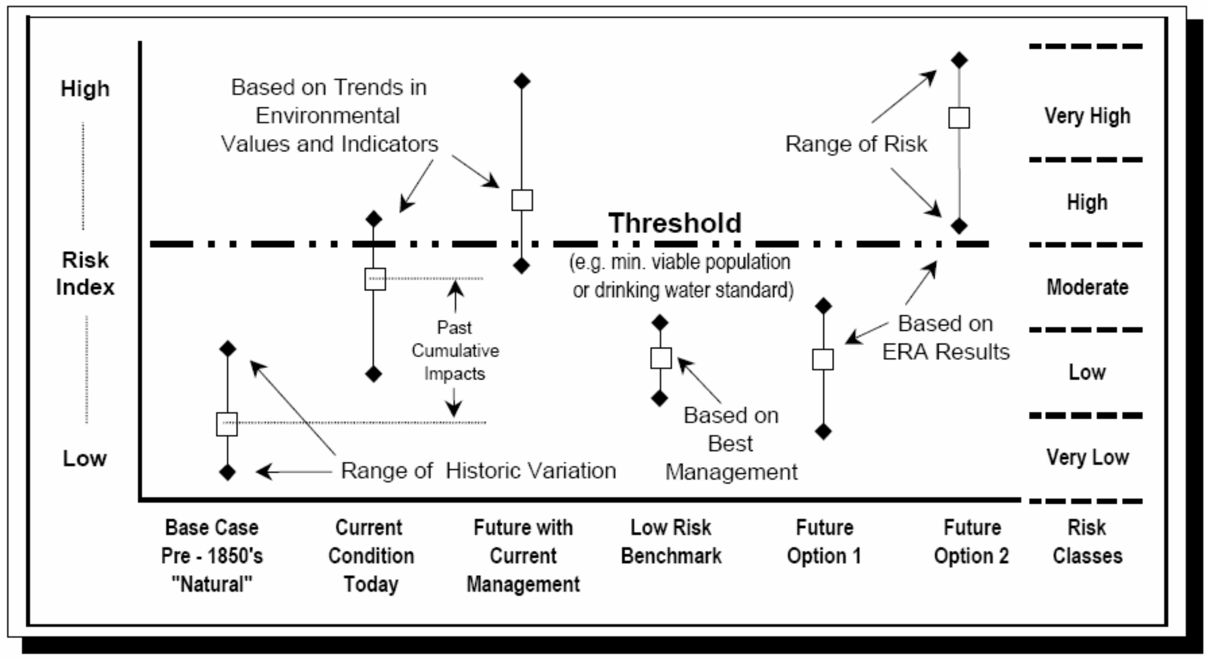

Figure 10. Conceptual Framework for ERA. From MoE 2000.

4.1 Applying the generic monitoring framework to culturally important botanical species

STEP 1. Establish the context

The context is set by the LRMP objectives, measures /Indicators and Implementation direction. The LRMP states the culturally important botanical are to be maintained and measured using a variety of indicators (see Step 3).

STEP 2. Identify and characterize key environmental pressures

Key pressures affecting the distribution and abundance of cultural plants are listed below and summarized in Table 6. Collectively the pressures change the environment to varying degrees over time and thus represent cumulative effects.

Changes in Natural Disturbances Regimes. Natural disturbances such as wildfire determine seral stage distribution across the ecosystems of the LRMP area. The reduction in natural wildfire as a result of fire suppression over the last 70 years has reduced the occurrence of early seral communities and increased late seral stage components in the landscape for forest and non forested ecosystems. Although a human-induced pressure, there are then 'natural' changes associated with changes in other disturbance agents such as insects and other diseases. MPB is the most obvious, but others are likely, and their effects are generally unquantified. Understanding natural disturbance regimes could help improved understanding of biodiversity trends in the LRMP area especially with regard to fire, insects and other diseases.

Change in traditional cultural practices. The extent to which First Nations applied prescribed fire as a means to produce higher abundance of culturally important plants is generally unquantified. Johnson-Gottesfeld 1994 noted that the aboriginal burning for vegetation management was practiced by the Gitksan - Wet'suwet'en and that berry patch burning was the most important traditional vegetation manipulation. Black huckleberry and low bush blueberry patches were burned to stimulate growth of new stems and production of berries, while preventing invasion by other shrub species and conifers. Spring burning on south facing slopes, village sites, and garden sites was also practiced. Burning occurred in aspen, pine, or grass dominated seral communities, or cottonwood floodplain forest, and was intended to control brush and encourage growth of grass. This practice declined in the 1930 and 1940s because of fire suppression by the British Columbia Forest Service. The extent of decline in this practice may only be understood if there are interviews with elders especially in areas where there is no published information. Section 7 contains a partial list of references on cultural plants and practices. The relationship, knowledge and usage of the plants by First Nations are a complex subject, involving many interrelated variables (Turner et al 1990). Section 7 is partial list of cultural plant publications with specific reference to the Gitksan - Wet'suwet'en.

Recommendation 7. Support a project to improve understanding of traditional knowledge (TK) for the northern portion of the LRMP area.

Agriculture. Agriculture has converted portions of the SBSdk to fields, with a direct and permanent loss of natural ecosystem plants proportional to the area in cultivation. The area under cultivation is quantifiable in term of hectares within each biogeoclimatic variant.

Industrial development. The areas associated with sawmill and mine sites in the LRMP represent permanent loss of productive natural ecosystems. Though a small area is impacted, the change is permanent and quantifiable in terms of hectares.

Urban development area. The areas associated with communities also represents a permanent loss of productive natural ecosystems which is quantifiable in terms of hectares.

Grazing. Grazing impacts are extensive in that they affect a large number of plants over a large area, with variable impacts by species. There is uncertainty over the exact size of the area influenced by grazing, the intensity of the grazing and the stress on plants. This is difficult to quantify, but effects may be significant on some values.

Forest practices. Fire suppression policy began in the 1930's and 1940s and reduced the extent of natural early seral communities. Harvesting has however created somewhat similar early seral stages at higher levels than were present under natural disturbance conditions, especially at higher elevations where wildfires were less frequent naturally. Prescribed burning was practiced silviculturally for a few decades but is no longer a common silvicultural practice. Though forest harvesting creates early seral stages these differ from fire-initiated plant communities, and with respect to cultural plants the link between berry production and fires is known. Silviculture practices with high stocking standards and short free-to-grow periods post harvest also have reduced the length of time that shrubs and forbs are at higher densities on a site.

Roads and Rail. Road and rail beds are permanent loss of productive ecosystems directly proportional to the area they occupy. These linear developments are quantifiable in terms of hectares.

Hydro-electric development and reservoir flooding. The Ootsa Reservoir resulted in permanent loss of a very large area of productive ecosystems. In addition, transmission lines mean that a portion of the landscapes is in continual early seral, but with altered species composition from natural early seral. The size of the area flooded is quantifiable.

Climate change. All ecosystems will be affected as well as frequency and types of naturally disturbances. Climate change will stress some plants in some ecosystems more than others and provide others greater opportunity for growth. Section 5 proposes monitoring to detect local climate trends, and plant responses. In terms of overall impact this stressor provides enormous uncertainty to sustaining many values identified as important by the LRMP and adds doubt to whether existing measures will be effective in maintaining values into the future.

Table 6. Summary of stressors and estimated trend on natural ecosystems.

Stressor	Nature of stress	Amount of area affected currently	Estimated Trend direction
Change in natural disturbances	Moderate, recovery and alternatives available	Entire LRMP	Uncertain
Agriculture	high permanent loss	Area under cultivation	Increasing area being converted to agriculture

Grazing	Consumption of plants and changes in community plant composition.	Area under grazing leases and intensity and condition of vegetation	Expansion of grazing likely.
Alien species	Competition with native species. Effects vary by site.	Small?	Expansion likely
Traditional Cultural practices	Loss of burning as a cultural practice. Other specific practices?	Uncertain	Unknown
Invasive Species	Compete with native species	Uncertain	Expansion likely
Forestry Silviculture obligations	High stocking and rapid succession "free grow" Low prescribed burning	Extensive, timber harvest land base	Current practices likely to continue. Currently increasing rapidly from recent past due to AAC uplifts.
New Forestry tenures	Total AAC is 2 126 536 cubic metres	8% more under tenure than in AAC.	Increasing
Roads	Permanent removal of ecosystem productivity	Percent of land base in roads and landings.	Road systems still being built out.
Hydro development	Permanent removal of ecosystem productivity	Area flooded	No predicted trend.
Climate Change	Change in ecosystems plants	Entire land based	Scope under study, but increasing

There will continue to be allocation of resources for new economic opportunity for forestry, agriculture, mines, and other tenures that will add stress to environmental resources. In order to fully understand the natural baseline, all areas where cultural plants have likely been removed should be quantified, though most permanent removal is relatively small, compared with the size of whole plan area (with the exception of agricultural impacts including grazing, and the reservoir).

Identifying the range of stressors impacting a value is also important so that when a negative trend is identified, it is possible to identify what practice, plan or tenure is best able to reduce risk to the value. Is it the land use plan objective/strategy and therefore ILMB that needs to lead to mitigate risk? Is it the forest practice/strategy proposed in forest stewardship plans that need to adapt?

Recommendation 8. Loss of natural ecosystems be quantified (area in hectares) for private land, land cleared for agricultural, linear development, and reservoirs and expected trend identified is possible for future land conversion. The areas converted are recommended for inclusion when assessing cultural plant baseline and current risk as they were part of the historic available land base**.**

STEP 3. Identify indicators and a natural baseline

The LRMP objectives and indicators for cultural plants from page 69 of the LRMP are used to demonstrate how the risk assessment framework can be applied to implementation these LRMP objective. We demonstrate the generic framework only for Objective 1 and the 3 indicators (1.1, 1.2 and 1.3). The objectives for 2.1, 3.1 and 5.1 are shown below as they need the same fundamental historic base line information generated.

1. ***Maintain or enhance the distribution and abundance of culturally important botanical species over time.***

Measures/Indicators	Targets

1.1 Area on which the distribution and abundance of culturally important botanical species is consistent with their BEC zone, subzone, site series and natural disturbance regime	No net loss
1.2 Area on which naturally high abundance and quality of culturally important botanical species are retained or restored	No net loss
1.3 Area on which old growth dependent species of interest are present within their natural range of distribution and abundance.	No net loss

These are the other objectives in the LRMP for cultural plants.

2. Maintain and enhance access to area with culturally important botanical species

Measures/Indicators	Targets
2.1 Percent of areas with naturally high abundance of culturally important botanical species where access is retained or restored within 5 years.	100

3. ***Minimize impacts to culturally important botanical species and the ecosystem that support them.***

Measures/Indicators	Targets
3.1 Incidence of impact to important botanical species, and ecosystems that support them, beyond natural disturbance regimes	Zero

Culturally important plants are also referenced under Biodiversity Objectives on page 97 in the LRMP which states:

5.1 . Manage culturally significant ecosystems of concern identified in Table 19, in a manner that ensures a sustainable supply of culturally important attributes, distributed across the plan area, through time

Measures/Indicators	Targets
5.1 Loss of functionality of culturally significant ecosystems (Table 19) at the landscape level.	Not net loss

Identifying a baseline

The LRMP Tables 11 and Table 19 provide a list of culturally important plants and list of culturally important site series. In seeking to establish a natural baseline for cultural plants we reviewed these tables and we classified plants in Table 11 for presence and absence associated with seral stages. This was done to link abundance to seral stages if possible in order to address indicators 1.1, 1.2 and 1.3 from the LRMP table. We also classified species by relative moisture preference in order to assess which plants might be most at risk when considering climate change monitoring (section 5).

The table in Appendix C was derived from LRMP Table 11 and ranks plants for early seral and later seral presence and absence, though very few species are truly seral stage specific. Red clover, fireweed, and dandelion were rated as present only in early forest stages. Some species such as aspen are rarely present in old growth seral stage > 140 years. Epiphytic lichen species are identified as old seral dependent. Appendix C shows abundance by site series but only for old seral stages.

We explored the use of LRMP Table 11 as a means of estimating a natural base line. This was on the presumption that PEM would supply hectares of area in each site series. PEM/TEM type data are not yet available, but it is assumed that TEM/PEM will achieve quality assurances in the future. However, we also note that to achieve this goal, additional work would be required, in particular:

1) We recommend that the 21 species listed in Table 11 for which there is no site series occurrence or abundance estimates shown have this information completed. These plants are listed in Table 7 below.

2) We recommend that prominence classes (% area) be assigned to all cultural plants listed in Table 11 for all sites series in ESSF and SBS zone variants of the LRMP area. Table 8 is included to show how extensive the sites series not included in LRMP Table 11 are. For example in Table 8 the SBSmc2 mesic sites (01 sites series) comprise 232,119 hectares in the LRMP area for which there is no abundance estimate for cultural plants.

3) We recommend that the plants we have noted as absence in Appendix C be confirmed as absent from the LRMP despite their inclusion in LRMP Table 11. For example *Artemisia tridentate* and Douglas fir are shown as present in the SBSdk02. However, we could find no evidence that they are in the LRMP area. Inclusion of plants absent from the LRMP may be explained because the plants in LRMP Table 11 may have been developed for the whole Gitksan - Wet'suwet'en territory, which includes an area larger than the LRMP area.

4) We recommend that epiphytic lichens be collected and identified as to species. LRMP Table 11 lists genus name only but there is considerable variation in habitat preference at the species level. Lichens are very responsive to changes in climate and are recommended as good climate change indicators in Section 5.

It is for these reasons that in the short term site series may not be the approach feasible to establishing the cultural abundance baseline and a seral stage approach is the next best alternative (see discussion under indicators below).

Recommendation 9. In the longer term refine LRMP table 11 and as begun in Appendix C so that site series can be used to define plant baselines in combination with disturbance return intervals and seral stages. In the short term set baseline using disturbance return intervals for seral stages only.

It should be noted that all of the CWH and MH zones are either in parks or in no harvest zones. Setting a baseline against which to measure no net loss in these areas was assumed to be unnecessary as there was no risk of failure to meet plan objectives. The CWH and MH are subject to climate change and but are not included when selecting vegetation monitoring plots (section 5) as the need for adaptation of practices and plans in these areas was considered unlikely.

Table 7. Species lacking in sites series abundance rankings in Table 11 of the LRMP.

Species Name–Latin	Species Name Common	Data Gaps X = no site series/abundance	Data required Site series/abundance	
			Early seral	Mid mature and old
1. Actea rubra	Baneberry	X		
2. Alectoria spp		X		
3. Aquilegia formosa	Red Columbine	X		
4. Aralia nudicaulis	Wild Sarsaparilla	X		
5. Bryoria spp.		X		
6. Cetraria spp.		X		
7. Fritillaria camschatcensis	Riceroot Lily	X		
8. Lycopodium clavatum	Running Clubmoss	X		
9. Malus fusca	Crabapple	X		
10. Peltigera britannica	Freckle Pelt	X		

11. Peltigera spp	Pelts	X		
12. Pyrola asarifolia	Evergreen	X		
13. Ribes divaricatum	Gooseberry	X		
14. Ribes laxiflorum	Wild Currant	X		
15. Rosa acicularis	Prickly Rose	X		
16. Sambucus racemosa	Red Elderberry	X		
17. Taraxacum officinale	Dandilion	X		
18. Thalictrum occidentale	Meadow Rue	X		
19. Usnea spp		X		
20. Vaccinium oxycoccus	Lowbush Cranberry	X		
21. Vaccinium vitis-idaea	Cranberry	X		

Table 8. A summary of site series and area in Candidate Old Growth Management Areas. The bold and larger font highlights the site series from LRMP Table 19 that are considered particularly culturally important in the Wet'sunwet'en territory.

Morice PEM Site Series	Vegetation Class	Total in Morice PEM (ha)	Total in COGMA v1 (ha)	% captured in COGMA v1
ESSFmc 01	moist/mesic	47,500	11,216	23.6%
ESSFmc 02|03	**dry**	**6,549**	**1,108**	**16.9%**
ESSFmc 04	moist/mesic	85,830	11,347	13.2%
ESSFmc 05|06	moist/mesic	20,173	4,089	20.3%
ESSFmc 07	**wet**	**12,340**	**2,501**	**20.3%**
ESSFmc 08	**wet**	**16,313**	**2,375**	**14.6%**
ESSFmc 09|10	**wet**	**8,749**	**2,123**	**24.3%**
ESSFmv 3 01	moist/mesic	12,654	3,583	28.3%
ESSFmv 3 02	dry	1,055	420	39.8%
ESSFmv 3 04	moist/mesic	6,116	1,225	20.0%
ESSFmv 3 05	wet	1,484	375	25.2%
ESSFmv 3 06|07	wet	1,367	427	31.3%
ESSFmv 3 08	wet	1,179	513	43.5%
SBS dk 01	moist/mesic	38,321	2,104	5.5%
SBS dk 02	**dry**	**1,042**	**42**	**4.0%**
SBS dk 03	**dry**	**2,006**	**68**	**3.4%**
SBS dk 05	moist/mesic	19,816	473	2.4%
SBS dk 06	moist/mesic	25,098	1,392	5.5%
SBS dk 07	**wet**	**7,808**	**298**	**3.8%**
SBS dk 08	**wet**	**5,353**	**436**	**8.1%**
SBS dk 09	**wet**	**501**	**28**	**5.6%**
SBS dk 10	**wet**	**183**	**0**	**0.0%**
SBS mc 2 01	moist/mesic	232,119	20,238	8.7%
SBS mc 2 01c	dry	63,101	3,184	5.0%
SBS mc 2 02	dry	4,502	458	10.2%
SBS mc 2 03	moist/mesic	18	1	4.3%
SBS mc 2 05|06	moist/mesic	170,137	23,208	13.6%
SBS mc 2 09	wet	48,783	7,504	15.4%

SBS mc 2 10	wet	62,372	6,457	10.4%
SBS mc 2 12|07	wet	5,184	373	7.2%
SBS wk 3 01	moist/mesic	13,035	1,248	9.6%
SBS wk 3 02	dry	62	36	57.9%
SBS wk 3 03	dry	1,768	203	11.5%
SBS wk 3 04	moist/mesic	38	3	7.6%
SBS wk 3 05	moist/mesic	14,447	1,700	11.8%
SBS wk 3 06	moist/mesic	2,201	378	17.2%

Indicator 1: Area on which the distribution and abundance of culturally important botanical species is consistent with their BEC zone, subzone, site series and natural disturbance regime

Discussion. The range of natural seral stages created by disturbance agents is the natural baseline from which cultural plants would have been historically available. To establish the parameters around this baseline it is necessary to reconstruct probable seral stage distribution by BEC zone. The fire disturbance return interval is best understood. Steventon 2001 in review of stands established from 1800 to 1970 in the Lakes and Morice area found that the mean fire return interval for stand replacing events in the SBSdk was 93 years, the SBSmc was 133 years and the ESSFmc was 219. In a provincial review of disturbance ecology, (Wong et al 2002) it is indicated that the fire return intervals for stand replacing events as predicted by Biodiversity Guidebook for the SBSdk was 125 years, SBSmc was 125 years and ESSFmc was 200. This is similar to Steventon 2001 and therefore adopting the BGB seral stage maximums (early seral) and minimums (old) to set the natural cultural plants baseline is reasonable (Table 9).

Table 9. Example baselines, applying the negative exponential equation based on Natural Disturbance Intervals

BEC variant	Return interval	Predicted % <40 years	Predicted % >140 years
SBSdk	93	34%	22%
SBSmc	125	27%	33%
ESSFmc	200	18%	50%

Though seral stage by LU/BEC is recommended as the initial approach the historic baseline and distribution can also be in improved with better traditional knowledge of specific areas used for specific plants by First Nations. The knowledge may still exist as to which areas were culturally managed by burning to maintain early seral condition. Interviews with elders are recommended as a means to improve the natural baseline.

It is also recommended that improvements be made in this baseline based sites series and abundance as discussed earlier and plant specific abundance in site series be used once PEM has been improved. This will reduce uncertainty over use of seral stage alone.

Indicator 1 Assessing and reporting: Use seral stages and calculate natural baseline targets for LU/BEC variants (see Table 9). Include the entire LRMP landbase. Table 10 is an example of the data needed to set targets and assign risk based on surplus/deficits. Risk classes are defined in Table 12 for the LRMP indicators. To assess whether the objective has been meet summarize targets for variants and compare to current forest cover condition. Then using Table 12 assign risk values to LU/BECs.

Table 10. Example of data roll-up for Indicator 1.

Landscape Unit / BEC variant	% of zone in grazing lease **	Successional stages															
		Early Max				Mid Minimum				Mature Minimum				Late/old forest Minimum			
		Target (Table 13 %) X area	Actual (ha)	Surplus/ Deficit	Risk Class	Target	Actual	Surplus/ Deficit	Risk Class	Target	Actual	Surplus/ Deficit	Risk Class	Target %	Actual	Surplus/ Deficit	Risk Class
LU 1 SBSdk		34												22			
LU 1 SBSmc		27												33			
LU 2 ESSFmc		18												50			
Roll up to BEC/territory*																	

* When all LUs are considered is there a deficit or a surplus of plants based on natural disturbance seral stages?

** Since cultural plants are subject to grazing leases it is important to account for GL and determine where these are in terms of LU/BECs. The LRMP indicates that grazing leases restrict access to culture plants to plants that are surpluses after grazing.

Based on changes in seral stages it will be possible to infer whether there is a loss in abundance at the BEC zone level based on this level of assessment.

Indicator 2 Area on which naturally high abundance and quality of culturally important botanical species are retained or restored

Discussion. Culturally important plants and their relative abundance are listed in Table 11 in the LRMP. It is presumed that prominence and abundance ratings were developed from BEC sample plots in mature and old forests since there was no sampling of earlier seral stages during BEC classification. This table was reviewed earlier in the report with recommends for improvement. It is also not entirely clear from this indicator what "high abundance" means. Abundance classes 1 to 5 in Table 11 are defined as follows: 1= <1% of the area in the sites series, 2 is = 1% - 5%, 3 = 5% - 10%, 4 =10 - 25% and 5 => 25%. These abundance or prominence ratings need to be assigned to all sites series in the SBS and ESSF zones to generate an area estimate in terms of hectares occupied by each plant but they would only be accurate for mature and old seral stages. To account for plant abundance differences in early seral stages it is necessary to assume a difference in abundance to account for seral stage differences. It is recommended that early seral sampling abundance be done to confirm actual differences in abundance between early seral and late seral stages. Early seral stage sampling is not considered practical for all site series however especially that are not extensive in the LRMP area– a focus on sampling of xeric, mesic and hygric sites as outlined in Section 5 is recommended to improve abundance relationships in key areas of the landbase. Once this is done the abundance estimates can be improved and the baseline established.

Proposed approach for monitoring/reporting on indicator 2 abundance.

Complete the abundance ratings for the 155 plants identified in LRMP Table 11 for all sites series in the SBS and the ESSF variants for early seral stage as in the example in Table 11 below. Assume that mid, mature and old abundance are the same and as shown in LRMP Table 11. The relative increase in abundance between early seral would be new information provided initially be vegetation specialists. Sampling of early seral (as suggested in section 5) could provide quantified data for some of the most extensive site series. Table 11 in this report is a subset of list of cultural plants which has simply had early seral columns added and abundance estimated to illustrate the concept of accounting for seral stage differences. Once the table is completed a natural baseline can be developed if one were to assume that seral stages for each site series had the maximum early seral stages and minimum old based on natural disturbance then it is possible to create a baseline in terms of area in hectares for each plant using PEM to supply site series area. Using this baselines as with indicator 1 it is now possible to assess current condition of the sites series (seral stage) and assign a risk class per plant as per Table 12.

Table 11. Estimated abundance late seral and early seral by site class.

Species Name–Latin	Species Name–Common	Soil Moisture	ESSFmc/02	ESSFmc/02 early seral estimated	Area (ha(s in site series PEM	Natural baseline			Current condition			Current Risk
						Assumed young	Assumed not young	Ha occupied by plants	Actual young	Actual no young	Total ha estimated	Use risk classes table 12 (risk threshold indicator 2)
Dicranum fuscescens	Curly Heron's Bill Moss	D	3	4								
Juniperus communis	Common Juniper	D	2	3								
Sherperdia canadensis	Soapberry	D	1	2								

Old growth seral stage plant abundance 1= <1% of the area in the sites series, 2 is =1%-5%, 3 = 5%-10%, 4=10 to25% and 5 => 25%.

Indicator 3 Old growth dependent botanical species

Area on which old growth dependent species of interest are present within their natural range of distribution and abundance.

Discussion. In Appendix C we rank species as to their dependence on old growth seral stage, based on LRMP Table 11. We conclude that epiphytic lichens are the only strongly linked old growth species. There were four genuses of lichens but only one Lungwort (*Lobaria pulmonaria*) is the identified to the species level. Three other genuses are named 1) Witch's hair lichen *Alectoria spp*, 2) Speckled horse hair (*Byoria spp*) and 3) Arboreal lichen *Usnea spp*. Each genus has many species each with a somewhat different ecological niche. It will be necessary to sample and identify these before natural abundance baselines can be established. (Trevor Goward pers. comm.). Lichens are more abundant in stands with older forests but can also be present in mature and mid seral stages at lower densities. All the plants identified as old forest dependent lack site series abundance ratings and are among the group of 21 identified in Table 7. Lichens respond to atmospheric moisture such as dew and fog. High rainfall washes nutrients out of the canopies and therefore is not conducive to abundance lichen growth. There is a relationship to site types as well as soil types provided there is older stand structure. Generally lichen abundance is higher on sites that have the oldest trees. Therefore it also be possible to develop an initial baseline abundance on age class giving higher rankings to age class 9 (250+ years), somewhat lower abundance to age class 8 (141 to 249 years) and the lowest abundance to age class 7 (120 to 140 years).

Epiphytic lichens may possibly be the best vegetative indicator of climate change because they are so directly dependant on atmospheric conditions and respond relatively quickly (Trevor Goward pers. comm.).

Proposed Approach for LRMP level Monitoring and reporting on indicator 3.

Establish a baseline for old growth species based on natural disturbance intervals in Table 9. Assess the current condition LU/BEC variants as done for indicator 1.1. This is will be the same as the Late/old seral risks as already calculated for indicator 1.1. In time improve the estimate based on improved lichen species identification and their links to site series. Then use sites series occurrence and abundance estimates and PEM/TEM sites series to set a new plant species baselines.

STEP 4. Forecast the Trends

The previous section we outline how to apply the risk framework to 3 indictors, set a natural baseline and assess current condition and assign risk classes. To forecast indicators it is recommended that this be done by linking seral stages to timber supply forecasts and reporting on changes to risk in LU/BEC variants based on assumptions used model timber supply.

STEP 5. Set risk classes

The following tables are suggested as starting point for risk thresholds for indicators. The tables provide a relative measure of risk and can be applied at difference scales i.e. BEC variant, LU/variant. The percentages breaks are arbitrary but the principle is that the when the current condition meets or exceeds the baseline condition for the area assessed risk will be less and higher the level of deviation from the natural condition the greater the risk. The numbers to generate the percentages are from expected seral stages (baseline) when compared to current seral stages or future projected seral stages. Note that the risk classes used are generic, but based on a variety of reviews of a wide range of responses to habitat change (CIT 2004; Price et al. 2007 submitted). The risk thresholds can be altered by participants – however, a crucial aspect of ERA is in explicitly identifying assumed risk curves.

Table 12. Proposed risk thresholds for the three indicators.

Risk threshold indicator 1. Area on which the distribution and abundance of culturally important botanical species is consistent with their BEC zone, subzone, site series and natural disturbance regime.		
Risk Class (Probability that LRMP objectives failing)	**Description Based on deviation from base case**	**Actions best able to reduce risk**
Very low or low	There is likely no net loss of culturally important botanical plants because current condition are at or below the natural baseline (threshold).	N/A
Moderate	There is likely some net loss of culturally important botanical plants because the areas assessed is 30% below the natural threshold (baseline)	Confirm that areas and plants affected. Review stressors
High	There is likely significant loss in the availability of culturally important plants because the areas assessed is 31% to 60% below the natural threshold (baseline)	Confirm that areas and plants affected and review adaptive management options.
Very High	There is likely significant loss of culturally important botanical plants because the areas assessed is 60% below the natural threshold (baseline).	Major review and commitment to adapt plan or practices as appropriate.

Risk threshold indicator 2. Area on which naturally high abundance and quality of culturally important botanical species are retained or restored		
Risk Class (Probability that LRMP objectives failing)	**Description**	**Adaptation actions**
Very low Or low	There is likely no net loss of culturally important botanical plants because current condition are at or below the natural	None

	baseline (threshold).	
Moderate	There is likely some net loss of culturally important botanical plants because the areas assessed is 30% below the natural threshold (baseline)	Confirm that areas and plants affected.
High	There is likely significant loss in the availability of culturally important plants because the areas assessed is 31% to 60% below the natural threshold (baseline)	Confirm that areas and plants affected and review adaptive management options.
Very High	There is likely significant loss of culturally important botanical plants because the areas assessed is 60% below the natural threshold (baseline).	Major review and commitment to adapt plan or practices as appropriate.

Risk Threshold indicator 3. Area on which old growth dependent species of interest are present within their natural range of distribution and abundance.		
Risk Class (Probability that LRMP objectives failing)	**Description**	**Adaptation actions**
Very low or low	There is likely no net loss of culturally important botanical plants because current condition are at or below the natural baseline (threshold).	None
Moderate	There is likely some net loss of culturally important botanical plants because the areas assessed is 30% below the natural threshold (baseline)	Confirm that areas and plants affected.
High	There is likely significant loss in the availability of culturally important plants because the areas assessed is 31% to 60% below the natural threshold (baseline)	Confirm that areas and plants affected and review adaptive management options.
Very High	There is likely significant loss of culturally important botanical plants because the areas assessed is 60% below the natural threshold (baseline).	Major review and commitment to adapt plan or practices as appropriate.

STEP 6. Report results and develop risk reduction strategies

At this point in the analysis there would be results and at a minimum an assessment of current risk to an indicator. This would inform and guide decisions on the whether the LRMP objective is likely to be met and what actions are best able to reduce risk if not. Using the information developed in the proposed framework means that effective risk reduction strategies become clearer and may include projects to improve inventories, a re -assessment of risk analysis by altering uncertain assumptions (testing assumption sensitivities), review of practices, and change in plans objectives, communications on improvements to practices etc. Scheduling and reporting of LRMP monitoring may be more effective when it is planned to provide information prior to revision dates of the SFMP and FSPs. The SFMP coordinates a number of strategy initiatives in the LRMP and making know sources of risk and uncertainty may gain support for projects through the SFMP

In an adaptive management cycle such as the LRMP with many agencies and many participants, the assessment needs to be structured as much as possible to partition the responsibility and to inform decision makers and agencies responsible. This is the approach that has been taken in the SFMP between licensees when partitioning responsibility to ensure that the LRMP objectives have been met.

4.2 Improving important cultural plant baselines through FN consultation

The LRMP identifies five First Nations with traditional territories in the Morice LRMP area: 1) the Lake Babine Nation, 2) the Yekooche First Nation, 3) the Carrier Sekani 4) the Cheslatta Carrier Nation and 5) Wet'suwet'en First Nation with communications to the LRMP from the Office of the Wet'suwet'en. The information on site series and plants (LRMP Tables 11 and 19) was supplied by the Wet'suwet'en. Use of these Tables for implementation assumes that other FN uses the same plants and values the same sites series in their territories equally. Though there is likely overlap in cultural plant use it is advisable to confirm from elders, to the extent possible, the ethno botanical use of culturally important plants for other FNs, and particularly in the northern half of the LRMP area.

First Nation information on epiphytic lichen species is also needed to complete the list of cultural plants as these have been identified to genus level only in Table 11. Currently the epiphytic lichens in the genus *Usnea, Byoria* and *Alectoria* contain numerous species with different ecological niches. It is recommended that lichen samples be taken for identification to improve abundance baselines. The FREP consultation evaluation questionnaires may be useful as a means to engage FN and provide new information through an interview component.

Recommendation 10. Propose a project to improve understanding of traditional knowledge (TK) linked to epiphytic lichens. Sample lichens for identification to improve baseline and seek insight in TK on use and collection areas for the entire LRMP.

5. Monitoring to detect vegetation response to climate change

This section of the report provides a framework for monitoring vegetation response to climate change. A vegetation monitoring project would require a commitment to establish the plots and collect the baseline data and then a commitment to sampling and analysis at periodic intervals. The start up costs for this monitoring are considered to be highest as they require a review of the existing climate and vegetation plots to determine their suitability and well as the statistical sampling design, and field data collection costs.

We recommend vegetation baseline plots be established as soon as practical and that existing plots be given preference as these afford an opportunity to back cast in time and assess whether a trend is already quantifiable. It is recommended that vegetation sampling capture the diversity of ecosystems and include the following strata:

1) non forested ecosystems,
2) listed rare and endangered ecosystems,
3) forested ecosystems with sampling to include
    a) xeric,
    b) mesic and
    c) hygric sites

with replicates in a) early and b) late seral forest stages for each of major BEC variants in the LRMP.

Sites in close proximity to existing Fire Weather Index stations and other Environment Canada maintained climate stations should be given priority when possible.

It is recommended that the monitoring be designed to address a number of values that depend on vegetation if possible, for example the arboreal lichen trend may in future provide insight into winter forage availability for the Telkwa caribou.

This section of the report discusses factors to consider for plot level vegetation monitoring with regard to maintaining LRMP objectives. Plot level monitoring is advocated as opposed to landscape level monitoring as the data is more conclusive than changes at the landscape level with regard to detecting vegetation trends. Climate change affects the entire LRMP but some ecosystems are expected to respond more dramatically and at different rates.

It is recommended that sampling reflect the diversity of BEC variants and site types in the LRMP. Table 13 provides a stratification of the diversity of ecosystems in the LRMP. Xeric sites are expected to respond sooner to changes in moisture and temperature than mesic and hygric sites. Finding xeric sites that are in relatively natural condition may be difficult at lower elevations. Monitoring heavily grazed areas will mask ecosystem shifts such as changes to temperature (degree growing days) and precipitation (moisture deficits). Monitoring of both forest and non forested sites is considered necessary to inform on zonal shifts.

Questions that will be addressed through monitoring are:

1) Is data from climate stations trending?
2) How are ecosystems responding? (species composition, increasers and decreasers)
3) Which ecosystems are most affected?
4) What LRMP objectives may be most affected by changes?

Table 13. Proposed vegetation sampling strata to represent ecosystem diversity and seral stages in the LRMP.

BEC variants	Climate stations	Existing Plots BEC/ PSP	Successional stage	xeric	mesic	hygric
SBSdk			Early seral			
			Old Growth			
			Non forested ecosystems			
			Rare site series			
SBSmc2			Early seral			
			Old Growth			
			Non forested ecosystems			
			Rare site series			
ESSFmc			Early seral			
			Old Growth			
			Non forested ecosystems			
			Rare site series			
CWH			Early seral			
			Old Growth			
			Non forested ecosystems			
			Rare site series			

There are a number of considerations in addition to sampling the moisture gradient and seral stage differences to consider for such a monitoring project. In terms of climate change and what to monitor we consider plants with low abundance occurring on a few site series as well as those on dry sites to be most at risk of loss from changes in climate. It is recommended that the location of rare ecosystems (Appendix A) be confirmed in the LRMP and that vegetation monitoring plots be placed in some of these rare listed ecosystems to establish a baseline. There may be other site series that are rare but not listed that could also have vegetation plots established now as a baseline.

Interpreting information from early seral stages sampling is problematic for climate change because plant dominance is confounded due to successional change as well as regional climate change. These early seral plots have been included because BEC vegetation plots were placed only in forests greater than 140 years old, and so abundance classes in Table 11 reflect mature and old growth forest abundances. Sampling early seral provides better estimates of cultural plant abundance and therefore refines the LRMP abundance estimates.

Monitoring in old growth is recommended but the expectation for change detection in long lived plants such as tree species may be slow in the absence of natural stand level disturbance. Therefore old growth forests and understory plants are expected to display relatively slow response to change in climate in comparison to other sites such as non forested dry sites and sites where plants are establishing and new species may be establishing in greater numbers or for the first time, (e.g. range shifts such as hemlock on what was a spruce site). Old growth with interior forest habitat also influence within stand microclimate and understory plants are somewhat insulated from changes in climate in comparison to other sites. Although this may be generally true xeric old growth pine lichen sites are expected to show changes in terrestrial lichen components with only slight increases in summer moisture. It may be hard to find pine lichen sites where the pine overstory survives the current MPB epidemic.

The only species we classify as old growth obligates are epiphytic lichens (Appendix C). These species do respond rapidly to climate change as their habitat suitability is driven primarily by the atmosphere and therefore these organisms may be the earliest populations to indicate climate change. Consideration needs to be given on how to sample arboreal lichen diversity and measure abundance accurately. Ideally the BEC plot review would also include areas used traditionally for lichen collection. This would require more information on historically used old growth forest collection areas in the LRMP. There is also a need to identify which species of Alectoria, *Byroria* and *Usnea* are present and if possible more information on the traditional use of these species.

Where it occurs, cattle grazing will mask climate change impacts on vegetation so monitoring plot selection needs to consider likelihood of grazing.

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Appendix A: Rare Ecosystems, identified from CDC.

It is recommended that the location of these rare ecosystems be confirmed in the LRMP and that vegetation monitoring plots be placed in some of these rare ecosystems to establish a baseline.

Description	Scientific Name	English Name	Global Rank	Prov Rank	BC Status CDC	Track	BGC	Endemic
Forest upland	*Pinus albicaulis / Cladonia spp. - Dicranum fuscescens*	whitebark pine / clad lichens - curly heron's-bill moss	GNR	S3	Blue	Y	**ESSFmk/02;ESSFmk/03**	
Forest upland	*Pinus contorta / Carex pauciflora / Sphagnum spp.*	lodgepole pine / few-flowered sedge / peat-mosses	GNR	S2S3	Blue	Y	**ESSFmc/11;ESSFmc/Wb10**;ESSFwc3/04;ESSFwc3/Wb10;ICHwk2/10;ICHwk2/Wb10;**SBSmc2/15;SBSmc2/Wb10**	
Forest upland	*Pinus contorta / Juniperus communis / Oryzopsis asperifolia*	lodgepole pine / common juniper / rough-leaved ricegrass	GNR	S3	Blue	Y	**SBSdk/02**	
Forest upland	*Pinus contorta / Vaccinium membranaceum / Cladina* spp.	lodgepole pine / black huckleberry / reindeer lichens	G3	S3	Blue	Y	SBSvk/09;SBSwk1/02;SBSwk2/02;**SBSwk3/02**	Y
Forest swamp	*Populus balsamifera* (ssp. *balsamifera*, ssp. *trichocarpa*) - *Picea* spp. / *Cornus stolonifera*	(balsam poplar, black cottonwood) - spruces / red-osier dogwood	GNR	S2	Red	Y	BWBSdk1/12 ;BWBSdk1/Fm02 ;BWBSmw1/09 ;BWBSmw1/Fm02 ;ICHwk4/10 ;ICHwk4/Fm02 ;**SBSdk/08**;SBSwk1/13 ;SBSwk1/Fm02	
Forest upland	*Pseudotsuga menziesii - Picea engelmannii* x *glauca / Rubus parviflorus*	Douglas-fir - hybrid white spruce / thimbleberry	GNR	S3	Blue	Y	SBSdh1/06;SBSdw1/06;SBSmh/01;SBSmh/05;SBSmh/06;SBSvk/03;**SBSwk3/03**;SBSwk3a/01;SBSwk3a/03	
Forest upland	*Pseudotsuga menziesii / Pleurozium schreberi - Hylocomium splendens*	Douglas-fir / red-stemmed feathermoss - step moss	G3	S3	Blue	Y	IDFdk3/05;IDFdk4/07;IDFxm/05;IDFxm/06;**SBSdk/04**	Y
Forest riparian	*Alnus incana / Cornus stolonifera / Athyrium filix-femina*	mountain alder / red-osier dogwood / lady fern	GNR	S3	Blue	Y	ICHmc2/Fl02;ICHvc/52;ICHvc/Fl02;ICHwc/52;ICHwc/Fl02;ICHwk1/Fl02;ICHwk4/Fl02;**SBSdk/Fl02**;SBSmk2/Fl02;SBSvk/Fl02;SBSwk1/Fl02	
Shrub upland	*Amelanchier alnifolia / Elymus trachycaulus*	saskatoon / slender wheatgrass	GNR	S2	Red	Y	**SBSdk/81**	
Fen wetland	*Carex lasiocarpa / Drepanocladus aduncus*	slender sedge / common hook-moss	GNR	S3	Blue	Y	BWBSdk1/Wf05;ICHdk/Wf05;ICHmc1/Wf05;ICHmc2/Wf05;ICHmw1/Wf05;ICHmw3/Wf05;ICHvk1/Wf05;ICHwk1/Wf05;ICHwk2/Wf05;IDFdk1/Wf05;IDFdk3/Wf05;IDFdk4/Wf05;IDFdm2/Wf05;MSdk/Wf05;MSdm1/Wf05;MSdm2/Wf05;MSdm3/Wf05;MSdm3w/Wf05;SBPSdc/Wf05;SBPSmk/Wf05;SBPSxc/Wf05;**SBSdk/Wf05;SBSmc2/Wf05**;SBSmk1/Wf05;SBSwk1/Wf05	
Fen Wetland	*Carex limosa - Menyanthes trifoliata / Drepanocladus* spp.	shore sedge - buckbean / hook-mosses	GNR	S3	Blue	Y	ESSFwc3/Wf08;ESSFxc/Wf08;ESSFxv1/Wf08;MSdc1/Wf08;MSdc1d/Wf08;MSdm3/Wf08;MSdm3w/Wf08;MSmw1/Wf08;MSxk/Wf08;MSxv/Wf08;SBPSdc/Wf08;**SBSdk/Wf08;SBSmc2/Wf08**;SBSmk2/Wf08;SBSwk1/Wf08	
Marsh Wetland	*Eleocharis palustris* Herbaceous Vegetation	common spike-rush	GNR	S3	Blue	Y	BGxw2/Wm04;CDFmm/Wm04;ESSFdv d/Wm04;ESSFdv/Wm04;IDFxm/Wm04;**SBSdk/Wm04**;SBSmk2/Wm04	
Fen Wetland	*Eleocharis quinqueflora / Drepanocladus* spp.	few-flowered spike-rush / hook-mosses	GNR	S2	Red	Y	**ESSFmc/Wf09**;ESSFxc/Wf09;ESSFxv1/Wf09;MSdm2/Wf09;MSxv/Wf09;SBPSxc/Wf09;**SBSmc2/Wf09**	
Marsh Wetland	*Equisetum fluviatile - Carex utriculata*	swamp horsetail - beaked sedge	GNR	S3	Blue	Y	BGxh2/Wm02;BWBSdk1/Wm02;ESSFmw/Wm02;ICHmw3/Wm02;ICHwk4/Wm02;IDFdm2/Wm02;MSdc2/Wm02;MSdm3/Wm02;MSdm3w/Wm02;MSmw2/Wm02;MSxk/Wm02;MSxv/Wm02;SBPSdc/Wm02;SBPSmk/Wm02;SBPSxc/Wm02;**SBSdk/Wm02**;SBSdw3/Wm02;SBSmk2/Wm02;SBSwk1/Wm02	
Fen Wetland	*Eriophorum angustifolium - Carex limosa*	narrow-leaved cotton-grass - shore sedge	GNR	S3	Blue	Y	ESSFdc1/Wf13;ESSFdc3/Wf13;**ESSFmc/Wf13**;ESSFmw/Wf13;ESSFwc2/Wf13;ESSFxc/Wf13;MSdm1/Wf13;SBSwk2/Wf13	
Fen Wetland	*Menyanthes trifoliata - Carex lasiocarpa*	buckbean - slender sedge	GNR	S3	Blue	Y	CDFmm/Wf06;CWHws1/Wf06;ICHwk1/Wf06;IDFdk2/Wf06;**SBSdk/Wf06**	
Grassland	*Poa secunda* ssp. *secunda - Elymus trachycaulus*	Sandberg's bluegrass - slender wheatgrass	GNR	S1	Red	Y	**SBSdk/82**	
Swamp Wetland	*Salix bebbiana / Calamagrostis canadensis*	Bebb's willow / bluejoint reedgrass	GNR	S3	Blue	Y	BGxw1/Ws03;**SBSdk/Ws03**	
Swamp Wetland	*Salix maccalliana / Carex utriculata*	MacCalla's willow / beaked sedge	GNR	S3	Blue	Y	ESSFdv d/Ws05;ESSFdv/Ws05;ESSFxc/Ws05;IDFdk1/Ws05;IDFdk3/Ws05;IDFdk4/Ws05;MSdm1/Ws05;SBPSmk/Ws05;SBPSxc/Ws05;SBSdh1/Ws05;**SBSdk/Ws05**	
Bog Wetland	*Scheuchzeria palustris / Sphagnum spp.*	scheuchzeria / peat-mosses	GNR	S3	Blue	Y	ICHmc2/Wb12;ICHmk3/Wb12;SBSdw3/Wb12;**SBSmc2/Wb12**;SBSvk/Wb12	
Fen Wetland	*Trichophorum alpinum / Scorpidium revolvens*	Hudson Bay clubrush / rusty hook-moss	GNR	S2	Red	Y	CWHxm1/Wf10;**SBSmc2/Wf10**;SBSmk2/Wf10	

Appendix B. Permanent Sample Plot current data standards

The Resource Inventory Committee Standards (RICS) March 2003 Version are shown in the tables below, and the data collection form in 'Appendix 25'. Some of the 1990 plots may provide a monitoring site. The circular PSP plots are smaller than BEC 20 by 20 meter plots.

Collecting Ecological Data and Permanent Sample Plots.

All samples established in natural stands are ecologically assessed. The PSPS collect and record Ecological data to the Biogeoclimatic Ecosystem Classification (BEC) site series level. See Appendix 25. If it is not possible to collect the ground data at the time of measurement, at minimum, obtain the BEC Zone, Sub-Zone, and Variant.[25]

Chapter 1: Establishing PSPs in Natural Stands Chapter 1: Establishing PSPs in Natural Stands

Plots sizes for Permanent sample sizes

Stand type	Sample area	Plot radius	Stems/ha
Open Stands	0.09 ha	17.84 m	<600 -1000
Basic	0.08 ha	15.96m	1000-1500
Dense Stands	0.07 ha	14.93 m	1500 – 2000+

Appendix 25: Minimum Data Collection Requirements for Ecological Field Forms (FS 882)

Site Form

1. Date (Y/D/M)
2. Plot number
3. Surveyor(s)
4. General location
5. Forest region
6. Mapsheet
7. UTM (zone, easting and northing) or latitude and longitude
8. Site diagram
9. Plot representing
10. Biogeoclimatic unit
11. Site series
12. Transition/Distribution
13. Moisture regime
14. Nutrient regime
15. Successional status
16. Structural stage
17. Site disturbance
18. Elevation
19. Slope
20. Aspect
21. Meso slope position
22. Surface topography
23. Exposure type (if applicable)
24. Surface substrates (organic matter, decaying wood, bedrock, rocks, mineral soil, water)

Soil Form

1. Plot number
2. Surveyor(s)
3. Bedrock (at least to general level, where significant to site)
4. Coarse fragment lithology (at least to general level)
5. Terrain texture, surficial material, surface expression
6. Soil classification (to subgroup)
7. Humus classification (at least to group)
8. Hydrogeomorphic unit (at least to system)
9. Rooting depth
10. Rooting zone particle size
11. Root restricting type and depth (if applicable)
12. Water source (if applicable)
13. Seepage depth (if applicable)
14. Soil drainage
15. Flooding regime (if applicable)
16. Organic horizons/layers; for each: horizon/layer code depth
    - mycelial abundance
    - fecal abundance
    - von Post (for organic soils)
17. Mineral horizons/layers; for each: horizon/layer code
    - depth
    - colour (when required for diagnostic purposes)
    - colour aspect (when colour entered)
    - soil texture (< 2 mm fraction)
    - % coarse fragments (gravel, cobbles, stones, and total)
    - comments (especially mottles)
18. Profile diagram
19. Notes

[25] http://ilmbwww.gov.bc.ca/risc/pubs/teveg/g&y2k3/g&y_standards_procedures2k3.pdf

Vegetation Form

1. Surveyor(s)
2. Plot Number
3. % cover by layer (A, B, C, D)
4. Species by layer
5. Cover for each species by layer and sublayers
6. Note

B.C. Ministry of Forests, Research Branch, 1999

Appendix C. Culturally important plants.

Culturally important plants identified in the SBS and ESSF zones of the Morice LRMP and their soil moisture and seral stage preferences. NF – Non Forested. Soil Moisture D = dry, M = intermediate, W = wet AQ = aquatic NA = not applicable Abundance/Prominence classes 1. The plants in this table are sorted by soil moisture preferences.

Species Name–Latin	Species Name–Common	Soil Moisture	Old	Mature	Mid seral	arly Seral	ESSFmc/02	ESSFmc/07	ESSFmc/08	ESSFmc/09	ESSFmc/10	ESSFmc/31	ESSFmk/02	SBSdk/02	SBSdk/03	SBSdk/04	SBSdk/07	SBSdk/08	SBSdk/09	SBSdk/10	SBSdk/31	SBSdk/32	SBSdk/81	SBSdk/82	SBSmc2/02	SBSmc2/03	SBSmc2/09	**SBSmc2/10**	**SBSmc2/12**	**SBSmc2/31**
Menyanthes trifoliata	Buckbean	AQ	N	N	N	N																								
Calla palustris	Wild Calla	AQ	N	N	N	N																							1	1
Potentilla palustris	Marsh Cinquefoil	AQ	N	N	N	N													2	2	2	2								
Achillea millefolium	Yarrow	D	•	•	•	•								2		1							1	3	1	1				
Arctostaphylos uva-ursi	Kinnikinnick	D	•	•	•	•								4	4	1							1	1	2	1				
Dicranum fuscescens	Curly Heron's Bill Moss	D	•	•	•	•	3	3	3	1	1		4																	
Juniperus communis	Common Juniper	D	•	•	•	•	2							2	1								2							
Peltigera aphtosa	freckle pelt	D	•	•	•	•								1	3										1	1				
Sherperdia canadensis	Soapberry	D	•	•	•	•	1							2	3	5									1	1				
Spiraea betulifolia	Birch-Leaved Spirea	D	•	•	•	•								1		3														
Viola adunca	Violet	D	•	•	•	•										2									3	3				
Alium cernuum	Wild Onion	D	•	•	•	•																	2	2	2					
~~Artemisia tridentata~~	~~big sagebrush~~	~~D~~	N	N	N	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	~~1~~	-	-	-	-	-
Cetraria spp.	icelandmoss lichens	D	•	•	•	•																								
Cladina spp	Reindeer Lichens	D	•	•	•	•	4					1	3	3	2				1											
Cladonia spp	Cladonia Licherns	D	•	•	•	•	4					1	2												3					
Elymus trachycaulus	Slender Wheatgrass	D	N	N	N	N										1							3	3						
Koeleria	June Grass	D	N	N	N	N																	3	5						
Rhacomitrium spp.	Rock Mosses	D	•	•	•	•																								
Stipa spp.	Needle Grasses	D	•N	•N	•N	•N																	3	5						
Carex spp.	Sedges	D-AQ	•	•	•	•			2	2	2	5							2	5	3	5							2	4
Salix spec.	Willow	D-AQ	N	•N	•N	•N		1			1	4		1	1		3	2		1					1		2	2	3	3

Species Name–Latin	Species Name–Common	Soil Moisture	Old	Mature	Mid seral	arly Seral	ESSFmc/02	ESSFmc/07	ESSFmc/08	ESSFmc/09	ESSFmc/10	ESSFmc/31	ESSFmk/02	SBSdk/02	SBSdk/03	SBSdk/04	SBSdk/07	SBSdk/08	SBSdk/09	SBSdk/10	SBSdk/31	SBSdk/32	SBSdk/81	SBSdk/82	SBSmc2/02	SBSmc2/03	SBSmc2/09	**SBSmc2/10**	**SBSmc2/12**	**SBSmc2/31**
Amelanchier alnifolia	Saskatoon	D-M	●	●	●	●								2		1		1					4		1	1				
Anemone multifida	Cut-Leaf Anemone	D-M	●	●	●	●																	1	1	2					
Fragaria vesca	Strawberry	D-M	●	●	●	●	1							2	2	2	1						1	1	1	1				
Lathyrus nevadensis	Purple Peavine	D-M		●	●	●											3	2					2	3						
~~Daucus carrota~~	~~Wild Carrot~~	D-M	-	-	-	N																								
Populus tremuloides	Trembling Aspen	D-M		●	●	●								1	1		3													
Prunus pensylvanica	Wild Cherry	D-M			●	●																			2					
Pseudotsuga menziesii	Douglas Fir	D-M	●	●	●	●										5														
~~Rosa canina~~	~~Rose~~	D-M				N																								
Symphoricarpus albus	Common Snowberry	D-M	●	●	●	●								1				2					4	4	3					
Abies lasiocarpa	Subalpine Fir	D-W	●	●	●	●	3	5	5	4	5		3												1	1	3	3		
Acer glabrum	Douglas Maple	D-W	●	●	●	●																			1					
Alnus sinuata	Sitka Alder	D-W	●	●	●	●		1									2	2							1	1	1		1	
Alnus crispa	Sitka Alder	D-W	●	●	●	●																								
Anaphalis magaritacea	Pearly Everlasting	D-W		●	●	●																								
Barbilophozia spp	Leafy Liverworts	D-W	●	●	●	●	2	1	3	2	2		3																	
Betula papyrifera	Paper Birch	D-W		●	●	●											1								2	2	1	1		
Brachythecium spp	Ragged Mosses	D-W	●	●	●	●		4	2	1	3	3																		
Castilleja miniata	Indian Paintbrush	D-W			●	●	2							2									1		2	2				
Cornus canadensis	Bunchberry	D-W	●	●	●	●	2	2		1	1				1		3								2	3	2	2	2	
Dicranum spec.	Heron's- Bill Mosses	D-W	●	●	●	●																								
Empetrum nigrum	Crowberry	D-W	●	●	●	●	2						1																	
Ephilobium angustifolium	Fireweed	D-W				●	1	2	1	1	1						4	1						4	3	1	1	1		
Hylocomium splendens	Step Moss	D-W	●	●	●	●				3					2	5	3			4									1	
Lupinus spp.	Lupines	D-W	●	●	●	●																								
Peltigera britannica	Freckle Pelt	D-W	●	●	●	●																								
Peltigera spp	Pelts	D-W	●	●	●	●																								

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Picea glauca/engelman.	White/Engelmann Spruce	D-W	●	●	●	●	2	1		4	2					1	5	2		3					1	1	3	4	1	1
Pinus contorta	Lodgepole Pine	D-W	●	●	●	●	2						1	5	5		2								3	3	1	1		
Pleurozium schreberi	Redstemmed Feathermoss	D-W	●	●	●	●	1	2	2	3	2		3	1	5	4	3		4	3										
Poa spp.	Blue Grasses	D-W	●	●	●	●																	3	5						
Ptilium crista-castrensis	Knight's Plume	D-W		●	●	●									1		3			1									1	
Ribes lacustre	Currant	D-W	●	●	●	●		2		1	3						1	1							1		1			
Rubus paviflorus	Thimbleberry	D-W	●	●	●	●		3			1						1													
Rubus spp.	Raspberry family	D-W	●	●	●	●											1	1										1		
Drepanocladus uncinatus	Sickle Moss	D-W	●	●	●	●			4	2	2	3																		
Solidago canadensis	Golden Rod	D-W		●	●	●											1	1									1	1		
Taraxacum officinale	Dandilion	D-W			●	●																								
Thuja plicata	Western Redcedar	D-W	●	●	●	●																								
Trifolium pratensis	Red Clover	D-W				●		1	1	1																	2			
Tsuga heterophylla	Western Hemlock	D-W	●	●	●	●																								
Tsuga mertensiana	Mountain Hemlock	D-W	●	●	●	●							3																	
Vaccinium vitis-idaea	Cranberry	D-W	●	●	●	●																								
Actea rubra	Baneberry	M	●	●	●	●																								
Aquilegia formosa	Red Columbine	M		●	●	●																								
Aralia nudicaulis	Wild Sarsaparilla	M	●	●	●	●																								
Arnica cordifolia	Heartleaved Arnica	M	●	●	●	●	2		2		2					1									3	2				
Aster conspicuus	Showy Aster	M	●	●	●	●																	2							
Calamagrostis canadensis	Bluejoint	M	●	●	●	●											3	2			2								3	3
Cassiope mertensiana	White Mountain-Heather	M	N	N	N	N							2																	
Clintonia uniflora	Queens Cup	M	●	●	●	●																								
Coptis aspleniifolia	Fern-Leaved Goldthreat	M	●	●	●	●																								

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Lycopodium complanatum	Ground Cedar	M	●	●	●	●	2							2											2	2				
Fritillaria camschatcensis	Riceroot Lily	M			●	●																								
Geum macrophyllum	Large-Leaved Avens	M	●	●	●	●											2										1			
Gymnocarpium dryopteris	Oak Fern	M	●	●	●	●		4			2																3	2	2	
Lycopodium clavatum	Running Clubmoss	M	●	●	●	●																								
Menziesia ferruginea	False Azalea	M	●	●	●	●		3			2																			
Otilia secunda	One-Sided Wintergreen	M	●	●	●	●																								
Phyllodoce empetriformis	Pink Mountain-Heather	M	N	N	N	N																								
Pinus albicaulis	Whitebark Pine	M	●	●	●	●	1						4																	
Populus trichocarpa	Black Cottonwood	M		●	●	●											2	5									1		1	
Disporum hookery	Hooker's Fairybells	M	●	●	●	●											1	1												
Prunus virginiana	Choke Cherry	M		●	●	●																			2					
Pyrola asarifolia	Evergreen	M	●	●	●	●																								
Rhytidiadelphus loreus	Lanky Moss	M	●	●	●	●																								
Rhytidiopsis robusta	Pipecleaner Moss	M	●	●	●	●																								
~~Ribes divaricatum~~	~~Gooseberry~~	~~M~~	●	●	●	●																								
Rosa acicularis	Prickly Rose	M	●	●	●	●		1						1	2	2	3	3					2	1	3	1	1			
Rubus idaeus	Raspberry	M			●	●		2																	2		1			
Rubus pedatus	Fiveleaved Bramble	M	●	●	●	●		3	2	1	2						1													
Sambucus racemosa	Red Elderberry	M	●	●	●	●																								
Sorbus scopulina	Common Mountain Ash	M	●	●	●	●	1	1																	1					
Sorbus sitchensis	Sitka Mountain Ash	M	●	●	●	●	1	1																	1					
Thalictrum occidentale	Meadow Rue	M	●	●	●	●																								
Vaccinium alaskaense	Alaskan Blueberry	M	●	●	●	●																								
Vaccinium caespitosum	Dwarf Blueberry	M	●	●	●	●	2			1	1				3		2	2							3	3	2			

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Vaccinium membranaceum	Black Huckleberry	M	●	●	●	●		2	4	1	2		4												3	1	4	1		
Vaccinium ovalifolium	Oval-Leaved Blueberry	M	●	●	●	●			2		3																1			
Valeriana sitchensis	Sitka Valerian	M	●	●	●	●			5	2	2	3																		
Virburnum edule	Highbush Cranberry	M	●	●	●	●											3	3										1		
Spiraea douglasii	Douglas Spirea	M-W	●	●	●	●											1	1		1										
Streptopus amplexifolia	Twisted Stalk	M-W	●	●	●	●			2		1						1	1									1	1		
Tiarella trifoliata	Three-Leaved Foamflower	M-W	●	●	●	●		3	2	1	1																			
Urtica dioica	Singing Nettle	M-W	●	●	●	●																					1	1		
~~Alnus rubra~~	~~Red Alder~~	~~M-W~~			●	●																								
Aster subspicatus	Aster	M-W	●	●	●	●	2									1		1					1	2						
Cornus sericea	Red Osier Dogwood	M-W	●	●	●	●	1	1	1	1	1						3	5		1							2	2	1	
Dryopteris expansa	Spiny Wood Fern	M-W	●	●	●	●																								
Cladothamnus pyroliflorus	Copperbush	M-W	●	●	●	●																								
Equisetum arvense	Common Horsetail	M-W	●	●	●	●			1	4	5	1					3	1		4		1								
Equisetum spp	Horsetails	M-W	●	●	●	●																					1	5	2	1
Ledum groenlandicum	Labrador Tea	M-W	●	●	●	●													5	2	4								2	2
Smilacina racemosa	False Salomonseal	M-W	●	●	●	●											2	1									2	2		
Mentha canadensis	Mint	M-W			●	●																					1	1	1	
Mnium spp.	Leafy Mosses	M-W	●	●	●	●		2	3		5	4					3											4	2	
Petasites frigata/palmatus	Coltsfoot	M-W		●	●	●		1	1	1	1	1					1	2												
Populus balsamifera	Black Cottonwood	M-W		●	●	●												5							3					
Ribes laxiflorum	Wild Currant	M-W	●	●	●	●																								
Streptopus roseus	Rosy Twistedstalk	M-W	●	●	●	●			2		1																1			
Alectoria spp	Witch hair	NA	●	●																										
Bryoria spp.	Speckled Horse Hair	NA	●																											

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Lobaria pulmonaria	Lungwort	NA	•	•																										
Usnea spp	Aboreal Lichen	NA	•	•	•																									
Aulacomnium palustre	Glow Moss	W	•	•	•	•				5	2	5															1	1	2	2
Caltha leptosepala	White Marsh-Marigold	W	N	N	N	N			1			3																		
Coptis trifolia	Three-Leaved Goldthreat	W	•	•	•	•																								
Gaultheria hispidula	Creeping Snowberry	W	•	•	•	•													4	1	2								1	1
Kalmia microphylla	Bog-Laurel	W	N	N	N	N																								
Lonicera involucrata	Twinberry	W	•	•	•	•		1	1	1	1						4	4		1							3	3		
Lysichiton americanum	Skunk Cabbage	W	•	•	•	•																								
~~Malus fusca~~	~~Crabapple~~	~~W~~			•	•																								
Sanguisorba canadensis	Sitka Burnet	W	N	N	N	N			1	1	1	1																		
Veratrum viride	Indian Helebore	W	•	•	•	•			2		2																			
Alnus tenuifolia	Mountain Alder	W		•	•	•																						1	3	
Angelica genuflexa	Angelica	W	•	•	•	•																					1	1	1	
Athyrium filix-femina	Lady Fern	W	•	•	•	•		2			2																1	2	1	
Betula glandulosa	Scrub Birch	W	•	•	•	•													2	3	2	1							1	2
Heracleum lanatum	Cow-Parsnip	W	•	•	•	•		1	1	1	1						3	3												
Oplopanax horridus	Devil's Club	W	•	•	•	•		4			1	1															1	1		
Vaccinium oxycoccus	Lowbush Cranberry	W	N	N	N	N																								
Picea mariana	Black Spruce	W	•	•	•	•													5	4		1				2			2	2
Senecio triangularis	Arrow-Leaved Groundsel	W	•	•	•	•			1	1	1																			
Fauria crista-galli	Deer Cabbage	W-AQ	N	N	N	N																								
Salix pedicellaris	Bog Willow	W-AQ	N	N	N	N															4	4								
Sphagnum spp.	Sphagnums	W-AQ		•	•	•			2		1	3							5	2	5	2					2	2	5	5
Tomenthypnum nitens	Golden Fuzzy Fen Moss	W-AQ	N	N	N	N																3							4	3