

RETENTION MAPPING FOR NON-TIMBER OBJECTIVES: VANDERHOOF AND QUESNEL MANAGEMENT UNITS

MOE FFT Works Project 13

Prepared for:

Chris Ritchie
Section Head, Ecosystems Section
Ministry of Environment – Prince George
40510 18th Avenue
Prince George, B.C.
V2N 1B3

Charlotte Kurta
Ecosystems Officer
Ministry of Environment - Cariboo Region
Quesnel Forest District Office
322 Johnston Avenue
Quesnel, B.C.
V2J 3M5

and

Glen Thiem
Forsite Consultants Ltd.
P.O. Box 2079
Salmon Arm, B.C.
V1E 4R1

Prepared by



1579 9th Avenue
Prince George, B.C.
V2L 3R8

March 17, 2006

Version 2.0

EXECUTIVE SUMMARY

A retention mapping exercise and analysis were completed for the Vanderhoof and Quesnel management units. The purpose was to identify retention options and alternatives and develop a framework that would assist licencees and the ministries plan for retention due to large-scale forest pest infestations in other provincial management units.

Base maps were produced as tools to visualize existing forms of retention. Projection maps were created to compliment the base maps and spatially identify options or alternatives for retention. Indicators and a ranking matrix were developed to assign value to forest stands based on their attributes and potential to provide valuable retention. The scoring of individual categories relied largely on expert knowledge and current scientific understanding. An overall priority ranking was completed by tallying the scores for each polygon. The resultant map shows areas with very high, high, moderate, and low potential for retention.

An analysis was completed for both base and projection maps in order to understand the amount of area that currently contributes to the various forms of legislated retention and what impact to the timber harvesting land base might be realized through optional forms of retention.

The results of this project address the biophysical underpinning of making retention choices. The results provide the user with a foundation for closely examining the purpose, location, duration, quantity and within reason, quality of retention.

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

1.0 BACKGROUND 1

2.0 METHODS 3

2.1 Phase I: Preliminary Meetings, Refinement of Contact List and Project Protocol 3

Phase II: Data Acquisition 6

Phase III: Base Map Production 6

2.4 Phase IV: Develop Indicators For Selecting Retention Options; Create Priority Classes ... 9

 2.4.1 *Criterion and Indicators* 9

An Example 15

 2.4.2 *Priority Classes* 16

2.5 Phase V: Review Of Base Maps And Indicators; Rationalize Retention And Conduct Analysis 17

 2.5.1 *Review* 17

 2.5.2 *Rationalize* 17

 2.5.3 *Base Map Analysis* 19

2.6 Phase VI: Spatial Projection of Ranked Indicators 25

 2.6.1 *Projection Map Analysis* 26

2.7 Phase VII: Projection Map Review 29

2.8 Phase VII: Final Map Products 29

3.0 POTENTIAL IMPACTS OF RETENTION OPTIONS TO THE THLB..... 29

4.0 NON-GEOGRAPHICALLY LOCATED RECOMMENDATIONS FOR RETENTION..... 30

5.0 PROJECT RECOMMENDATIONS..... 31

5.1 General 31

5.2 Interpreting The Base And Projection Maps 32

5.3 Future Direction 32

5.4 Conclusion 33

6.0 REFERENCES..... 34

LIST OF FIGURES

Figure 1: Base Map Example for the Dragon Landscape Unit in Quesnel..... 7

LIST OF TABLES

Table 1: Summary of project phases 3

Table 2a: Contact list for Vanderhoof..... 4

Table 2b: Contact list for Quesnel..... 5

Table 3: Base map spatial data for each management unit 8

Table 4: Indicators, categories, and ranking used to identify options for retention 11

Table 5: An example of how a polygon might be scored using the matrix in Table 4 above. 16

Table 6a: Summary of priority groups for the Vanderhoof management unit projection maps 16

Table 6b: Summary of priority groups for Quesnel management unit projection maps 17

Table 7a: Summary table of analysis from Vanderhoof management unit base maps 21

Table 7b Summary table of analysis from Quesnel management unit base maps. 23

Table 8a Summary table of analysis from Vanderhoof management unit projection maps (*within the 2004 THLB – reported in hectares*) 26

Table 8b Summary table of analysis from Quesnel management unit projection maps (*within the 2004 THLB – reported in hectares*) 27

1.0 BACKGROUND

On June 1, 2002 the allowable annual cut (AAC) for the three most impacted timber supply areas (TSAs) (Quesnel, Lakes, and Prince George) was increased to help suppress the spread of mountain pine beetle. Limited knowledge on the shelf life (decay rates) of lodgepole pine (*Pinus contorta*.) spurred a second AAC increase.

The second uplift amounted to approximately 4.9 million meters³ (or 27%) between the three TSA's, and was intended to facilitate harvesting in mountain pine beetle damaged stands, reflecting recommendations made by Eng in his 2004 Interpretation Paper. Larry Pedersen (B.C. MoF 2004a & 2004b) made the second uplift using an analysis that assumed a retention target of 20% to 25%, especially on large (>1000 ha) openings. This was a 12% increase in stand level retention in pine leading stand types that were deemed moderately or severely attacked by mountain pine beetle – above and beyond current standards. The balance would occur at levels of retention required by regulation in areas with non-timber values such as wildlife tree patches (WTP) and riparian reserve zones (RRZ). This project focuses on identifying this latter type of retention.

The uplifts in AAC for the interior permit the harvesting of approximately 56 million meters³ of this wood (Eng 2004). The mountain pine beetle however has been outpacing logging activities by far (Province of B.C. 2005). Eng et al. (2005) predicted that expansion of the current outbreak will peak in 2006, however, large volumes of pine will continually (annually) be killed until 2015. By the time the epidemic subsides it is predicted that eighty percent of the susceptible (mature) lodgepole pine in the province will have been killed.

It is important to recover as much economic value from dead lodgepole pine as possible and large-scale salvage cutblocks in some areas may be an appropriate ecological and economic response. Harvesting all the infested timber however, will not be possible, nor is it feasible or practical, and may be unsound ecologically (Eng 2004). The impacts of this outbreak, coupled with large-scale salvage operations will likely lead to forest conditions outside the natural range of disturbances these ecosystems have experienced historically, impacting a multitude of values, including non-timber values (Lindenmayer et al. 2004; Taylor & Carroll 2004).

As it is not possible to salvage all mountain pine beetle-killed timber (Eng 2004), it is important that forest managers consider their options for retention in a strategic manner. In doing so, it is beneficial to consider forest values such as biodiversity, hydrology, and soil, and as far as is possible, stand structure and age class distribution (B.C. MoF 1995a).

The current mountain pine beetle outbreak will have significant impacts on a large proportion of the forests in British Columbia (Eng 2004). An accelerated harvesting regime will compound the impacts that the mountain pine beetle is having on the landscape (Lindenmayer et al. 2004). There is therefore cause for concern for future timber supply and the protection of non-timber values in areas impacted by mountain pine beetle. Non-timber resource values include but are not limited to the following:

- Recreation and backcountry recreation
- Biodiversity

- Water resources
- Stand and landscape level functionality
 - Interior forest condition
 - Connectivity
 - Coarse woody debris
 - Wildlife habitat features
- Cultural heritage and archaeological sites
- Fish and wildlife
- Natural range barriers

Timberline Forest Inventory Consultants Ltd. (Timberline) was contracted to conduct a retention mapping project to identify landscape level retention options for non-timber resource values in light of the accelerated harvesting and silviculture resulting from the mountain pine beetle infestation in the Vanderhoof and Quesnel management units. This project is part of a collaborative effort geared at assisting with province-wide large scale planning efforts.

In an environment of such harvesting activity, strategic planning is of increased importance as a means of identifying and protecting non-timber resource values. Identifying non-timber values at risk and their spatial representation on the landscape is the beginning of developing a framework that will assist with strategic level retention planning. For purposes of this project, retention and retention planning was considered to be the identification, spatially or aspatially, of forested areas which, even if attacked by mountain pine beetle, will remain intact, untreated, and unsalvaged at least in the near to mid term.

While the Chief Forester's retention recommendations are aimed at preserving a component of mountain pine beetle killed stands, the purpose of this project was to take his recommendations one step further and identify high value stands (especially those with non timber values) and landscape level attributes that will assist with making the best choices for retention. The results of this project address the biophysical underpinning of retaining forested stands or tracts of forested land. This project identifies retention options and alternatives specifically in the Vanderhoof and Quesnel management units and provides a framework that will assist licencees and the ministries in retention planning efforts for large-scale forest pest infestations in other provincial management units. Encompassed in the scope of this project is also the task of identifying potential impacts to timber supply within each individual management unit.

This report addresses the Vanderhoof and Quesnel management units in unison. Following the background, the methods (framework) used are described, including an account of the base mapping data and base retention analysis. The criteria used to judge the priority of retention options (alternatives), and an analysis of the options follows. A list of experts for each management unit is provided. The potential impacts to the timber harvesting land base (THLB) are then discussed along with some assumptions that could be used in place of geographically located areas. The document concludes with a recommendations section and some general comments about the project.

2.0 METHODS

The process for this project consisted of eight main phases or tasks. These are summarized in Table 1 and subsequently elaborated in the sections below.

Table 1: Summary of project phases

Phase	Description
I	Preliminary meetings, refinement of contact list and project protocol
II	Data acquisition
III	Base map production
IV	Develop indicators for selecting potential retention options; create priority classes
V	Review base maps and indicators; rationalize retention; conduct analysis
VI	Spatial projection of ranked indicators
VII	Projection map review
VIII	Final map production

2.1 PHASE I: PRELIMINARY MEETINGS, REFINEMENT OF CONTACT LIST AND PROJECT PROTOCOL

An approach to this project was sent to Forsite Forest Management Specialists Ltd. (Forsite) in response to the original request for proposals on October 25, 2005. It was fully expected at that time the project would evolve and be adjusted as the project commenced and experts were consulted. The results of this project will continue to evolve especially once employed by field practitioners and land use planners.

On December 2, 2005 a meeting was held in Prince George at the Ministry of Environment (MoE) Regional office with the Vanderhoof group. Representatives from the MoE, Ministry of Forests and Range (MoFR), Integrated Land Management Bureau (ILMB) and Timberline were present. The project, objectives, and preliminary methodology were reviewed.

The meeting was followed by a conference call that brought together project participants from other areas in the province. The project, rationale (direction) and stakeholders for the project were discussed. It was determined that expert knowledge about what constitutes valuable retention could be obtained through consultation with ministry experts. Public input regarding areas of social or cultural importance could be captured by using data from the Vanderhoof Land and Resource Management Plan (LRMP) (B.C. MSRM 1997) and the Cariboo-Chilcotin Land Use Plan (CCLUP) (B.C. MSRM 1995), and therefore new public consultation was not necessary.

After the conference call, the Vanderhoof group compiled a list of potential experts presented in Table 2a and discussed pertinent base map data as well as acquisition of the data. The group determined that map products would be at 1:50,000 scale and the Vanderhoof management unit would be divided logistically into 10 map sheets for efficient reporting purposes as well as future utility. The meeting ended with a discussion on preliminary indicators of valuable retention.

Table 2a: Contact list for Vanderhoof

Contact	Contact Information	Organization
Chris Ritchie	614-9910 Chris.Ritichie@gov.bc.ca	MoE Prince George Region
Brady Nelles	614-9916 Brady.Nelles@gov.bc.ca	MoE Prince George
Traci Leys-Schirok	565-4471 Traci.LeysSchirok@gov.bc.ca	ILMB Prince George
Craig Delong	565-4113 Craig.Delong@gov.bc.ca	MoFR at the Prince George Regional Office
Vince Sewell	567-6401 Vince.Sewell@gov.bc.ca	MoFR in the Vanderhoof Forest District
John DeGagne	567-6371 John.Degagne@gov.bc.ca	MoFR in the Vanderhoof Forest District – Stewardship
Kathleen Hebb	567-6417 Kathleen.Hebb@gov.bc.ca	Stewardship Vanderhoof MoFR
Dale Seip	565-4125 Dale.Seip@gov.bc.ca	MoFR Prince George – Wildlife Ecologist
Richard Thompson	356-5467 Richard.Thompson@gov.bc.ca	MoE Victoria – Ecosystem Branch
John Rex		MoFR Prince George – Hydrologist
Dave Maloney		MoFR Prince George – Hydrologist
Dave Mainer	567-6353 Dave.Mainer@gov.bc.ca	MoFR Vanderhoof Forest District
Randy Sulyma	Sulyma@unbc.ca	MoE Ft St James
Ramona Blackwell	ramona.blackwell@gov.bc.ca	ILMB Prince George
Doug Wilson	Doug.J.Wilson@gov.bc.ca	Regional Biologist, Prince George
Andrew Pantel	Andrew.Pantel@gov.bc.ca	MoFR – Prince George District – Range Branch- Range Agrologist

On December 8, 2005, a meeting was held at the MoFR district office in Quesnel to review the project and discuss the Quesnel Forest District Enhanced Retention Strategy. A group of government personnel and local licencees had been developing a strategy that would address the Chief Forester’s emphasis on enhanced retention in the second AAC uplift. As a result of the Quesnel District Enhanced Retention Committee’s efforts, base map production had commenced, but was not complete.

The Quesnel strategy was intended as the “best non-legal direction” to assist field practitioners with the selection and distribution of conservation legacy areas (CLA). A CLA is defined as a lodgepole pine leading area of such size and location that future harvest or rehabilitation remains feasible.

In keeping with the Quesnel District Enhanced Retention Committee’s direction and scope, the completion of the base maps as well as some baseline analysis was discussed. Arrangements were made to acquire pertinent spatial data to complete the base mapping task. It was determined that mapping would be done by landscape unit as these are the current planning cells in the Quesnel Forest District. Scales for the maps would therefore range between 1:50,000 to 1:80,000. The meeting ended with the development of a list of experts to contact for the project presented in Table 2b, and a discussion of indicators of valuable retention.

Table 2b: Contact list for Quesnel

Contact	Contact Information	Organization
Mike Pelchat	992-4477 Michael.Pelchat@gems3.gov.bc.ca	MoFR Quesnel Stewardship Officer
Wayne Boudreau	992-1700 wayne_boudreau@tolko.com	Tolko Industries – Quesnel
Allan Johnsrude	992-9244 allan.johnsrude@westfraser.com	West Fraser Mills – Quesnel
Harry Jennings	250 398-4398 Regional Forest Practices Specialist Harry.jennings@gov.bc.ca	MoFR – Williams Lake
Darcy Peel	250 398-4448 Planning Officer Darcy.Peel@gov.bc.ca	ILMB – Williams Lake
Darren Bubela	GIS Analyst 250-992-4416 Darren.bubela@gov.bc.ca	MoFR – Quesnel
Charlotte Kurta	250-992-4480 Ecosystems Officer	MoE – Quesnel
Julie Steciw	250-398-4671 Julie.Steciw@gov.bc.ca	Regional Biologist in Williams Lake

Not all individuals listed in the above tables were available for input during the course of this project, but all individuals listed were identified originally as having expert knowledge of the area (either Vanderhoof or Quesnel) or the subject matter. Some individuals were involved indirectly through their participation in previous projects whose results were used to support this project. Additionally, not all individuals who were contacted for assistance necessarily responded to the request. All remain on these lists, however, as it may be necessary to contact them in the future.

Meetings were held throughout the duration of the project at the offices of the MoE and the MoFR in both Prince George and Quesnel as well as Timberline’s Prince George office. Communication also took place through email and over the phone.

The Quesnel District Enhanced Retention Committee was responsible for identifying applicable spatial data for the Quesnel management unit which also included areas of significant importance previously identified in the CCLUP. Furthermore, the base map information for the Quesnel management unit provided a solid foundation for deciding what type of information to include on the base maps for the Vanderhoof management unit.

The MoE, ILMB and MoFR were responsible for identifying pertinent spatial data for the Vanderhoof management unit. The ILMB and the MoE ensured that areas identified in the LRMP as having high value were included in the exercise.

PHASE II: DATA ACQUISITION

Two forms of data were obtained for this project; spatial data and technical data. Data were acquired from the following sources in both Vanderhoof and Quesnel: the MoFR, ILMB, and MoE, as well as the Quesnel Forest District Enhanced Retention Strategy Committee and Timberline.

Ministry File Transfer Protocol (FTP) sites were typically used to receive spatial data, and consultation over the phone, through email or in person was used to obtain and discuss technical elements of the project.

It became apparent early in the project that a first and crucial step must occur in other management units considering the undertaking of a retention identification project such as this one. It is important at the outset to identify biodiversity, values at risk, and non-timber values specific and important to a management unit and to define the objectives that are intended to be met through retention planning and subsequent action. Once this step has been completed, the collection of pertinent spatial and technical data can occur. This project had an advantage in that this crucial step had already been completed since both the Vanderhoof and Quesnel communities had previously been involved in processes that identified specific values and non-timber objectives.

PHASE III: BASE MAP PRODUCTION

The purpose of the base maps was to provide visualization of existing retention and to illustrate the highest value features and areas suitable for retention. These maps were therefore organized around existing forms of retention such as Old Growth Management Areas (OGMAs) and Ungulate Winter Range (UWR), but included such areas as identified wildlife habitat, culturally identified sites, and natural range barriers. An example base map from the Quesnel management unit is presented in Figure 1. The base maps were also created as a tool to compliment the projection maps and help rationalize retention options or alternatives by comparing the two types of maps. To assist with this, they also include a component of species composition.

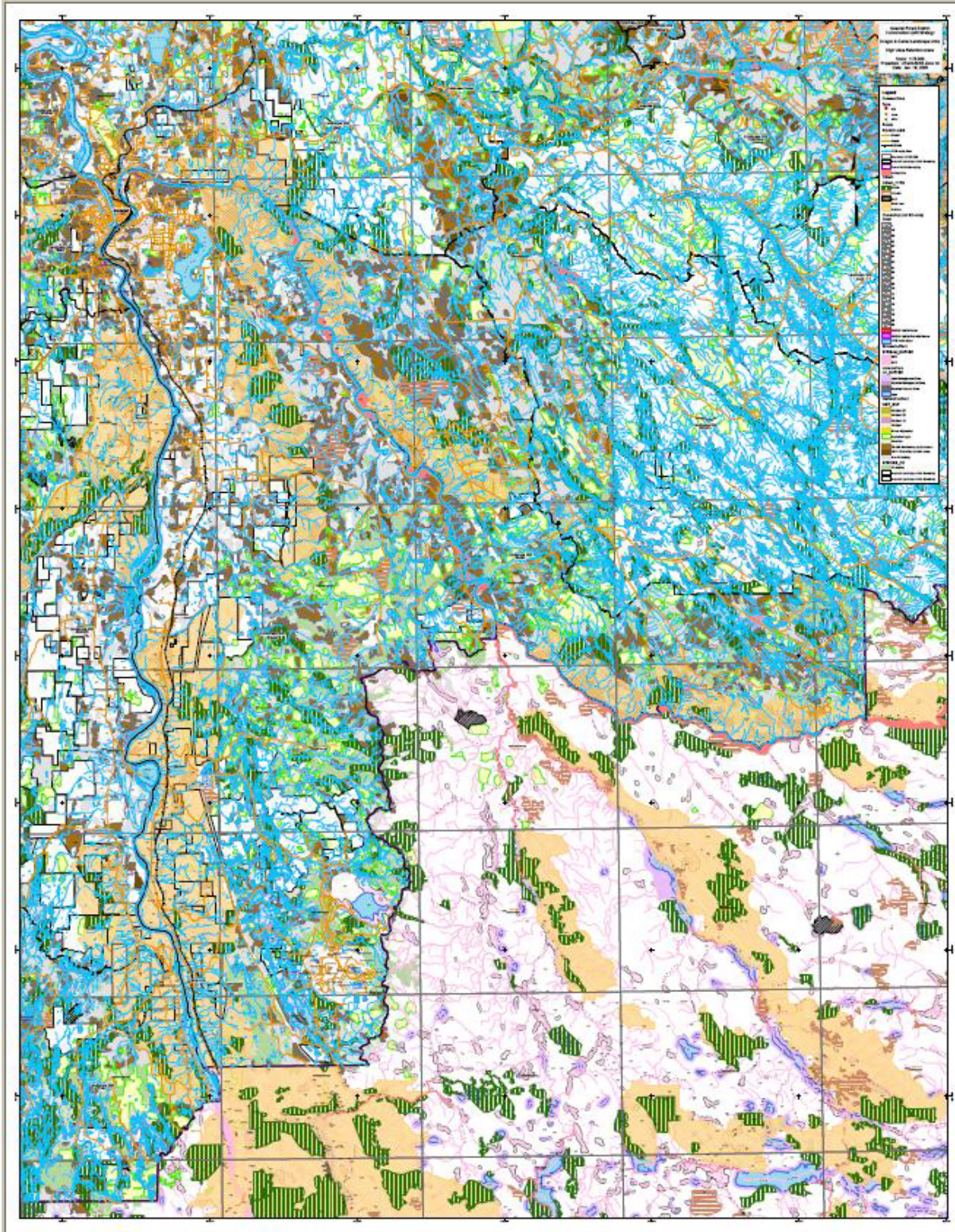


Figure 1: Base map example for the Dragon Landscape Unit in the Quesnel Forest District

Base maps for the Vanderhoof Management Unit were created at a scale of 1:50,000. The management unit was logistically divided into 10 map sheets. Base maps for the Quesnel

Management Unit conversely were created for each landscape (planning) unit. The scale of Quesnel’s landscape unit maps ranged from 1:50,000 to 1:80,000.

Base maps also included special features such as recent fires (2004 and 2005) and areas identified in community based plans such as the Vanderhoof LRMP and the CCLUP.

The spatial data used for the base maps in the Vanderhoof and Quesnel management units are summarized side by side in Table 3.

Table 3: Base map spatial data for each management unit

Vanderhoof Base Data	Quesnel Base Data
Planimetry – roads, rail	Planimetry – roads, rail
NDU-BEC Units	Quesnel landscape units
Hydrology – rivers/streams, lakes, wetlands	Hydrology – rivers/streams, lakes, wetlands
Map sheet neatlines	Map sheet neatlines
Forest district boundary	Forest district boundary
Administrative	Administrative
Ownership (private, woodlots, crown and others)	Ownership (private, woodlots, crown, and others)
Depletion layer (harvesting)	Depletion layer (harvesting)
Forest cover inventory data	Forest cover inventory data
	Cariboo-Chilcotin Land Use Plan coverage
Predictive Ecosystem Mapping layer	
Recent fires (2004 and 2005)	
Agricultural Land Reserve / settlement agriculture zone	
Fire breaks	
THLB boundary	THLB boundary
Vanderhoof Retention Data	Quesnel Retention Data
Parks and Protected Areas	Parks and Protected Areas
Special Management Zones identified in the LRMP (Euchiniko, Chedakus, and Savory Ridge)	GOAL2 Protected Areas identified in the Cariboo-Chilcotin LUP
Non-motorized access management areas	
Riparian Reserve Zones (RRZ)	Riparian Reserve Zones (RRZ)
Wildlife Habitat: <ul style="list-style-type: none"> • Mule Deer and Caribou Ungulate Winter Range (UWR) 	Wildlife Habitat: <ul style="list-style-type: none"> • Mule Deer and Caribou Ungulate Winter Range (UWR) • Critical Fish • Moose Habitat • Heron Areas
Fish and Wildlife Reserves	Old Growth Management Areas
Visual Quality Objectives	Visual Landscape Inventory
Elemental occurrence data from the Conservation Data Centre (CDC)	

2.4 PHASE IV: DEVELOP INDICATORS FOR SELECTING RETENTION OPTIONS; CREATE PRIORITY CLASSES

2.4.1 *Criterion and Indicators*

Ultimately it will be the local licencees that will utilize the suggestions that result from this exercise. It was therefore essential that the project be developed in a manner that made sense, was practical and could be implemented by forest managers once complete. A criterion and indicator approach to this project was chosen because of its utility. This approach is generally understood by most practitioners, is repeatable, and is valid providing that the most current scientific understanding/knowledge is employed.

The **Criterion** in this case is: Retaining ecologically valuable and appropriate tracts of forest in order to enhance non-timber values in forest ecosystems.

The **Indicators** chosen not only needed to include a measure of retention, but it was essential that the data for each indicator be captured spatially. Since data sets differed slightly between the Vanderhoof and Quesnel management units, certain indicators were not used in both management units. This project did not include a comprehensive review of the literature. Instead experts were relied upon for knowledgeable and scientific input into the selection and categorization of indicators.

The selection of indicators began with an examination of the data that was available for each management unit, and a determination of which would be useful. It was also important to choose indicators that would help forest managers meet the Chief Forester's recommendations on retention in pine stands. Particular attention was given to the work already accomplished by the Quesnel District Enhanced Retention Committee, and Craig DeLong's "red/green" map, as well as the science that played a role in its creation. The following principles/assumptions were incorporated into indicator selection whenever possible:

- Anchor retention areas were considered as areas of known ecological importance as well as existing stand and landscape level legislated retention;
- **Create ecological legacies of mountain pine beetle killed stands through retention in order to allow natural recovery processes;**
- **Retain areas with high biodiversity and non-timber resources values, especially in areas with live trees;**
- Temporal scale (expected duration of retention);
- Spatial scale (proximity to high value areas or anchors);
- Timber supply impacts; and
- Social and non-timber benefits.

Nine indicators were selected from the spatial attribute data. After each indicator was selected, it was categorized and then ranked based on the value that the individual category would provide if retained. The main reasons for retention in this case are to retain or consider retaining areas that

possess high non-timber value¹. Therefore, in categorizing the spatial attribute data, the value of the attribute or indicator was considered in a conservation context, and more specifically, of what value it would have if it were retained.

The more value that a category had for retention, the higher the ranking it would receive. The majority of indicators were divided into four logical categories (1 to 4), and the highest score an indicator could receive was 4. The exceptions to this were specific habitat potential, regeneration potential in pine leading stands, watershed sensitivity and riparian management areas. The resulting matrix is presented in Table 4.

Individual polygons were queried for each of the attributes listed in Table 4, and assigned the corresponding value. Once the attributes for each stand (polygon) were ranked, the rankings were summed and then grouped based on the sum of their ranking into a priority group. Each indicator is elaborated in the next section, and an example follows.

¹ The matrix does manage to capture some timber value, especially mid-term timber value by placing higher value on non-pine leading stands, and identifying areas of high potential for regeneration or understory composition.

Table 4: Indicators, categories, and ranking used to identify options for retention

Check marks in the boxes on the right indicate that the indicator was employed in that management unit.

Indicator	Category	Ranking	Vanderhoof	Quesnel
1. Proximity to existing anchor or retention	a. 0m - 100m	4	✓	✓
	b. 101m - 200m	3		
	c. 201m - 400m	2		
	d. >400m	1		
2a. Species Composition – Coniferous	a. ≤ 30% pine	4	✓	✓
	b. 30% - 50% pine	3		
	c. 51% - 70% pine	2		
	d. >70% pine	1		
2b. Species Composition – Deciduous	a. Pure Deciduous (100%)	4	✓	✓
	b. 70% Deciduous	3		
	c. 50% Deciduous	2		
	d. 30% Deciduous	1		
3. Age Class	a. 4 and 5	3	✓	✓
	b. 6	2		
	c. 7	1		
	d. 8+	4		
4. Polygon Size	a. 20 ha– 30 ha	1	✓	✓
	b. >30 ha - 60 ha	2		
	c. >60ha - 100 ha	3		
	d. > 100 ha	4		
5. Site Potential	a. Site indices ≤ 15m	4	✓	✓
	b. Site indices >15m - 17m	3		
	c. Site indices >17m - 20m	2		
	d. Site indices 21m+	1		
6. Specific Habitat Potential: i. Marten	b. Age Class > 7	4	✓	
7. Regeneration Potential: i. Proximity to non-pine seed source	a. 0m - 100m	4	✓	✓
	b. 101m - 200m	3		
	c. 201 - 300m	2		
	d. >300m	0		
ii. Pine-leading xeric site series	a. Xeric: SBSdk: 02,03,05 SBSdw2: 02,03,06,07 SBSdw3: 02,03,04,05 SBSmc2: 02,03 SBSmc3: 02,03,04,05 MSxv: 02,03,04	2	✓	
	b. Non-xeric	0		
8. Watershed Sensitivity	a. Priority 7	1	✓	
	b. Priority 6	2		
	c. Priority 5	3		
	d. Priority 4	4		
	e. Priority 3	5		
	f. Priority 2	6		
	g. Priority 1	7		
9. Riparian Management Zone	a. SMZ, LMZ, RMZ	3	✓	✓

1. Proximity to existing anchor or retention

Connectivity and size of retention in hectares were identified as important features. Polygons or stands that are in close proximity to existing retention (anchors) can readily be incorporated with the previously identified area to create a larger area of retention and in some cases conserve stand or landscape level connectivity. This indicator was categorized based on incremental distances from existing areas of retention. The basis for the distances was in consideration of the maximum RRZ identified in the Riparian Management Area Guidebook (1995b) (C. Kurta, pers. comm.)². In GIS, anchors were buffered according to the distances in Table 4, and then the concentric, adjacent areas were scored as per the ranking values given to the distances. The closer an area is to existing retention, the higher the score it receives.

2a. Species Composition – Coniferous

Coniferous species composition was originally identified as a means to find areas to conserve for mid-term timber harvesting opportunities (C. DeLong pers. comm.)³, and these are not necessarily viewed as areas that should be “locked up” as retention. Stands of leading species other than lodgepole pine however, have a higher potential value for habitat and biodiversity. These stands also provide important seed sources to surrounding areas. Additionally, live trees retained for the near and mid-term will continue to remove water from the soil through the evapotranspiration process therefore regulating stream flow, and reducing erosion and sediment transport (Snetsinger 2005). This projection analysis gives a higher value to non pine-leading stands for these reasons, and stands were ranked based on their percent lodgepole pine composition.

2b. Species Composition – Deciduous

Deciduous stands are high contributors to biodiversity, and can also play an important role as providers of species specific old growth habitat (R. Hoffos pers. comm.)⁴. Furthermore, live deciduous species will continue to move soil water and help maintain hydrologic function. Importantly, retention of deciduous species during salvage of pine-leading stands is an ecologically sound choice and meets the objectives of the Quesnel District enhanced retention strategy.

3. Age Class

Age class was chosen as a means of capturing old growth attributes and the habitat and biodiversity associated with older stands. Age class when combined with such attributes as species composition is an important indicator of certain types of habitat. This indicator was divided into categories based on its potential to be merchantable, and, for pine, its susceptibility to attack by mountain pine beetle. The closer a stand age is to being mature or merchantable, the lower the score it receives, with the exception of stands in excess of 140 years of age (RISC

² Charlotte Kurta, 2005. Ecosystems Officer. Ministry of Environment, Quesnel Forest District

³ Craig DeLong, 2005 and 2006. Regional Research Ecologist. Prince George Regional

⁴ Robin Hoffos, 2005. Planning Team Leader. Integrated Land Management Bureau, Williams Lake

1998) which receive the highest score for retention potential. This class is also naturally highly susceptible to mountain pine beetle (which is important for locating legacy stands). By focusing the query on the oldest stands (a score of 4), and stands that are not yet merchantable (a score of 3) the analysis placed an emphasis on both older and younger (future old) interior forest conditions.

4. Polygon Size

In the absence of other information, polygon size was chosen in part as a surrogate for interior forest condition as well as a means to protect larger, intact areas. The Vanderhoof Forest District has a complete model for interior forest condition, while the Quesnel Forest District does not. The choice to leave the Vanderhoof interior forest condition layer of the map was made in order to reduce the amount of data already present on the maps.

Interior forest condition constitutes the stable environment found inside of a large, intact forest patch (LOWG 2004). The larger a forest cover polygon the more potential it has to contain a desirable interior forest condition. Additionally, larger intact forests reduce forest fragmentation and increase connectivity (R. Hoffos pers. comm. 2005)². Interior forest condition requires a 200m buffering distance from the edge of the stand, and only the area more than 200 m from an edge is considered to be interior forest (LOWG 2004; C. DeLong pers. comm.²). Thus, an area that is 400m by 400m (16 ha) has an interior score of zero. Thus, the minimum polygon size is greater than the 16 ha, and is 20 ha.

5. Site Potential

The rationale for site potential came from Eng's (2004) Interpretation Paper. Prompt reforestation can help address some hydrologic stability and slope failure concerns because seedling establishment and subsequent growth tends to be more favourable on sites with higher productivity. Selecting appropriate productive sites to harvest and reforest will get productive, robust stands back onto the landscape.

Sites with poor productivity in both the Vanderhoof and Quesnel management units tend to be lodgepole pine leading sites, and placing a higher value for retaining these stands types has two advantages. First, it helps locate legacy areas on the landscape that are consistent with the Quesnel District enhanced retention strategy. Second, as indicated above poor pine sites tend to have a more significant component of natural lodgepole pine regeneration, which by leaving these sites intact, can release and replace the mature (possibly dead) canopy (DeLong et al. 1993).

6. Habitat Potential

Habitat potential was chosen as an indicator that could be used in place of actual mapped habitat. This indicator relies on expert knowledge as to which stand level attributes best describe a particular type of habitat. The Vanderhoof group identified caribou and marten habitat.

In Vanderhoof, marten are observed or known to inhabit older forest types (D. Herd pers. comm.)⁵, and a simple score of 4 was given to stands older than age class 7 in order to capture this habitat potential.

The caribou habitat query was eventually dropped because it was felt that it has been sufficiently identified in previous exercises, and a caribou coverage was obtained from the ILMB (R. Sulyma pers. comm.)⁶. Had this query been used, pine lichen woodlands would have been used to identify potentially valuable caribou habitat. This information would have come from predictive ecosystem mapping (PEM) data.

The concept of habitat potential could be used in future iterations of this project in order to capture specific habitat for a specific species.

7. Regeneration Potential

The concept for regeneration potential stemmed from DeLong's "red/green" map project. The idea is relatively simple and supported by scientific studies (C. DeLong pers. comm.)². The purpose was to identify lodgepole pine leading stands that are likely to have a well developed understory of non-lodgepole pine species. "Seed rain" for spruce and fir has been observed to be significant up to 200m from the seed source, but between 200 and 300 metres the potential for seed rain drastically drops (C. DeLong pers. comm.)². In GIS, stands of a non-lodgepole pine leading were buffered by the increments in Table 4. The closer that a pine stand is to a non-pine seed source, the higher the score it would receive.

The rationale for choosing drier or xeric site types (DeLong et al. 1993) was based on an understanding of how and where pine best germinates. Natural regeneration of lodgepole pine seedlings is often more abundant on drier sites. Although lodgepole pine seeds can germinate on nearly any substrate, they frequently germinate and subsequently establish on (or in) less developed forest floor material (Lotan and Critchfield 1990). Germinants are able to access the mineral soil and put down stable roots beneath the moss or duff layer sooner than in well developed forest floor material. The moss layer and organic matter on the forest floor of submesic to xeric sites are shallower than that of mesic to hygric sites and have less decomposition. Additionally, there is less competition for pine seedlings on drier sites because the shrub and herb layers are not as developed as those on moisture site types, and crown closure is typically reduced (Banner et al. 1993).

8. Watershed Sensitivity

The watershed sensitivity data were particular to the Vanderhoof management unit. The data were the result of an analysis that ranked the sensitivity of 160 third order and higher basins into a framework that can be used by forest managers to guide accelerated logging efforts due to

⁵ Doug Heard. Senior Wildlife Biologist. Ministry of Environment, Prince George

⁶ Randy Sulyma. Acting Ecological Biologist. Ministry of Environment, Prince George/Ft St James

mountain pine beetle (Triton 2005). The intent is to focus on the maintenance of environmental values, in particular those relating to fish.

For the watershed sensitivity analysis, criteria were developed and used to rank the sensitivity of identified basins based on terrain, hydrological, and fisheries sensitivity as well as existing and future impact factors. The result was a set of sensitivity classifications (high, medium or low) and priorities (1 to 7) assigned to each basin. Priority 1 basins were given the highest value, priority 7 basins, the lowest. The data is reflected in the same manner for the projection analysis (Table 4). Using the resultant data from the watershed sensitivity analysis for the projection analysis in this project permitted the capture of fish habitat values.

Critical fish habitat had been mapped for specific areas in the Quesnel management unit. This information is on the base maps and has been treated as a legislated form of retention so it is captured in the projection mapping by serving as an anchor (indicator 1). At such time that the Quesnel Forest District completes a similar watershed sensitivity analysis as the one for Vanderhoof Forest District, the maps could be updated to reflect the new information.

9. Riparian Management Zone

Riparian areas often support a unique mixture of trees and shrubs that can maintain a wide variety of plant and wildlife communities (B.C. MoF 1995a). Both the density and diversity of plant and wildlife species is normally higher in riparian areas than on adjacent uplands. Well-vegetated riparian areas help maintain water quality and reduce the impact of flooding and solar radiation.

Maintenance of hydrologic function has been identified as having great importance in light of the current mountain pine beetle situation. Eng (2004) identifies hydrologic stability and open slope failure as key concerns, which are carried forward in Snetsinger's (2005) guidance paper on stand and landscape level retention. The Quesnel group also had a primary focus on riparian retention, especially where it overlaps with other values such as specific wildlife habitat, wildlife corridors (connectivity), legacy lodgepole pine stands, known archaeological sites, and areas of high archaeological potential.

An Example

In order to provide a simplistic, hypothetical example, consider the following polygon in the Vanderhoof management unit:

It has species composition of 60% spruce, 30% pine and 10% aspen. It is 64ha in size, age class 8, a non-xeric leading site series, has a site index of 20, and is surrounded on all sides by wide (>300m) pine leading stands. The outer side of the polygon is situated 350m from a permanent OGMA, and in a priority 4 watershed. There are no RMAs present. The scoring of this polygon according to the matrix in Table 4 as outlined in Table 5:

Table 5: An example of how a polygon might be scored using the matrix in Table 4 above.

Indicator	Category	Ranking
1. Proximity to existing anchor or retention	201m-400m	2
2a. Species Composition – Coniferous	30%-50% pine	3
2b. Species Composition – Deciduous	N/A	N/A
3. Age Class	8	1
4. Polygon Size	>60ha – 100ha	3
5. Site Potential	Site indices >17m-20m	2
6. Specific Habitat Potential:		
i. Marten	Age Class ≥ 7	4
7. Regeneration Potential:		
i. Proximity to non-pine seed source	0	0
ii. Pine-leading xeric site series	Not pine leading	N/A
8. Watershed Sensitivity	Priority 4	4
9. Riparian Management Area	No RRMZ	N/A

The sum of these values is 19. The polygon is then assigned to a priority class which is described in the next section. This polygon would be ranked moderate for its potential to be retained and be coloured yellow on the projection map.

Note: The actual GIS task of assigning values is of course much more complicated, and involves buffering of such things as RRZs and OGMAs. The above example is intended to provide an idea of how the assigning of values was implemented.

2.4.2 Priority Classes

The priority classes for each management unit are presented in Tables 6a and 6b for the Vanderhoof and Quesnel management units respectively; the summed classes differ due to the variation in data used for each management unit. The priority classes for the Vanderhoof and Quesnel management units range from 0 to 38, and 0 to 27 respectively.

In tallying the maximum ‘score’ that an area or polygon could have, species composition is only counted once as is regeneration potential. Thus for Vanderhoof, the maximum score a polygon could receive is 38, and the maximum score a polygon in Quesnel could receive is 27.

The final map product is themed (colour coded) to reflect these priority classes (red, orange, yellow, and green), and complement the base maps.

Table 6a Summary of priority groups for the Vanderhoof management unit projection maps

Priority Group	Summed Ranking (classes)	Final Ranking	Map Colour
1	34-38	Very high	Red
2	23-33	High	Orange
3	12-22	Moderate	Yellow
4	0-11	Low	Green

Table 6b Summary of priority groups for Quesnel management unit projection maps

Priority Group	Summed Ranking (classes)	Final Ranking	Map Colour
1	22-27	Very high	Red
2	15-21	High	Orange
3	8-14	Moderate	Yellow
4	0-7	Low	Green

2.5 PHASE V: REVIEW OF BASE MAPS AND INDICATORS; RATIONALIZE RETENTION AND CONDUCT ANALYSIS

2.5.1 Review

Base map review and indicator refinement has been ongoing. Base maps for the Quesnel management unit were produced relatively quickly due to previous initiation. Quesnel management unit base maps were then used as examples for the Vanderhoof group to evaluate and assist in refining the data that would be presented on Vanderhoof Management Unit base maps. Base maps and indicators were reviewed by members of the MoFR, MoE, ILMB, and the Quesnel District Enhanced Retention Committee.

Once base maps were finalized, analysis was conducted and the production of projection maps began.

2.5.2 Rationalize

In order to run an analysis on base map data and produce projection maps, landscape delineations and classification needed rationalization. Areas of private land (residential, municipal, etc.) were excluded from the mapping exercise. **For purposes of this project**, three ‘types’ of retention on Crown land were rationalized:

- Legislated non-harvest
- Legislated constrained, and
- Non-legislated optional.

Legislated non-harvest retention (LNHR) was considered to be a form of retention that is legally mandatory and refers to areas where no harvesting is presently permitted. These serve as the “anchors” when ranking stands for potential retention (in indicator 1) The following were included in this category:

- Permanent OGMA's,
- Riparian reserve zones,

- Ungulate winter range non-harvest⁷,
- Fish and wildlife reserves,
- Parks and protected areas (including Goal 2 protected areas from the CCLUP), and
- Visual Quality Objective (VQO) full retention.

Legislated constrained retention (LCR) was considered to be a form of retention that is also legally mandatory, but refers to areas where a modified harvest regime instead of full retention can be employed. These are often comprised of areas that possess stand level or area specific elements that make them particularly valuable to retain on the landscape. Also included in this category was specially identified wildlife habitat, and extensions to existing legislated retention such as the preservation of full riparian management areas over just the riparian reserve zone. The following were included in this category:

- Ungulate winter range modified
- Riparian management zones
- VQO partial/modified
- Natural range barriers
- Identified wildlife habitat:
 - Moose
 - Heron
 - Swan (time sensitive)

Non-legislated, optional retention (NLOR) is not mandatory retention. These are existing, spatially defined areas, identified through the Vanderhoof LRMP as having high social or cultural importance. The following were included in this category:

- Specific sites identified in the Vanderhoof LRMP
 - Savory Ridge
 - Euchiniko
 - Chedakus
 - Non-motorized access areas

There were no areas identified in the Cariboo-Chilcotin LUP that were placed into this category of retention; areas from the Cariboo-Chilcotin LUP were better described by the above two categories – legislated non-harvest and legislated constrained.

The definitions for the three forms of retention described above differ somewhat from those used for timber supply review purposes. Areas that would normally be considered as contributing to the THLB in this case have been classified as legislated non-harvest retention. For example, VQO full retention would normally be considered as part of the THLB, but because the purpose

⁷The ungulate winter range classification for the Vanderhoof and Quesnel management units includes both caribou and mule deer.

of this project is to identify options and alternatives for retention, it is reasonable to consider full retention of these areas.

2.5.3 Base Map Analysis

In his rationale for the second uplift, the Chief Forester speaks specifically to enhanced retention within moderately or severely attacked lodgepole pine-leading stands. Leaving these types of legacies on the landscape ensures that representations of the natural disturbance agent remain and thus preserve the particular habitat and diversity associated with these stand types. It also provides opportunity to for research and to collect baseline data, documenting succession post mountain pine beetle which is essential for understanding structural change over time. Analyses for the Chief Forester were specific to the THLB (C. Ritchie pers. comm.)⁸.

For the above reasons, the following Tables (7a and 7b) list the number of hectares of lodgepole pine (Pl) leading stands within a reporting unit defined as legislated non-harvest, and legislated constrained harvest retention in addition to listing the total hectares that fall into these two categories within the THLB. The analysis was carried out specifically for the THLB in order to identify potential impacts of retention on timber supply. Additionally, tracking the impacts to the THLB is consistent with the measures used by Eng (2004) and the Chief Forester (2004 and 2005).

The resultant data base for the Vanderhoof IFPA timber supply review (2004) was used for the Vanderhoof management unit. A timber harvesting land base coverage for the Quesnel management unit (2004) was supplied by the MoFR. Since the time that these data sets were compiled, new areas of retention such as UWR in Vanderhoof have been identified, and new spatial data has been created. LNHR is therefore reported as either being in or not in the THLB, recognizing that in future timber supply analyses, it will likely be removed from the THLB.

Total Crown forested land is also included in the following tables. It was identified as important because it is the area that is used to monitor the contribution of old growth in the Prince George Timber Supply Area (LOWG 2004). For purposes of this project, Crown forested land is Provincially owned treed land, not including woodlots.

Areas classified as either non-harvested or constrained retention were systematically removed from the land base in a specific order to ensure that areas were only counted in one particular retention category. Areas were classified into retention categories in the following order:

1. Permanent Old Growth Management Areas.
2. Riparian Reserve Zones, Conservation Data Centre identified sites and Class 'A' Lakeshore Management Zones.
3. Riparian Management Zones and other Lakeshore Management Zones.

⁸ Chris Ritchie, Section Head, Ecosystems. Ministry of Environment, Prince George Region.

4. Wildlife Habitat Areas, Critical Fish Habitat, Moose Wetlands.

Vanderhoof Management Unit

Forest management activities in the Vanderhoof Forest District are reported on in terms of combined Natural Disturbance Units (NDU) and associated Biogeoclimatic ecosystem classification (BEC) subzones (DeLong 2002). There are seven such combinations in the Vanderhoof management unit, D1 to D7 as presented in Table 7a. It was determined by the MoE and the ILMB that this approach best reflected the method for which biodiversity management is accounted for in the Vanderhoof Forest District.

Table 7a Summary table of analysis from Vanderhoof management unit base maps (LNHR=legislated non-harvest retention*, LCR=legislated constrained retention†, CF=Crown forested land, and THLB=timber harvesting land base).

NDU/BEC Unit	Total Area	Total CF Area	Total THLB Area	Parks & Protected Areas	LNHR THLB	LNHR Non-THLB	PI Leading LNHR THLB	LCR THLB	LCR non-THLB	PI Leading LCR THLB	% LNHR of the CF	% LCR of the CF
D1 MI – Mnt. ESSF mv1 ESSF mvp1 ESSF xv1	153745	150647	113756	6053	8588	11933	5571	13997	3142	10449	14	11
D2 MI – P. SPBS mc	56135	47993	15753	33942	159	1162	125	10289	2639	8853	3	27
D3 MI – P. SBSdk	290175	175121	136329	7772	3857	10698	2885	21929	13604	17211	8	20
D4 MI – P. SBS dk	55309	49461	38737	9505	89	606	52	79	24	67	1	0
D5 MI – P. SBS dw2	342298	218402	178221	12130	4854	8539	3737	15543	16455	10633	6	15
D6 MI – P. SBS dw3 mc2	250543	244029	216862	11889	12505	3699	9454	24465	2520	20079	7	11
D7 MI – P. MS mc3	239332	224637	187244	12647	4403	5221	3749	26461	3985	21896	4	14
Grand Total	1387537	1110291	886901	93938	34455	41857	25574	112762	42369	89188	7	14

* Indicates the percent of area occupied by legislated non-harvest retention in the Crown forested land.

† Indicates the percent of area occupied by legislated constrained retention in the Crown forested land.

The utility of this exercise is limited in that only the quantity of retention within each reporting unit is presented, not the quality. Identifying good quality retention will require local expertise and expert or scientific input. This reporting exercise is useful as a guide however to assist the user with identifying units where the amount of legislated forms of retention (both full and constrained) is approaching the 20% to 25% recommended by the Chief Forester (2004a, b & c). For the Vanderhoof management unit, this is the case in all NDU/BEC combinations except D4, locating minor amounts of additional retention in these units to reach the 20% to 25% target if necessary will not be as difficult as in D4 which currently fall short of this target even when constrained retention is considered. Of the seven units, it is this last unit that may require exerted efforts to identify additional retention. **To assist the user, a summary table specific to the mapsheet is present on each base map.**

Quesnel

Strategic forest planning in the Quesnel Forest District generally begins in individual landscape units. Thirty-eight landscape units are presented in Table 7b for the Quesnel management unit. Because landscape level planning is carried out by landscape unit in this management unit it was determined by the MoE and the Quesnel District Enhanced Retention Committee that this was the appropriate way to produce base maps and to summarize existing retention.

Table 7b Summary table of analysis from Quesnel management unit base maps (LNHR=legislated non-harvest retention*, LCR=legislated constrained retention†, CF=Crown forested land, and THLB=timber harvesting land base).

Landscape Unit	Total Area	Total CF Area	Total THLB Area	Parks & Protected Areas	LNHR THLB	LNHR Non-THLB	PI Leading LNHR THLB	LCR THLB	LCR Non-THLB	PI Leading LCR THLB	% LNHR of the CF	% LCR of the CF
Plateau Units												
Ahbau (TFL5)	34393.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Baezaeko	83185.3	76003.5	71149.1	34.9	5673.5	863.8	4197.3	5632.7	502.6	4755.8	8.6	8.1
Baker	94124.2	72648.2	65387.9	165.6	6929.4	1072.5	4184.4	5480.5	1102.1	3656.9	11.0	9.1
Chine	61195.0	44500.0	39698.7	8630.3	884.5	520.4	773.0	3730.6	748.6	3005.8	3.2	10.1
Clisbako	64040.8	55941.7	52430.9	0.0	4354.6	767.9	3995.1	7947.0	676.5	7600.3	9.2	15.4
Coglistiko	55255.2	49696.4	43924.6	4759.8	2298.8	2554.9	2002.6	19223.1	1049.5	18188.0	9.8	40.8
Dragon	95074.4	47084.8	35137.2	1837.5	4382.6	795.2	1492.8	7469.9	3162.0	2220.0	11.0	22.6
Eliguk	39699.2	27844.3	23224.4	6693.6	941.0	2378.6	802.1	5772.2	998.7	4473.0	11.9	24.3
Euchiniko	59006.2	50930.0	43504.9	3521.9	2223.2	415.8	1711.2	4715.0	1171.2	3378.5	5.2	11.6
Gerimi	43086.8	38117.3	20719.5	0.0	2031.3	2284.1	763.9	4628.5	5113.5	1329.7	11.3	25.6
Kluskus	77232.9	65447.1	47937.0	11754.3	1329.2	10147.1	709.4	23067.4	3900.6	18002.2	17.5	41.2
Marmot	52906.3	46289.8	41404.6	0.0	3104.0	402.4	2470.6	4546.3	762.7	3622.7	7.6	11.5
Pan	75627.8	43278.3	29272.7	34737.8	1156.2	9688.9	718.3	14908.2	3112.5	12403.6	25.1	41.6
Pantage	78579.2	68087.4	63058.4	0.0	3674.5	580.5	2553.1	4177.9	462.0	3323.2	6.2	6.8
Pelican	78527.4	65380.7	53142.3	4237.0	1375.8	591.1	1072.2	5872.0	1847.0	5038.1	3.0	11.8
Ramsey	70663.9	63735.0	59146.4	0.0	3646.6	621.0	2811.8	4157.9	377.4	3718.2	6.7	7.1
Snaking	64637.1	58235.0	55420.9	0.0	3232.6	442.7	2489.7	4232.8	249.2	3661.4	6.3	7.7
Tibbles	68835.6	59028.0	56037.4	0.0	4295.0	304.4	3296.5	3721.4	320.3	3131.0	7.8	6.8
Toil	51804.8	47482.0	21145.0	27097.5	216.0	22663.1	151.3	17511.0	3288.3	16330.1	48.2	43.8
Twan	30021.7	22715.5	19233.6	0.0	3307.9	630.4	1765.1	2247.9	503.2	850.1	17.3	12.1
Umiti	83792.2	18516.8	12233.1	280.0	1346.7	459.6	372.2	1379.8	827.6	395.3	9.8	11.9
Victoria	63838.3	13383.2	10326.5	0.0	1688.3	439.0	561.3	793.1	229.8	192.7	15.9	7.6
Whittier	61835.8	45376.2	31120.5	0.0	3648.9	1485.3	1636.0	6811.1	4801.1	2802.2	11.3	25.6

Table 7b *Continued*

Landscape Unit	Total Area	Total CF Area	Total THLB Area	Parks & Protected Areas	LNHR THLB	LNHR Non-THLB	PI Leading LNHR THLB	LCR THLB	LCR Non-THLB	PI Leading LCR THLB	% LNHR of the CF	% LCR of the CF
Mountain Units												
Antler	47103.6	0.0	0.0	12459.2	0.0	0.0	0.0	0.0	0.0	0.0		
Betty Wendle	34470.6	23.9	0.0	34468.5	0.0	1.3	0.0	0.0	1.4	0.0	5.4	5.9
Big Valley	19551.3	0.0	0.0	887.4	0.0	0.0	0.0	0.0	0.0	0.0		
Bowron	48629.9	0.0	0.0	41775.6	0.0	0.0	0.0	0.0	0.0	0.0		
Cunningham	36574.2	30244.9	20117.2	9217.8	707.5	4923.6	14.2	6918.4	2295.1	46.4	18.6	30.5
Downton	14793.1	2759.3	0.0	14793.1	0.0	2525.0	0.0	0.0	234.3	0.0	91.5	8.5
Indian Point	20151.2	1.6	0.0	7098.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack of Clubs	26248.5	4324.0	4006.3	3017.1	215.1	4.6	2.1	1335.8	67.9	34.6	5.1	32.5
Lightning	35886.9	18167.6	14894.9	2516.5	646.2	2184.2	43.2	2844.2	366.4	205.2	15.6	17.7
Mathew	44385.7	13617.3	10297.3	32572.8	735.7	1930.1	217.4	857.0	375.1	79.4	19.6	9.0
Narcosli	76867.9	42694.6	34528.0	0.0	3808.4	827.9	1279.4	2658.5	879.0	843.3	10.9	8.3
Sandy	33034.8	47.6	36.1	32995.6	0.4	3.0	0.0	3.9	0.6	0.0	7.1	9.5
Swift	36656.5	8817.6	4619.6	9110.7	390.2	3768.5	3.6	360.6	249.8	17.0	47.2	6.9
Wentworth	66510.3	59536.7	53833.1	616.3	3847.0	489.9	3355.7	5323.9	786.0	4347.2	7.3	10.3
Willow	47646.9	26567.1	25610.6	0.0	3565.3	157.3	353.1	2222.7	69.4	221.4	14.0	8.6
Grand Total	2075875.4	1286523.5	1062598.7	305278.8	75656.4	76924.1	45798.6	180551.3	40531.4	127873.3	11.9	17.2

* Indicates the percent of area occupied by legislated non-harvest retention in the Crown forested land.

† Indicates the percent of area occupied by legislated constrained retention in the Crown forested land.

As with Table 7a above, Table 7b can be used to identify landscape units where the retention target of 20 to 25% is met, or close to being met and assist with identifying landscape units where extra effort may be required to locate sufficient retention. **To assist the user, a summary table specific to the management unit is present on each base map.**

2.6 PHASE VI: SPATIAL PROJECTION OF RANKED INDICATORS

The purpose of the projection exercise was primarily to provide guidance toward increasing stand and landscape level retention and secondly to help meet the Chief Forester's recommendations. Projection maps are intended as a tool to help forest managers make best management decisions regarding their choices of retention. The projection maps not only assist with the spatial arrangement of retention, but when viewed along side a base map can also provided an indication of the quality and quantity of retention.

The three types of retention (defined in Section 2.5.2 above) were presented on the projection maps in the following manner:

- **Legislated non-harvest retention** - These areas are crosshatched in RED on the projection map.
- **Legislated constrained retention** - These areas are crosshatched in GREEN on the projection map with the exception of natural range barriers that are identified by thick TEAL lines because NRBs are comprised of arc, not polygon data.
- **Non-legislated, optional retention** - Where these areas are present on a projection map, they are crosshatched in PURPLE.

A special case was made to add recent fires (2004 and 2005) to the Vanderhoof management unit projection maps. Experts maintain that recent burns are a source of high biodiversity, especially when moderate to low fires occur in older stands. Particular organisms, especially birds such as black backed woodpeckers, are attracted to recent burns. Additionally, experts claim that certain vegetation tends to flourish in moderately to lightly burned areas. Recently burned areas are indicated on the Vanderhoof management unit projection maps with YELLOW cross-hatching. Underneath the yellow cross-hatching, areas were ranked using the stand level data from before the fire occurred. This was done because the attributes of a stand that increased its value for retention prior to fire are the same features that would make it valuable post fire.

The choice to cross-hatch the above forms of retention was made so that an individual viewing the projection map could still see the priority class assigned to the forest (red (very high), orange (high), yellow (moderate) or green (low) underneath. This choice was intended to assist with rationalizing retention choices based on the potential value(s) assigned to an area.

Once the different types of retention were categorized, projection map production commenced. The data were coded and a series of buffering exercises were used to match the data with the matrix categories presented earlier in Table 4. Values were then assigned as per the ranking. The ranked values were summed and placed in the priority groups listed in Tables 6a and 6b for the Vanderhoof and Quesnel management units respectively.

The result is a projection map that has four main colours (red, orange, yellow, and green) as the base with areas of cross-hatching (red, green or purple) over top to show the spatial arrangement of existing legislated retention, and optional retention.

2.6.1 Projection Map Analysis

Table 8a Summary table of analysis from Vanderhoof management unit projection maps (*within the 2004 THLB – reported in hectares*)

NDU/BEC Unit	Crown Forested	THLB	Very High	High	Moderate	Low	VH PI Leading	H PI Leading	M PI Leading	L PI Leading	% VH of the THLB	% H of the THLB
D1 MI – Mnt. ESSF mv1 ESSF mvpl ESSF xv1	150647	113756	473	41710	66126	5447	110	22715	54377	5447	0.4	36.7
D2 MI - P. SPBS mc	47993	15753	41	5067	10425	220	5	3365	9962	220	0.3	32.2
D3 MI - P. SBSdk	175121	136329	905	63052	69840	2531	247	46985	62286	2531	0.7	46.3
D4 MI - P. SBS dk	49461	38737	123	13297	24011	1307	108	11373	21805	1307	0.3	34.3
D5 MI - P. SBS dw2	218402	178221	228	30004	116544	31445	81	19936	96212	31445	0.1	16.8
D6 MI - P. SBS dw3 mc2	244029	216862	549	60772	133784	21756	425	43786	114684	21756	0.3	28.0
D7 MI - P. MS mc3	224637	187244	719	63381	115659	7486	426	50148	104626	7486	0.4	33.8
Grand Total	1110291	886901	3038	277284	536388	70191	1401	198306	463953	70191	0.3	31.3

Summary tables are provided on the projection maps to assist with understanding the potential impact of particular management decisions.

Table 8b Summary table of analysis from Quesnel management unit projection maps (*within the 2004 THLB – reported in hectares*)

Landscape Unit	Crown Forested	THLB	Very High	High	Moderate	Low	VH PI Leading	H PI Leading	M PI Leading	L PI Leading	% VH of the THLB	% H of the THLB
Plateau Units												
Ahbau (TFL5)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Baezaeko	76003.5	71149.1	5986.1	13641.4	45258.6	6263.0	509.9	12899.3	43827.3	6212.9	8.4	19.2
Baker	72648.2	65387.9	6627.8	9779.8	42028.1	6952.2	256.6	7987.7	38127.9	6888.1	10.1	15.0
Chine	44500.0	39698.7	3522.7	4848.0	29458.4	1869.6	146.6	4433.6	29234.0	1869.6	8.9	12.2
Clisbako	55941.7	52430.9	2221.3	10704.6	36866.6	2638.4	716.8	10404.1	35489.4	2603.4	4.2	20.4
Coglistiko	49696.4	43924.6	2728.0	6018.0	33062.1	2116.5	236.8	5839.8	32677.2	2116.5	6.2	13.7
Dragon	47084.8	35137.2	13020.9	6647.8	13799.6	1668.9	54.3	2889.6	12047.8	1599.6	37.1	18.9
Eliguk	27844.3	23224.4	3001.9	4011.3	15217.2	994.0	156.1	3790.7	15206.8	994.0	12.9	17.3
Euchiniko	50930.0	43504.9	5662.2	8778.0	27102.7	1962.0	184.2	8260.1	26511.1	1830.1	13.0	20.2
Gerimi	38117.3	20719.5	7118.8	4266.4	7365.8	1968.5	18.1	746.0	7058.0	1874.9	34.4	20.6
Kluskus	65447.1	47937.0	10862.6	6710.0	28370.8	1993.6	236.4	6392.1	28336.6	1993.6	22.7	14.0
Marmot	46289.8	41404.6	3885.9	5868.8	27774.5	3875.4	116.2	4903.4	25775.8	3642.2	9.4	14.2
Pan	43278.3	29272.7	4610.9	4333.7	19074.6	1253.5	239.5	4182.7	19038.1	1253.5	15.8	14.8
Pantage	68087.4	63058.4	6121.8	8106.3	40945.7	7884.6	136.1	6634.6	33441.5	6885.8	9.7	12.9
Pelican	65380.7	53142.3	3835.7	7431.3	36830.2	5045.1	297.3	6933.2	35577.0	5028.6	7.2	14.0
Ramsey	63735.0	59146.4	5059.7	8006.3	40960.5	5119.9	207.9	6686.4	36430.9	4946.7	8.6	13.5
Snaking	58235.0	55420.9	3865.8	7004.2	38549.6	6001.3	246.9	6654.8	37615.9	5662.3	7.0	12.6
Tibbles	59028.0	56037.4	3560.1	7125.3	38671.8	6680.2	180.8	6637.1	36553.7	6561.6	6.4	12.7
Toil	47482.0	21145.0	1343.3	3544.1	15620.0	637.6	77.9	3470.4	15495.2	637.6	6.4	16.8
Twan	22715.5	19233.6	7127.6	4247.1	7323.8	535.1	229.3	3019.2	6505.3	510.7	37.1	22.1
Umiti	18516.8	12233.1	6349.2	2270.8	3244.0	369.1	14.2	595.5	2691.8	344.5	51.9	18.6
Victoria	13383.2	10326.5	5133.5	2054.8	2876.0	262.2	7.6	617.6	2723.1	261.7	49.7	19.9
Whittier	45376.2	31120.5	8060.7	5390.1	15764.5	1905.2	86.9	3137.2	12420.4	1742.6	25.9	17.3

Table 8b *Continued*

Landscape Unit	Crown Forested	THLB	Very High	High	Moderate	Low	VH PI Leading	H PI Leading	M PI Leading	L PI Leading	% VH of the THLB	% H of the THLB
Mountain Units												
Antler	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Betty Wendle	23.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Big Valley	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Bowron	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Cunningham	30244.9	20117.2	17693.4	1305.9	852.9	265.0	4.6	146.6	611.1	179.3	88.0	6.5
Downton	2759.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Indian Point	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Jack of Club	4324.0	4006.3	3614.6	276.7	64.7	50.3		0.5	64.7	50.3	90.2	6.9
Lightning	18167.6	14894.9	12639.9	788.0	1165.3	301.7	0.9	74.2	944.4	231.7	84.9	5.3
Mathew	13617.3	10297.3	6831.6	2052.5	1073.1	340.1	41.5	254.3	1034.9	252.5	66.3	19.9
Narcosli	42694.6	34528.0	12208.8	4252.6	15521.4	2545.2	68.6	2944.8	13668.9	2290.1	35.4	12.3
Sandy	47.6	36.1	1.6	33.4	1.1	0.0	0.0	0.0	1.1	0.0	4.4	92.5
Swift	8817.6	4619.6	4064.3	171.1	312.2	72.0		1.7	273.4	41.0	88.0	3.7
Wentworth	59536.7	53833.1	2952.6	8550.2	38237.4	4092.9	541.6	8299.9	36631.1	4067.6	5.5	15.9
Willow	26567.1	25610.6	18740.1	2950.8	3495.0	424.7	20.2	462.4	1565.3	233.6	73.2	11.5
Grand Total	1286523.5	1062598.7	198453.4	161169.3	626888.2	76087.8	5033.8	129299.5	587579.7	72806.6	18.7	15.2

It is interesting to note that overall there is a higher percentage of area classified as very high potential for retention in the Quesnel management unit. The difference in the amount of potential retention in the very high classification between the Quesnel management unit and the Vanderhoof management unit is largely attributed the amount of legislated retention in the Quesnel Forest District. The biggest contributor to the very high classification in the Quesnel management unit is proximity to an existing anchor. The Quesnel Forest District has spatially defined permanent and transitional OGMAs, which the Vanderhoof Forest District does not. Additionally, it is possible that there are more or larger RRZs in the Quesnel management unit which again would not only increase the value of stands in proximity the RRZ but increase the value of the RMA – resulting in an increase to the amount of area classified as having a very high potential for retention. This idea would however require specific analysis to prove.

Summary tables are provided on the projection maps to assist with understanding the potential impact of particular management decisions.

2.7 PHASE VII: PROJECTION MAP REVIEW

It was important that the projection maps be useful. As such, projection maps were reviewed by numerous expert individuals over the course of the project. Adjustments were made based on comments, suggestions and further rationalization.

2.8 PHASE VII: FINAL MAP PRODUCTS

Map products were posted to an interim website, March 1, 2006. These products were reviewed by the MoE, ILMB, MoFR and Forsite, and subsequently revised and reposted on the 15th of March, 2006.

3.0 POTENTIAL IMPACTS OF RETENTION OPTIONS TO THE THLB

A common concern about increasing the amount of retention is the impact on timber availability. The benefits of retaining tracts of dead lodgepole pine are also the subject of much debate. Leaving standing dead pine on the landscape in the form of CLA's has also been viewed as a reduction to timber availability. The potential impacts of increased retention to the THLB in the Vanderhoof and Quesnel management units are suggested numerically in Tables 7a, and 7b. The percent of retention within each retention priority is also represented on the projection maps. How these numbers are interpreted depends upon how retention is carried out within individual management or landscape units.

An example would be in consideration of the Chief Forester's recommendations with regards to retention levels they require a starting place for determining how much additional retention is necessary to meet the goal of 20% to 25% retention. The maps and supporting analysis are intended to assist with this determination. For example, if 12% of a given landscape unit is currently classified as legislated retention, and is located in pine leading stands, then to meet a 20% retention goal harvest planners require an additional 8%.

The next step toward locating the 8% is to plan for effective landscape and stand level retention. The base maps provide a starting point with which to make best management decisions. The projection maps indicate where the higher value options/alternatives for retention exist. The base and projection maps are meant to be used together, and are not a replacement for local, on the ground knowledge. In fact, local knowledge is of the utmost importance when planning for the best types of retention and the best location for retention.

An example is the fire breaks that are placed on the Vanderhoof management unit maps. Individuals planning harvesting activities in these zones can use the maps to determine if valuable forested land could be retained by adjusting the boundaries of the fire breaks around areas that have been identified as having a very high ecological value. Understandably, a decision such as this requires site-specific (ground based) information. The maps simply provide a basis with which to examine options, and provoke thought.

An additional feature of concern in the Vanderhoof management unit was natural range barriers (NRBs). Natural range barriers are formed by thick stands of trees or other topographic features,

and used by ranchers to maintain quality of Crown resources by restricting livestock access to roads, wildlife areas, riparian areas, neighbouring Range Act Agreement Areas and unauthorized Crown land (A. Pantel pers. comm.)⁹. Natural range barriers are included on the projection maps to assist in their identification and maintenance during large scale salvage operations. Promoting stand retention within Range Act Agreement Areas may reduce the degradation of sensitive ecosystems and streams classed S4 to S6 by cattle.

In the Quesnel management unit, an example would be to examine the areas adjacent to where important wildlife habitat has been identified and look for ways to incorporate connectivity with preservation such where heron or swan habitat exists.

4.0 NON-GEOGRAPHICALLY LOCATED RECOMMENDATIONS FOR RETENTION

This project identified existing legal forms of retention as well as options or alternatives to augment that retention. The information used to develop the matrix and place value on stand level attributes could also be used in the field to help identify good candidates for retention. For example, well-developed understories are of particularly high value for retention of non-timber values as well as their potential to provide future timber opportunities.

While the literature on the effects of large scale salvage harvesting post catastrophic disturbance is limiting, poor planning and implementation of large scale salvage operations has the potential to be ecologically disastrous. Several guidelines and recommendations have been put forward in response to the current beetle outbreak. Eng's (2004) Interpretation Paper, the Chief Forester's (2005) recommendation and the Quesnel Forest District Enhanced Retention Strategy (2006) are examples that provide guidance for non-spatially defined retention.

The following bullets summarize the guidance found in these and other documents. To help mitigate negative impacts, field practitioners and planning foresters should consider the following where possible:

- Plan stand and landscape level retention in unison;
- Retain areas with live trees, especially those with a well developed sapling/pole understory;
- Preserve deciduous species as much as possible;
- Retain lodgepole pine leading stands with a significant component of non-pine species;
- Treat riparian areas as reserve zones, considering 100% retention especially when wind throw hazard is high;
- Expand the size of riparian areas especially where they will enhance connectivity;
- Treat S6 as S4 streams where they are directly tributary to fish bearing streams;

⁹ Andrew Pantel, Range Branch- Range Agrologist. Ministry of Forests and Range, Prince George District.

- Retain stands currently used as NRBs, especially where streams are present;
- Locate CLA's in lodgepole pine leading stands;
- Expand the size of existing retention anchors especially where they capture CLA's and improve connectivity and interior forest condition;
- Continue to leave stand-level retention, because dead or alive these areas provide valuable intact structure; and
- Refrain from harvesting operable areas on non-lodgepole pine leading stands in the near term.

Further to the above recommendations, planning for retention should also consider the following qualifiers:

- The **purpose** of choosing to retain an area is a critical decision. For example, is it for preservation, wind throw deterrent, future timber supply, connectivity, or to create a CLA?
- The **duration** that an area will be or is expected to be retained. For instance is a permanent reserve being created, or is a stand being conserved to address mid-term timber?
- The **location** of an area on the landscape and in relation to other values.
- **Size and shape** should be consistent with, as much as possible, natural disturbances patterns.
- Impacts that may be imposed on **access**, access structures and subsequent management.

5.0 PROJECT RECOMMENDATIONS

5.1 GENERAL

This project did not contain a literature review component, but relied strictly on the experience and knowledge of trained professionals. A formal literature review in the future however, would positively augment the matrix and analysis component of this project to identify valuable habitat, diversity and ultimately effective areas of retention.

Consultation with experts for this project took many forms. Meetings in person were held whenever possible, and consultation took place through email as well as over the phone. Each form of communication served its purpose and was useful. Phone calls were especially useful given busy individual schedules.

As indicated previously, public input for the Vanderhoof and Quesnel management units was obtained indirectly through prior community-based efforts. Special management zones and non-motorized access are two examples from the Vanderhoof LRMP that were used for this project. Goal 2 Protected Areas are an example of data used for this project that resulted from the CCLUP. This information was advantageous in spatially identifying areas of significant social and cultural importance. Future projects of this nature would benefit from incorporating the same type of information.

The benefits of leaving tracts or stands of dead lodgepole pine are most likely well understood amongst certain academics, ecologists and biologist however, this is not necessarily the case for field practitioners. Increasing the level of knowledge about the value of CLA's may be pertinent to a successful provincial retention planning program.

5.2 INTERPRETING THE BASE AND PROJECTION MAPS

The base maps and projection maps were intended to be used together as a tool to identify potential options for retention. Final decisions should not be made without considering the following:

- Natural disturbance patterns should guide the size and shape of retention choices paying special attention to connectivity and interior forest condition;
- Existing stand level retention should be considered as a building block for larger scale retention areas;
- Projection maps can aid in choosing suitable areas for large openings and where retention can be in relation to these areas; and
- Spatial data has inherent errors and cannot replace good ground based decision making. The development of ground based field guidance in the form of an instruction manual or decision matrix may be necessary to assist with applying best management practices.

5.3 FUTURE DIRECTION

The utility of this project will only be realized once it is put into practice. One of the next steps will most likely involve an introduction to licencees and other land use managers. It is important that future users of the projection maps understand their limitations and that the maps are not a substitute for best management practices on the ground. Local knowledge will be of utmost importance for the utilization of the maps resulting from this project. The best use of the maps should involve interpretation by local practitioners who are most familiar with the land base they are managing and can make knowledgeable decisions regarding retention.

An operational field manual would be beneficial for making on the ground decisions regarding the types of stands that should be retained, whether they are for biodiversity, timber supply or conservation legacy purposes.

A standardized system of monitoring and tracking contributions to enhanced retention (similar to that used to track wildlife tree patches) needs to be developed.

The projection exercise performed for this project could be better tested with more robust statistical tools. One such method would be to transform the indicator matrix into a Bayesian type analysis, which would provide more flexibility in scrutinizing the way the matrix is organized. Further, should future iterations of this project be realized in other provincial management units, or repeated for the Vanderhoof or Quesnel management units, the indicators in the matrix (Table 4) may need to be revisited and revised.

Indicator scoring could also be revisited. Perhaps some indicators are not necessary, and others should carry more or less ‘weight’ than they did in this exercise. Also, interior forest condition potential could be better captured by buffering each polygon with a 200m interior buffer, and scoring only the area inside the buffer as counting toward interior forest condition.

As new spatial data and technical information becomes available base and projection mapping may need to be recreated in order to reflect the most current level of knowledge.

During the course of this project, it became evident that there are several strategic reasons for addressing the issue of retention, and they are as follows:

- Non-timber values,
- Mid-term timber supply, and
- Conservation legacy areas.

Addressing non-timber values was the main purpose of this project, however some mid-term timber supply and CLA concepts were also captured in areas of overlap. It may be a useful exercise to map these issues separately. Also suggested was to map the duration of proposed retention using a theme of short, mid or long-term retention. This exercise would require rationalizing timeframes for specific types of retention.

Should the methods of this project be used to address timber supply concerns (mid-term timber supply for example), better data or better assumptions are required to ascertain where well developed understory composition exists. Additionally a current resultant data base rather than a THLB coverage should be utilized.

5.4 CONCLUSION

No one solution or project, but a collective effort of individuals committed to designing a conscientious, sound approach to retention will reduce the detrimental impacts that may arise from salvage operations. Although, the current uplift addresses the salvage of mountain pine beetle killed lodgepole pine, it has been predicted that is still not possible to harvest all the impacted pine (J. Pousette pers. comm.).¹⁰ The importance of making sound decisions regarding retention cannot be overstressed. The results of this project help identify the biological and ecological basis for retention. They do not provide the user with definitive instruction of how to carry out retention planning. What these results do provide however is a foundation for closely examining the purpose, location, duration, quantity and within reason, quality of retention.

¹⁰ John Pousette, Tenures Officer. Ministry of Forests and Range, Prince George District.

6.0 REFERENCES

- Banner, A., MacKenzie, W., Haeussler, S., Thomson, S., Pojar, J. and Trowbridge, R. 1993. Field Guide to Site Identification and Interpretation for the Prince Rupert Forest Region. Land management handbook ISSN 0299-1622; no 26. Province of British Columbia. Published by the Research Branch Ministry of Forests.
- B.C. Ministry of Forests. 1995a. Biodiversity guidebook. Province of British Columbia.
- B.C. Ministry of Forests. 1995b. Riparian management area guidebook. Province of British Columbia.
- B.C. Ministry of Forests. 2004a. Expedited timber supply review for the Lakes, Prince George, and Quesnel Timber Supply Areas. Public Discussion Paper. B.C. Ministry of Forests 1520 Blanshard Street, Victoria, B.C.
- B.C. Ministry of Forests. 2004b. Prince George Timber Supply Area rationale for allowable annual cut (AAC) determination. October 1, 2004. British Columbia Ministry of Forests.
- B.C. Ministry of Forests. 2004c. Quesnel Supply Area rationale for allowable annual cut (AAC) determination. October 1, 2004. British Columbia Ministry of Forests.
- B.C. Ministry of Sustainable Resource Management. 1995. Cariboo-Chilcotin land use plan. Ninety-day implementation process final report. Province of British Columbia.
- B.C. Ministry of Sustainable Resource Management. 1997. The Vanderhoof land and resource management plan. Province of British Columbia.
- Landscape Objectives Working Group 2004. The Order Establishing Landscape Biodiversity Objectives for the Prince George Timber Supply Area.
- Lindenmayer, D.B., Foster, D.R., Franklin, J.F., Hunter, M.L., Noss, R.F., Schmiegelow, F.A., and Perry, D. 2004. Salvage harvesting policies after natural disturbance. Science 303: no. 5662, 1303.
- Lotan, J.E. and Critchfield, W.B. 1990. Pinus contorta Dougl. Ex. Loud. Lodgepole pine. In Silvics of North America volume 1, conifers. Edited by R.M. Burns and B.H. Honkala. USDA For. Serv. Agriculture Handbook 654. Washington DC.
- DeLong, S.C. 2002. Natural disturbance units of the Prince George forest region: guidance for sustainable forest management. Ministry of Forests, Prince George, B.C. unpublished report.
- DeLong, C., Tanner, D. and Jull, M.J. 1993. A field guide for site identification and interpretation for the southwest portion of the Prince George Forest Region. Land Management

Handbook ISSN 0224-1622 no. 24. Province of British Columbia. Published by the Research Branch Ministry of Forests.

Eng. M. 2004. Forest stewardship in the context of large-scale salvage operations: An interpretation paper. Ministry of Forests Science Program. Technical Report 019.

Eng, M., Fall, A., Hughes, J., Shore, T., Riel, B., Hall, P., and Walton, A. 2005. Provincial level projection of the current mountain pine beetle outbreak: an overview of the model (BCMPB v2) and results of year 2 of the project. Canadian Forest Service and the B.C. Forest Service, Victoria, B.C.

Province of British Columbia. 2005. British Columbia's mountain pine beetle action plan 2005-2010.

Quesnel Forest District Enhanced Retention Strategy Committee 2006. Quesnel Forest District enhanced retention strategy for large scale salvage of mountain pine beetle impacted stands. Release 1.0.

Resource Information Standards Committee. 1998. Standard for terrestrial ecosystem mapping in British Columbia. Prepared by the Ecosystem Working Group Terrestrial Ecosystems Task Force Resources Inventory Committee. The Province of British Columbia.

Snetsinger, J. 2005. Chief Forester's guidance on landscape and stand level retention for large-scale mountain pine beetle salvage harvesting operations: Applicable to Lakes, Prince George, and Quesnel timber supply areas.

Taylor, S.W., and Carroll, A.L. (2004). Disturbance, forest age, and mountain pine beetle outbreak dynamics in BC: a historical perspective. *In* Mountain pine beetle symposium: challenges and solutions. *Edited by* T.L. Shore, J.E. Brooks, and J.E. Stone. *Held in* Kelowna B.C. October 30-31, 2003. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, B.C., Canada. Information Report BC-X-399. pp. 41-51.

Triton Environmental Consultants Ltd. 2005. Watershed sensitivity analysis for the Vanderhoof Forest District. Prepared for the Ministries of Forests and Range and Environment, June 2005.