FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

A Broad Scale Cumulative Impact Assessment Framework for the Cariboo-Chilcotin

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This draft report from the Cumulative Effects Framework Project summarizes work that has been completed to date. It is intended to facilitate discussion and solicit feedback, and does not represent a formal position or commitment of the Government of British Columbia.

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Mark McGirr did the GIS work for the analyses, provided excellent maps and designed a system for replicating the analysis across the region. Crispin Guppy's literature surveys for the wildlife species and early assessment approach were a starting point for development of assessment methodology for moose, marten and grizzly bear. Robin Hoffos and Clinton Webb further developed the wildlife assessments and initiated assessments for forest biodiversity and hydrology.

Cris, Robin and Clinton's work provided a sound starting point for this project. Clinton Webb's ongoing work on the Cariboo-Chilcotin Land Use Plan spatial and numerical databases ensured access to accurate, well organized data for biodiversity seral stage assessments and "no-harvest areas".

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Cover Photo of Chilko River by Leo Rankin

Preface to July 2015 Report Edition

The Cumulative Environmental Effects assessment for the Cariboo Region is a work in progress. While the previous edition provided ecologically meaningful assessments for six values, it also identified limitations to the assessment methodologies and input data. Since the last edition of this report (February 2014), significant improvements to the analysis methodology for moose winter habitat have been implemented based on additional thought by the authors, input from a local working group and a peer review. This edition incorporates and explains these improvements.

Over the next 6 to 12 months, provincial groups of value and assessment specialists will be working to develop provincial cumulative effects assessment standards for a number of key values to ensure provincial consistency while allowing a degree of flexibility for special considerations within regions around the province. While the assessment methodology described in this report is a major input into the provincial process, users of this information in the Cariboo must anticipate some changes in the substance and formatting of the assessment results in the future. We expect that the basic results from any new assessment methodologies will not dramatically change from the results presented here, but will potentially clarify, standardize and improve the meaningfulness of the results.

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Introduction

This report describes a decision support tool designed to assess relative environmental risks to large areas of land and water. It offers a systematic approach for assessing a cumulative view of landscape condition in support of First Nations consultation in British Columbia. The decision support framework described here is intended to provide an initial assessment that informs the selection of engagement level and assists in the determination of impacts and mitigation. This is part of the provincial obligation under the Tsilhqot'in Framework Agreement implementation plan and the *Updated Procedures for Consultation with First Nations.*

The tool will also have broader applicability for assessment of environmental impacts of development in the Cariboo-Chilcotin in general. This project has built on the work of Guppy (2010) and Hoffos (2011) by refining their assessment models and providing a systematic and comprehensive approach to describing risk. The tool is applied to a study area consisting of seven landscape units in the West Chilcotin for this report, and results for the entire Cariboo-Chilcotin are available online.

This project focused on development of sound assessment methodology and standardized descriptions of risk factors for broad-scale assessments. The risk description approach was designed to be efficiently applied to multiple areas, and to be easily understood by decision-makers and other resource professionals.

The overall environmental condition within defined assessment units is described relative to identified **valued ecosystem components (VECs)**, and will be updated as required to reflect landscape changes and new knowledge. Using this information, technical staff should be better able to assess current and future risk to wildlife species based on landscape changes. Activities and areas where risk is greatest can be identified and used to guide the development of mitigation and accommodation measures. Clients can also be advised early in their application process of the potential risks which may affect their investment choices.

The application of this initial assessment tool will also provide First Nations and other users with more consistent and comprehensive information with which to categorize and respond to referrals. This could lead to greater efficiency by providing a common information base to all parties involved in consideration of development proposals, and helping to focus on the most relevant issues.

The chosen VECs include the coarse-level environmental filters of forest biodiversity and hydrological stability as well as four wildlife species. The tool is proactive in that it can be applied to any area of land in the Cariboo-Chilcotin to assess the current state of development. In that way, the current risk to the environment can be established prior to review of specific project proposals.

The risk assessment for each VEC includes three components of risk:

1. **Ecological Importance** evaluates the ecological importance of each assessment unit for each VEC. This factor can also be thought of as the level of ecological consequence if the value is impacted.
2. **Hazard** evaluates the current state of the landscape and its ability to meet habitat requirements for each VEC. The assessment is a snapshot in time, evaluating the current ecological condition prior to the consideration of the effects of any new project or development.
3. **Current Mitigation** evaluates the level of risk reduction currently in place for each VEC. Mitigation measures include mapped, legal land-use designations that specify protection or special management requirements. Examples include mule deer winter ranges, protected areas and riparian reserves.

Risk assessment for moose and mule deer also includes a section on **site-level considerations** as an example of what type of information could be provided for decision-makers. This section provides basic information on what site-level habitat changes will impact moose/deer, and what parts of an assessment unit are most sensitive and/or provide the most important site-level habitat attributes. User input on the usefulness of these sections would be valuable to the authors.

The assessment framework developed in this project is expected to provide a number of benefits:

1. Demonstrates compliance with consultation obligations as determined by the *Updated Procedures for Consultation with First Nations* and the Tsilhqot'in Framework Agreement by:
    - Facilitating the correct selection of engagement levels.
    - Introducing decision support tools that will allow the Province to complete initial assessments as directed by case law.
    - Providing a consistent approach to determining impacts.

2. Provides more complete information for proponents to facilitate the assessment of project viability by:
   - Facilitating proactive assessment of cumulative impacts for significant projects to help proponents consider project viability and management design.

3. Provides a more informed decision process by:
   - Facilitating focused and efficient responses from First Nations.
   - Acknowledging the one land base concept by the inclusion of cumulative effects.
   - Facilitating identification of mitigation and accommodation options.

4. Presents a more systematic and explicit assessment approach by:
   - Facilitating critique and improvement over time.
   - Contributing to a larger provincial model of cumulative effects assessment.

Objectives

The objectives of this project are to:

a) Refine six VEC models to make full use of current information, and tailor them to the varying ecological conditions across the Cariboo-Chilcotin.
b) Develop and apply a systematic and standardized approach to risk description that can be used for large areas including many assessment units.
c) Document limitations of VEC assessments, and recommend potential future approaches to improve the assessments.
d) Apply the refined models and risk description approach to an area including seven landscape units in the West Chilcotin.
e) Develop and apply an approach to provide similar assessments across the Cariboo-Chilcotin region.

Methodology

The provincial government has defined cumulative effects as "changes to environmental, social and economic values caused by the combined effect of past, present and potential future activities and natural processes." The assessment framework outlined in this report is designed to evaluate cumulative effects on a subset of important environmental values.

It looks primarily at the current state but considers temporal trends for some indicators. Upcoming versions could be designed to consider possible future scenarios. Following the procedures outlined in the Government of Canada guide to impact assessment (Hegmann et al. 1999) the current landscape condition is described using a risk-based approach to evaluate specific VECs that represent key components of the environment.

The assessment presented in this report is a best current approximation of cumulative effects at an overview level. It relies on existing knowledge and expert opinion. Impact identification will involve qualitative and quantitative assessment of impacts but not complex computer modelling of habitat and population relationships.

Valued ecosystem components

For this assessment, six VECs will be used. Two coarse filter VECs – forest biodiversity and hydrological stability – are used to assess the overall state of forest lands and waters. The forest biodiversity VEC evaluates the seral condition of forest ecosystems, including the spatial pattern of older forests. The seral condition will be compared to both the legal biodiversity targets and the average landscape condition predicted by natural disturbance models. Hydrologic sensitivity and condition will be assessed at several scales using watershed variables designed by hydrologists to separately assess inherent sensitivity of the watershed and the impact of current development. In addition to these two biophysical indicators, a set of four wildlife species traditionally used by First Nations is included. The list of wildlife species is a subset of those described in the *Tsilhqot'in Nation v. British Columbia,* 2007 BCSC. Assessments will address: moose, mule deer, marten and grizzly bear. These species represent a variety of valued wildlife with a range of habitat requirements.

Climate change

Climate change has the potential to change habitats in the assessment area. General trends and effects of climate change in the study areas have been documented (Dawson et al., 2008), but the exact effects on local ecosystems and wildlife are unclear. As such, climate change will not be included as part of the risk assessment at this time, but may be added as the framework is developed.

Study area

The assessment is applied to seven landscape units in the West Chilcotin (Figure 1). This area was chosen for its relevance to First Nations and its biophysical diversity. It is an important part of the traditional territory of the Tsilhqot'in, and it contains 10 different biogeoclimatic subzones. While the results in this report focus on this one study area, assessments have been completed for the whole Cariboo-Chilcotin region as described in the later section entitled Regional Cumulative Effects Assessment.

Assessment units

For moose, marten and grizzly bear, assessment is done at both landscape unit scale and at a smaller subunit scale to provide more area-specific assessments. Landscape units are previously delineated biophysical units that have been used for biodiversity assessments in the Cariboo-Chilcotin since 1995. They are generally based on ecologically similar areas and drainages in consideration of historical natural disturbance regimes. They range from about 30,000 to 70,000 hectares in area, with larger units in the plateau areas and smaller units in more mountainous terrain. The reason for using nested geographic units is to allow sufficient size to capture most projects while addressing impacts at a local geographic scale that may be more meaningful to First Nations activities. The range in size of geographic units also recognizes natural variability among home range sizes for wildlife species, and differing scales of impacts to First Nations and other users of wildlife.

Other VECs used assessment units appropriate to their definition or management. For forest biodiversity, assessments are done at the level of biogeoclimatic subzones within each landscape unit. Mule deer assessments are based on the boundaries for the legally designated mule deer winter ranges. Hydrology assessments are reported at three different scales: watershed, basin and sub-basin.

Figures 1, 2, 3 and 4 below show maps of the analysis unit, satellite image, biogeoclimatic subzones and areas designated by the Cariboo-Chilcotin Land Use Plan as no-harvest or modified harvest areas.

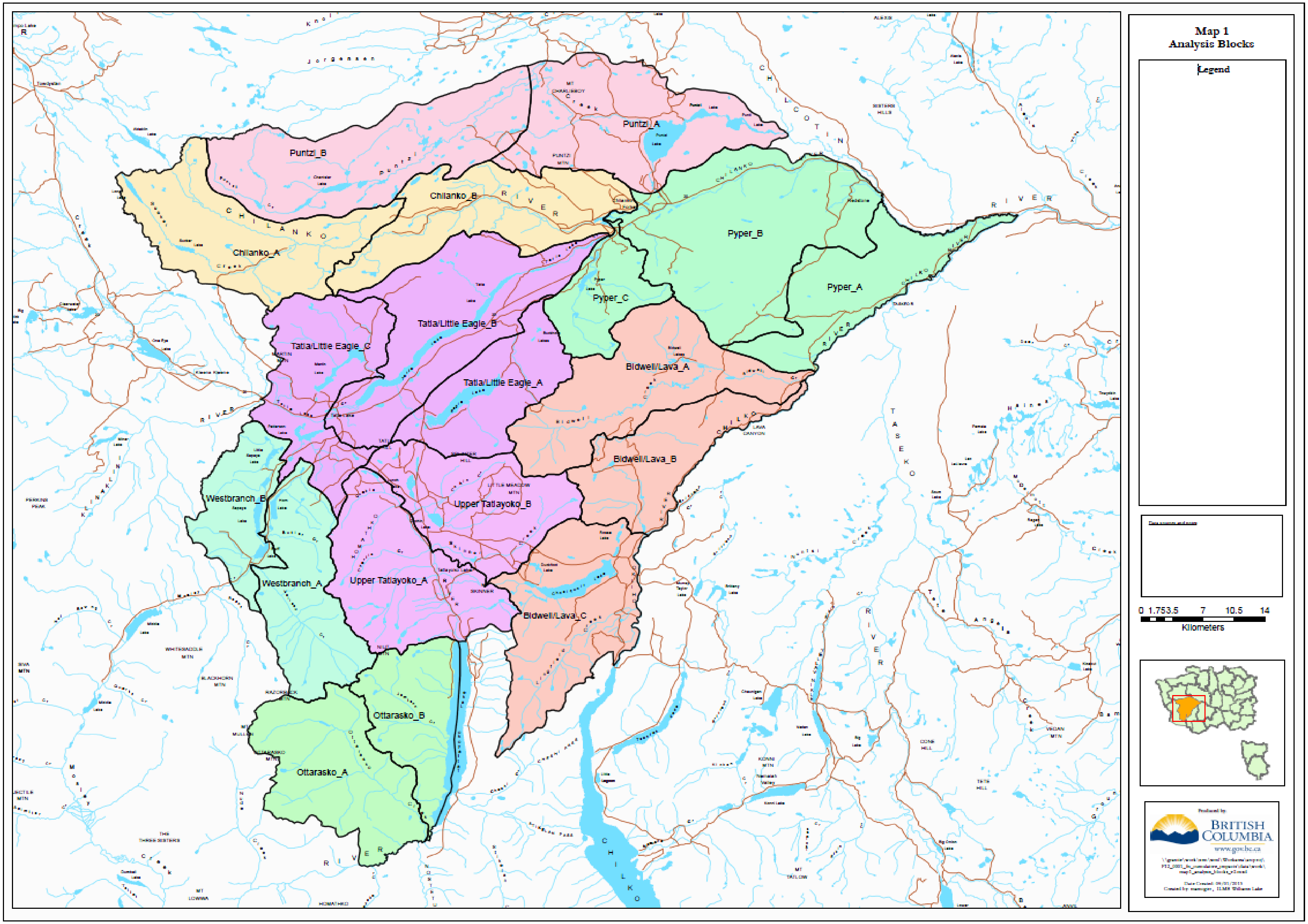

Figure 1. Map 1 – Analysis blocks.

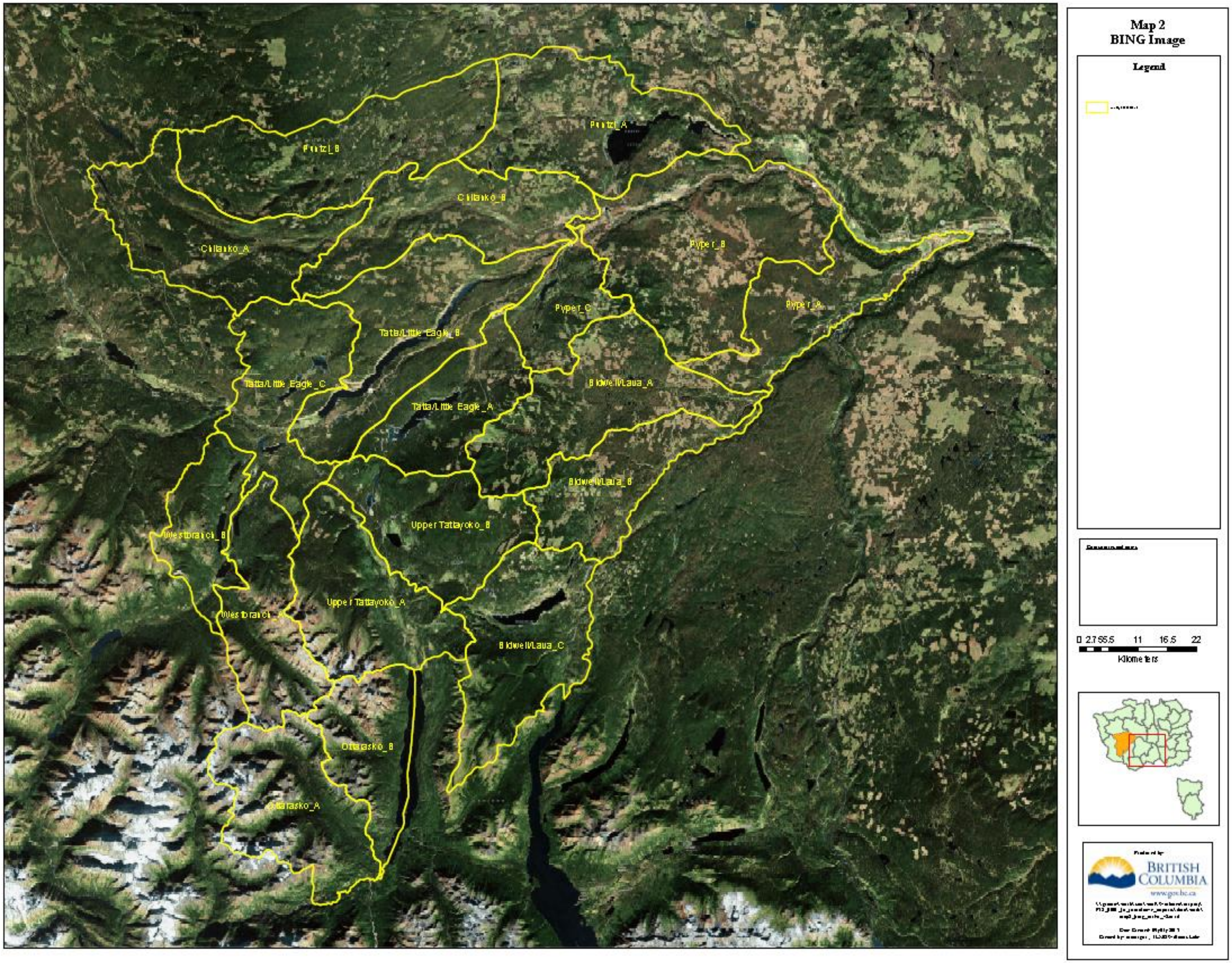

Figure 2: Map 2 – BING image.

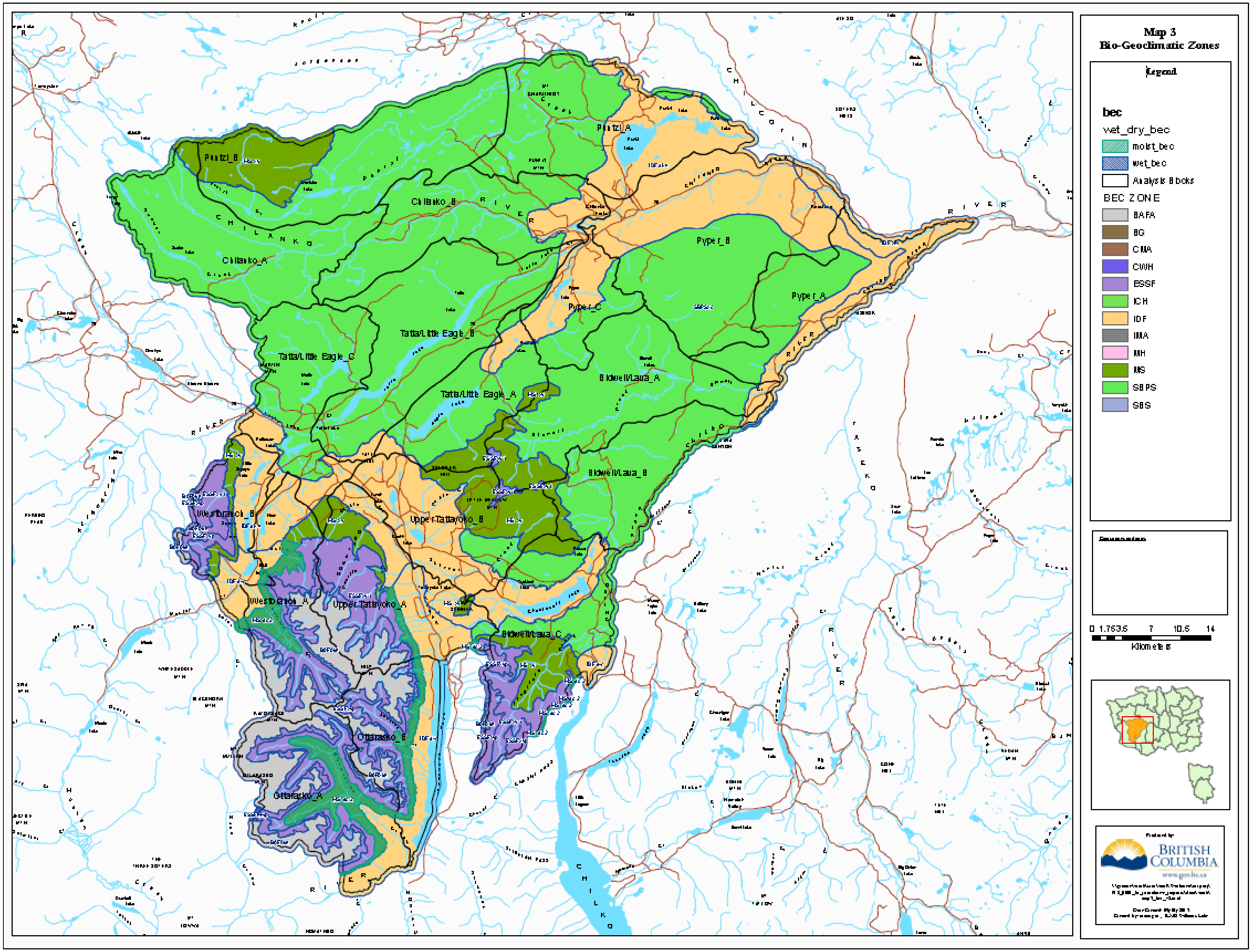

Figure 3. Map 3 – Biogeoclimatic zones.

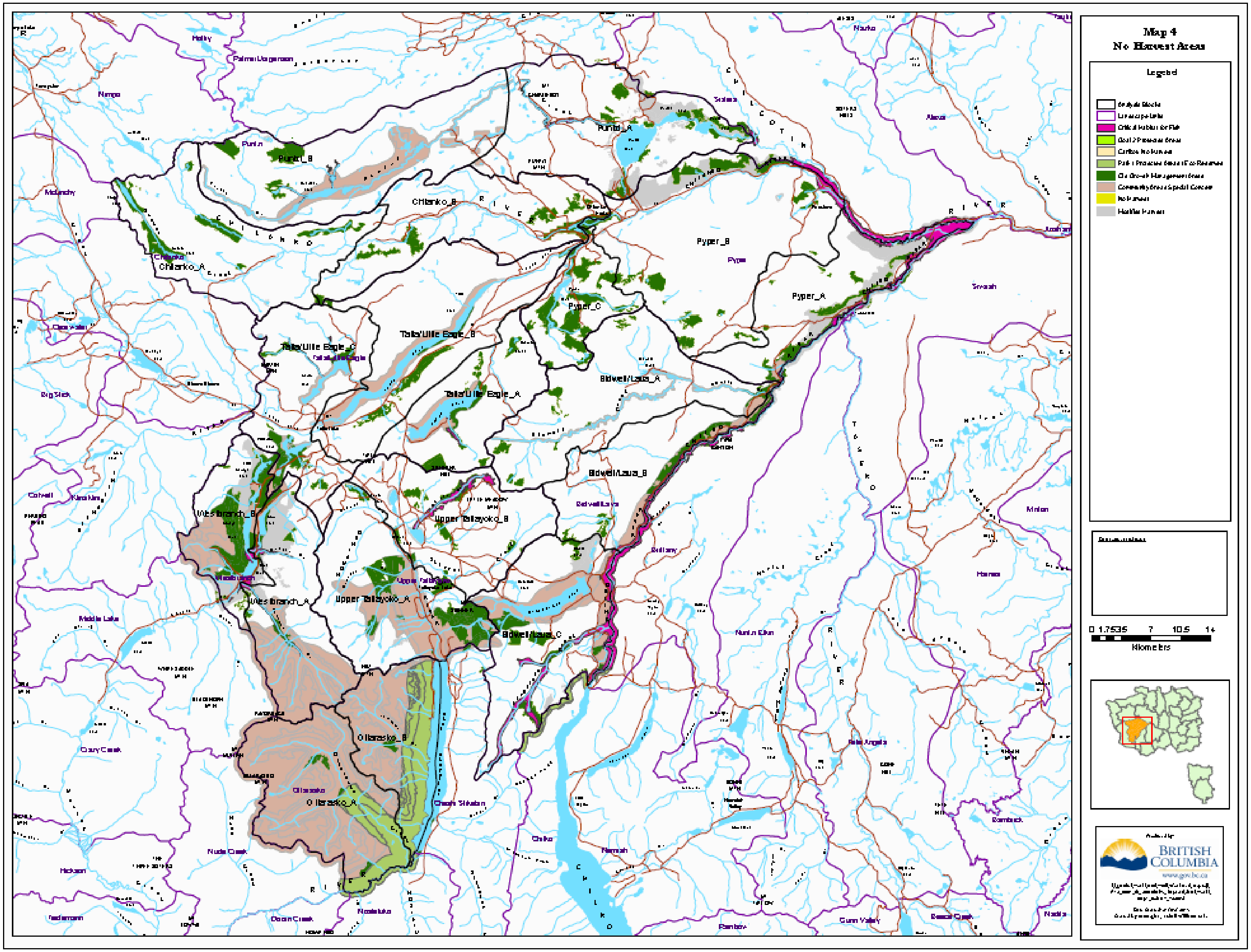

Figure 4. Map 4 - Areas designated by the Cariboo-Chilcotin Land Use Plan as no-harvest or modified harvest areas.

Selection of indicators

Careful selection and design of indicators is critical to produce meaningful assessments. Criteria used for selection of indicators included the following:

- Clear and meaningful relationship between each indicator and key habitat requirements for wildlife species, and key attributes for coarse filter values;
- Readily measureable and understandable;
- As simple as and as few as possible while still providing a meaningful assessment; and
- Hazard indicators that relate to expected types of impacts resulting from human activities and natural disturbance.

Underlying concepts

Concepts important to understanding the selection of indicators include key life requisites for wildlife, wildlife habitat capability, suitability and effectiveness, and dominant disturbance types.

Key life requisites for wildlife

Food, cover, reproduction and mobility are all basic requirements of the wildlife species under consideration. Although these needs are all important, and may change according to season, the assessment will focus on the life requisites that are considered <u>most</u> limiting to the population. These are referred to in this report as **key life requisites.** This type of simplification is often used in habitat modelling. It is necessary to simplify in order to complete assessments within acceptable timeframes, within resource limitations and with existing knowledge.

Wildlife habitat capability, suitability and effectiveness

Wildlife habitat capability, suitability and effectiveness describe the potential quality and current state of wildlife habitat in a given area and how it is affected by human disturbance. Capability mapping was available for moose, marten and grizzly bear habitat and used in their risk assessments. Capable habitat includes all the area that has potential value for wildlife habitat. Suitable habitat represents the current state of the habitat and is a subset of capable habitat. Reductions to suitable habitat from human access and disturbance result in effective habitat (Figure 5).

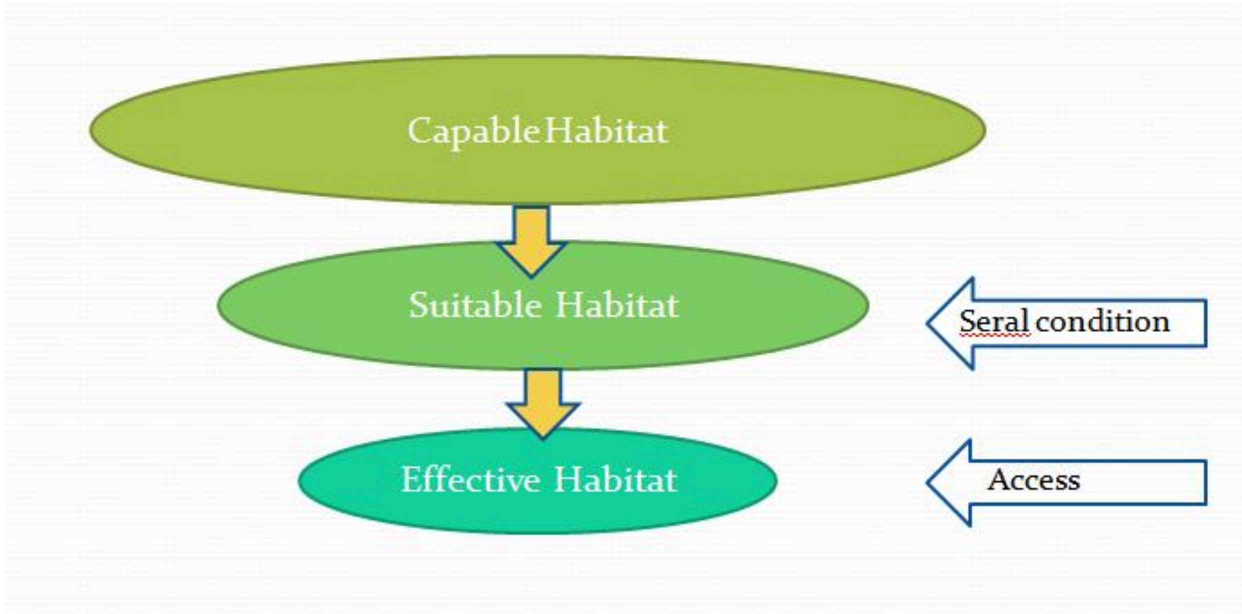

Figure 5. The relationship of capable, suitable and effective habitat.

Definitions for capability and suitability from the Ministry of Environment publication *British Columbia Wildlife Rating Standards*[1] are:

> ***Capability*** *is defined as the ability of the habitat, under the optimal natural (seral) conditions for a species to provide its life requisites, irrespective of the current condition of the habitat.* It is an estimate of the highest potential value of a particular habitat for a particular species and is useful in providing predictive scenarios for various habitat management options. Capability assumes non-intensive management and does not apply where the inherent soil characteristics and productivity have been artificially enhanced, as commonly occurs with irrigation or fertilization. The capability classification of these areas is based on what the ecosystems would be like if they reverted from their present state back to a non-intensive management state.
>
> ***Suitability*** *is defined as the ability of the habitat in its current condition to provide the life requisites of a species*. It is an estimate of how well current habitat conditions provide the specified life requisite(s) of the species being considered. The suitability of the land is frequently less than the capability because of unfavourable seral conditions.

[1] https://www.for.gov.bc.ca/hts/risc/pubs/teecolo/whrs/assets/whrs.pdf

Habitat effectiveness incorporates the effects of human access and disturbance on amount and quality of available habitat. The two definitions below capture the essence of the concept.

*"*The degree to which a patch of habitat is able to support an animal or group of animals. Habitat effectiveness in an otherwise 'good' patch of habitat can be reduced by high levels of human disturbance, long distances to other habitat patches or any other factors in the surrounding landscape that detract from the patch's ability to function as habitat."[2]

"Habitat effectiveness models an area's actual ability to support bears given the quality of the habitat and the extent of human disturbance."[3]

Main disturbance types

Two main disturbances are used to characterize hazards to each VEC in this assessment:

1. Roads and other access features, including rail lines and pipelines; and
2. Forest structure changes as a result of harvesting, development or natural disturbance.

The type, location, extent, duration and intensity of forest harvesting, natural disturbance and road development all affect the level of impact on various VECs.

Roads represent both direct and indirect risks to wildlife. The area of core habitat affected was determined for several species using individual disturbance distances for each wildlife species. Road density and the proportion of large roadless areas are used as indicators in the grizzly bear assessment because they have been correlated to population risk.

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[2] Singleton, P. 2000. *Preliminary Glossary of Biological and Landscape Ecology Terms Relating to the Ecological Impacts of Highways*. Unpublished. U.S. Department of Agriculture Forest Service, Wenatchee Forest Sciences Library, Wenatchee, WA.

[2] Herrero, S. and M. Gibeau. 1999. *Status of the Eastern Slopes Grizzly Bear Project (ESGBP): May 1999.* Eastern Slopes Grizzly Bear Project, University of Calgary, Calgary, Alberta. 5 pp.

Indicator and risk component ratings

The range of values measured by each indicator is classified into three or five levels of management concern to facilitate interpretation of assessment results. These indicator ratings are then rolled up to provide composite ratings for each of the three components of risk (i.e., ecological importance, hazard and current mitigation). The ratings at both the indicator and component level are meant to flag potential issues requiring management attention. As such, they are not designed to make decisions but rather to identify areas and issues where additional consideration is required. When reviewed over the entire region or large sub-regional areas, these results may also trigger possible need for broader planning efforts.

The **hazard** component ratings are key as they flag current environmental conditions. The **ecological importance** and **current mitigation** component information can help provide a deeper understanding of the management significance of any hazards. For example, two areas may have identical high hazard ratings, but one has high ecological importance while the other has low ecological importance. Obviously units with both high hazard and high ecological importance would warrant greater consideration. Mitigation ratings are the inverse of the other two since high levels of mitigation would lead to reduced management concern. The colour coding of the tables reflects this by shading assessment units with high mitigation in green while high hazard or ecological importance units are shaded orange. Table 1 provides a general interpretation from the ratings.

Table 1. Management concern ratings.

Management Concern Ratings		
Very low/Low	Moderate	High/Very high
Little or no further consideration required.	Consideration required. **For hazard component or indicators**: May require additional information and/or management actions designed to maintain current status.	Very careful consideration required. **For hazard component or indicators**: Likely requires additional information to clarify situation. May require management actions to reduce environmental impacts.

Development of management concern ratings associated with the range of values for each indicator is a challenging but important step in the assessment approach used in this project. Indicators were rated using a three- or five-class scale. These ratings are necessarily qualitative, but based on quantitative information from the literature and/or expert opinion. Validation of the model results by value experts and data such as census and radio-telemetry data is important to ongoing credibility and usefulness of the model. Transparency and credibility are also enhanced by clear discussions of the strengths and limitations of the assessment for each VEC. It is important to remember that the main purpose of the assessment is to flag potential management concerns, which should then be more fully explored rather than to make definitive judgments.

The following points summarize the factors used to develop the ratings:

- Available knowledge concerning habitat relationships or hydrological processes;
- Established or commonly used threshold values;
- Natural benchmarks based on the estimated attributes of naturally disturbed landscapes;
- Expert judgment related to habitat relationships, system sensitivity and ecological processes;
- Range and frequency distribution in regional data;
- Level of precision and/or certainty of the input assessment data; and
- Expert assumptions about the "shape" of the relationship between the range of indicator values to risk, e.g., linear vs. bell shaped vs. some other shape.

Advantages of this type of rating approach include transparency, uniformity of output between VECs, and ease of modification based on expert input. Because of the standardization of outputs, users can quickly comprehend the results of a variety of assessments. Model outputs can be checked and validated using a variety of actions including: comparison with local animal distribution data, comparison with other peer-reviewed models, and checks for reasonableness by topic experts, especially those familiar with the habitat relationships in the Cariboo-Chilcotin. Experts with local knowledge can validate assessment results by comparing results with their expectation for areas for which they have intimate knowledge. They can also compare assessment results across the region with their expectations of regional patterns of results. This type of expert review and validation has been done for the moose and marten assessments.[4] This review was a major input into improvements made to the moose assessment process in autumn of 2014.

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[4] Davis, R.L., 2014. Review of *A Cumulative Impact Assessment Approach for First Nations Consultation: Pilot Project for the West Chilcotin.*

User's guide

This is a generic user's guide. Once specific user groups identify more precisely how they will use this assessment information, more specific guidance can be written.

The substance of this report is found in three main sections for each VEC, with different users and uses in mind.

Risk Summaries: This section is intended for decision-makers and those assessing the potential impacts and mitigation of development proposals on the specific assessment units included in the study area. It provides assessment results including tables, maps and interpretations, but has minimal context or background information.

Indicator Descriptions: This section, which follows the risk summary for each VEC, may also be referenced by decision-makers but is primarily intended for those that need to understand exactly how the indicators were measured and rated. It contains detailed descriptions of the indicators for all VECs, a table showing the criteria for rating each indicator, and includes an evaluation of the strengths and limitations of the assessment for each VEC. It is meant to provide complete transparency about the assessment and, therefore, will be useful to those wanting to review the details of the assessment process.

Appendices: These are for those wanting background ecological information and more details of the analysis. They provide ecological background with a brief literature review and more detailed information on analysis methods.

What is included in the risk summaries for each VEC?

- A series of tables documenting assessment results for individual assessment units. The series starts with the big picture and then drills down to provide more detail. The tables are colour-coded to indicate levels of relative management concern related to ecological importance, hazards and current mitigation.
- A list summarizing the highlights of the results and providing some interpretation.
- Maps showing many of the factors used to arrive at the results.
- An example section on site-level considerations in the moose and mule deer summaries.

What can the broad-scale assessment results be used for?

Some possible uses include:

- Input for preparation of initial assessment letters to First Nations.
- Help to select priority VECs for ecological impact assessments.
- Input into determining consultation level with First Nations.

- Flagging specific issues and geographic areas requiring more management attention.
- Input into environmental impact assessments.
- Providing a common source of information to all stakeholders to stimulate and focus discussion.
- Prioritizing which geographic areas and/or VECs may benefit from additional information and/or evaluation prior to development decisions.
- Input to proponents to help them better assess their business case and better design projects to meet environmental concerns.
- Input to decision-makers to support authorization decisions and inform mitigation and monitoring requirements.
- For the *Forest and Range Practices Act (FRPA)*: to provide context information to professionals developing or approving Forest Stewardship Plans and Site Plans.

What is the structure of the assessments?

For each VEC, several attributes are evaluated in each assessment unit using indicators. The results of these assessments are grouped into three basic categories – ecological importance, hazards and current mitigation. The ecological importance is equivalent to the consequence of impact used in traditional risk analysis. Higher importance ratings reflect a greater consequence of any impacts. Hazard indicators assess the degree to which inherent sensitivity and development impacts have reduced available habitat or reduced the effectiveness of the habitat. They measure the probability of impact and/or the degree of impact. Current mitigation indicators assess the level of risk reduction currently provided by legally designated no-harvest and modified harvest areas from the Cariboo-Chilcotin Land Use Plan.

For moose, marten and grizzly bear, the assessment units are landscape units which are divided into two to three subunits. For mule deer, the legally defined winter ranges are the assessment units. For hydrology, three different assessment units are used: sub-basins, basins and watershed units. Forest biodiversity assessments are based on biogeoclimatic subzones within landscape units.

Provided **maps** can provide an intuitive and visual understanding of the situation in each assessment unit. A suite of maps is included in the analysis to supplement the numerical data and ratings provided in the assessment. The risk summary for each VEC will list and describe the maps relevant to that VEC.

Each VEC will have either **two or three results tables**. The first table presents the data in the most generalized format. It can be used to pick out the units where risks identified by the broad-scale assessment are minimal. The subsequent tables provide a finer geographic breakdown of the results, and show results for individual indicators.

Each assessment has a **notes and highlights** section at the end that summarizes the major results, adds notes on other relevant local information, and provides limited interpretations. These sections include examples of the type and level of interpretations that may be appropriate to make from this cumulative effects analysis.

Each assessment also includes a brief discussion of **strengths and limitations** of the approach. Decision-makers can use this information to help judge how much weight to put on the information provided, and what additional factors may need to be considered. Reviewers can use this information to better understand potential gaps and limitations in the assessment model. This transparency is important for building trust with users, and can help to identify aspects of the assessment that could be improved over time or should be taken into account when using the results.

Brief sections on **site-level considerations** were included for moose and mule deer, with:

- A list of site-level habitat changes that would result in impacts to the VEC, and
- A list of factors that can be used to determine degree of importance and/or sensitivity of various sites within an assessment unit.

These sections were included to give decision-makers additional guidance and information at a finer scale of detail than the broad-scale assessment provides. This type of information can lead to more informed discussions of the risk and more effective proposals for potential mitigation. Feedback on the usefulness of this information is encouraged.

Regional cumulative effects assessment

While the report focuses on one pilot area, similar analyses have now been completed for most of the Cariboo-Chilcotin region. The results of these analyses are available in the form of tables and maps. Assessment information is summarized at three scales: aggregate, landscape unit and regional overview. The aggregate units are shown on Figure 6 below.

Automation processes have also been set up to allow for summary of the information on custom areas for major projects and planning initiatives. A process to periodically update the assessments will be developed.

All of the regional data will be available for all users at the following FTP site:
ftp://ftp.geobc.gov.bc.ca/publish/Regional/WilliamsLake/cumulative_effects/

Regional B.C. Government users can also access the files at:
\\spatialfiles.bcgov\srm\wml\Workarea\arcproj\P12_0001_fn_cumulative_impacts\outputs\run_jan_2014\rca

The folders on the FTP site are organized as follows:

- aggregate
- landscape_unit
- overview_maps
- lu_groups_detail_key_map.pdf
- lu_groups_overview_key_map.pdf

For each assessment area, the information is categorized by value plus an additional folder for support maps that apply to all values.

- grizzly
- hydrology
- marten
- moose
- muledeer
- support

The folder for each value, such as moose shown below, includes interpretive maps and an excel file that summarizes the results of the cumulative effects assessment.

- map8a_moose_habitat.pdf
- map8b_moose_feeding.pdf
- map8q_moose_analysis_unit_ecological_importance.pdf
- map8s_moose_analysis_unit_hazard.pdf
- map8u_moose_analysis_unit_mitigation.pdf
- moose_analysis_final.xlsx

Additional maps may be included based on user input. The assessment models will also be improved and updated over time based on new data and additional input from value experts.

Figure 6. Landscape unit groups.

Risk summaries

Forest biodiversity risk summary

This assessment focuses on biodiversity of forested lands, which are the most extensive ecosystem type on landscapes in the Cariboo-Chilcotin. It does not address rare/sensitive ecosystems and non-forest ecosystems, which are also important components of biodiversity. It considers landscape-scale aspects of forest biodiversity and local or site-level factors such as snags, coarse woody debris and stand-level forest structure.

Indicators of seral distribution and patch size are used to evaluate the current ecological state of the land. The seral distribution for natural landscapes (from the 1996 *Biodiversity Guidebook*, Appendix 4) is used as a natural benchmark to assess current seral condition. Mitigation indicators include overlaps with the Cariboo-Chilcotin Land-Use Plan (CCLUP) designated no-harvest and modified harvest areas, and its seral targets for mature plus old forest. The conservation priority of each landscape unit, as determined in the 1996 CCLUP Biodiversity Strategy, is used as a measure of ecological importance in the assessment.

The forest biodiversity summary includes two sections. The first provides the results of the broad-scale cumulative effects assessment. The second provides more detailed information on the indicators. An appendix includes additional background information and analysis details.

Forest biodiversity broad-scale assessment

Table 2 lists the indicators used to assess the ecological importance, hazards and current mitigation for forest biodiversity. Table 3 summarizes the ratings for the three indicator classes for each combination of landscape unit and biogeoclimatic unit (LU/BEC). Table 4 includes the individual indicator information to help identify the factors driving the assessment results.

The following maps display relevant information including some of the factors used in the assessment:

- Figure 2 is a Bing satellite image showing the general topography
- Figure 3 shows the boundaries of biogeoclimatic units.
- Figure 4 shows the no-harvest and modified harvest areas designated by the Cariboo-Chilcotin Land Use Plan.
- Map 6 show high mortality pine stands and recent wildfires.

Table 2. Indicators used to assess overall ecological risk for forest biodiversity.

Note that assessments are done at the level of BEC subzone (or BEC group) within each landscape unit.

Indicator type	Attribute evaluated	Indicator
Ecological importance	Ecosystem representation in protected areas. Ecosystem diversity. Presence of threatened and endangered species. Sensitivity to forest development.	This indicator of Biodiversity Conservation Priority is from the 1996 Biodiversity Conservation Strategy for CCLUP (pages 15-18 plus map).
Hazard	Spatial characteristics mature plus old patches.*	% of M+O seral in patches >250ha. % of M+O forest that is interior forest.
	Forest seral stage distribution in relation to average "natural" condition	Early seral – divergence from average natural landscape condition.
		Mature plus old seral - divergence from average natural landscape condition.
Current mitigation	Current mature plus old seral area in relation to CCLUP targets.	Hectares above or below CCLUP targets for mature plus old seral.
	Protection resulting from CCLUP no-harvest areas.	% overlap with no-harvest harvest areas.
	Protection resulting from CCLUP no-harvest and modified harvest areas.	% overlap with combined no-harvest and modified harvest areas.

*Data and classification are not yet available for the spatial characteristics of mature plus old patches.

Table 3. Summary of the risk components for forest biodiversity.

Colours reflect the appropriate level of management concern: Very High, High, Moderate, Low, Very Low. Note that colours for current mitigation are reversed. For example, if the mitigation level is very high, the colour is dark green indicating a very low level of management concern. The percentage column shows the Crown forest area in each BEC combination as a percentage of total Crown forest in the landscape unit. Two right-hand columns show natural disturbance as a percentage of forested area.

Assessment Unit		Forest Area	Ecological Importance	Hazard	Current Mitigation	% Burned since 1999	% area with >50% Stand Mortality
Landscape Unit	**Amalgamated Unit**						
Bidwell/Lava	IDF dk 4_FirGroup/IDF dk 4_PineGroup/IDF dw_FirGroup/IDF dw_PineGroup	5326	**M**	**L**	**H**	23	10
Bidwell/Lava	SBPSxc	46921	**M**	**L**	**M**	9	3
Bidwell/Lava	ESSFxv 1/MS xv	14054	**M**	**M**	**M**	0	2
Chilanko	IDF dk 4_FirGroup/IDF dk 4_PineGroup	3080	**M**	**L**	**M**	0	9
Chilanko	MS xv/SBPSxc	47163	**M**	**VL**	**M**	0	21
Ottarasko	IDF dw_FirGroup	3898	**L**	**L**	**VH**	0	0
Ottarasko	IDF dw_PineGroup	2816	**L**	**M**	**VH**	0	0
	ESSFxv 1/MS dc 2	8273	**L**	**VL**	**VH**	0	0
Puntzi	IDF dk 4_FirGroup	3214	**M**	**L**	**M**	0	5
Puntzi	MS xv	8282	**M**	**L**	**M**	0	17
Puntzi	SBPSxc	38781	**M**	**L**	**M**	0	21
Puntzi	IDF dk 4_PineGroup	7517	**M**	**L**	**M**	0	19

Assessment Unit		Forest Area	Ecological Importance	Hazard	Current Mitigation	% Burned since 1999	% area with >50% Stand Mortality
Landscape Unit	**Amalgamated Unit**						
Pyper	IDF dk 4_FirGroup/IDF xm_FirGroup	9623	**M**	**L**	**M**	19	4
Pyper	SBPSxc	38724	**M**	**L**	**M**	38	17
Pyper	IDF dk 4_PineGroup/IDF xm_PineGroup	22804	**M**	**L**	**M**	10	31
Upper Tatlayoko	ESSFxv 1	5225	**H**	**VL**	**H**	0	1
Upper Tatlayoko	MS dc 2/MS xv/SBPSxc	13696	**H**	**L**	**L**	0	3
Upper Tatlayoko	IDF dk 4_FirGroup/IDF dw_FirGroup	5105	**H**	**M**	**M**	0	2
Upper Tatlayoko	IDF dk 4_PineGroup/IDF dw_PineGroup	13287	**H**	**VL**	**M**	0	16
Westbranch	IDF dk 4_FirGroup/IDF dw_FirGroup	3827	**VH**	**L**	**H**	0	1
Westbranch	IDF dk 4_PineGroup/IDF dw_PineGroup	5778	**VH**	**L**	**H**	0	13
Westbranch	ESSFxv 1/MS dc 2/MS xv/SBPSxc	9515	**VH**	**L**	**H**	0	0

Table 4. Summary of data and ratings for individual indicators and the three components of risk. Spatial indicators are planned but not yet available.

Assessment Unit		Ecological Importance	Hazard					Current Mitigation			
		Biodiv Conserv Priority	Seral difference from natural (x RNV)		Spatial assessments (%)			% Protected		M+O seral > CCLUP Target	
Landscape Unit	Amalgamated Unit		Early	M+O	M+O>250 ha	M+O Interior	Rating	NH	NH + Mod		Rating
Bidwell/Lava	IDF dk 4_FirGroup/IDF dk 4_PineGroup/IDF dw_FirGroup/IDF dw_PineGroup	6	-0.8	-1.0	NA	NA	L	58	63	801	H
Bidwell/Lava	SBPSxc	6	-0.9	0.3	NA	NA	L	12	13	10899	M
Bidwell/Lava	ESSFxv 1/MS xv	6	-0.9	-1.1	NA	NA	M	16	17	2018	M
Chilanko	IDF dk 4_FirGroup/IDF dk 4_PineGroup	6	-1.0	2.0	NA	NA	L	27	27	1929	M
Chilanko	MS xv/SBPSxc	6	-1.8	1.2	NA	NA	VL	6	6	19520	M
Ottarasko	IDF dw_FirGroup	4	-0.6	-0.4	NA	NA	L	100	100	2301	VH
Ottarasko	IDF dw_PineGroup	4	-2.5	-2.2	NA	NA	M	100	100	327	VH
Ottarasko	ESSFxv 1/MS dc 2	4	-2.1	1.9	NA	NA	VL	100	100	4740	VH
Puntzi	IDF dk 4_FirGroup	6	-0.4	-0.3	NA	NA	L	17	65	1920	M
Puntzi	MS xv	6	-1.0	0.4	NA	NA	L	17	17	3394	M
Puntzi	SBPSxc	6	-1.5	0.7	NA	NA	L	13	13	13941	M
Puntzi	IDF dk 4_PineGroup	6	-0.6	0.8	NA	NA	L	10	20	3187	M

Assessment Unit		Ecological Importance	Hazard					Current Mitigation			
			Seral difference from natural (x RNV)		Spatial assessments (%)			% Protected			
Landscape Unit	Amalgamated Unit	Biodiv Conserv Priority	Early	M+O	M+O>250 ha	M+O Interior	Rating	NH	NH + Mod	M+O seral > CCLUP Target	Rating
Pyper	IDF dk 4_FirGroup/IDF xm_FirGroup	**6**	0.4	-0.8	NA	NA	**L**	21	55	5285	**M**
Pyper	SBPSxc	**6**	-0.1	-0.5	NA	NA	**L**	6	6	9384	**M**
Pyper	IDF dk 4_PineGroup/IDF xm_PineGroup	**6**	-0.1	0.6	NA	NA	**L**	15	25	9103	**M**
Upper Tatlayoko	ESSFxv 1	**8**	-1.7	3.6	NA	NA	**VL**	41	42	3277	**H**
Upper Tatlayoko	MS dc 2/MS xv/SBPSxc	**8**	-1.6	0.1	NA	NA	**L**	14	14	3434	**L**
Upper Tatlayoko	IDF dk 4_FirGroup/IDF dw_FirGroup	**8**	0.2	-1.5	NA	NA	**M**	46	46	1325	**M**
Upper Tatlayoko	IDF dk 4_PineGroup/IDF dw_PineGroup	**8**	-2.4	1.0	NA	NA	**VL**	29	30	4283	**M**
Westbranch	IDF dk 4_FirGroup/IDF dw_FirGroup	**10**	0.2	-0.1	NA	NA	**L**	36	90	665	**H**
Westbranch	IDF dk 4_PineGroup/IDF dw_PineGroup	**10**	-1.4	0.1	NA	NA	**L**	40	69	714	**H**
Westbranch	ESSFxv 1/MS dc 2/MS xv/SBPSxc	**10**	-0.9	2.3	NA	NA	**L**	38	41	3332	**H**

Notes and highlights of the forest biodiversity broad-scale assessment:

- Indicators for spatial distribution of mature plus old forest are not yet included.

- The seral assessment does not account for recent natural disturbance from the various bark beetles or recent wildfires but supplementary information helps to consider mountain pine beetle and wildfire impacts. Map 6 estimates the extent of stand mortality from mountain pine beetle and shows the location of recent wildfires (mostly 2009 and 2010). Table 3 includes natural disturbance percentage from recent wildfire and stand mortality from mountain pine beetle. This information can be used to supplement the seral analysis from the assessment when making interpretations. In most cases the area affected by heavy mountain pine beetle infestations and/or fire will no longer be mature plus old seral, but most of it will not likely be early seral except where wildfires were very intense.

- The forest biodiversity assessment indicates few current issues with landscape level forest biodiversity for the study area as a whole, with low to moderate hazard ratings across the area. A few areas indicate significant potential impacts of recent wildfire and stand mortality from mountain pine beetle. Units with more than 20% burned or affected by high mortality mountain pine beetle attacks should be further evaluated using recent aerial photography or on the ground to further evaluate these impacts. **Westbranch** Landscape Unit is rated very high for ecological importance but is generally well mitigated as indicated by high mitigation ratings. The **Upper Tatlayoko** Landscape Unit, with a high ecological importance rating, has moderate to high current mitigation ratings except for in the Montane Spruce/Sub-boreal Pine Spruce biogeoclimatic units, which have low mitigation. However the current hazard in these units is low with no indication of significant natural disturbance so there is little current management concern for forest biodiversity.

Forest biodiversity indicators

Table 5. Description of forest biodiversity indicators.

Indicator	Measurement	Comments
Biodiversity conservation priority	The indicator considers combined effects of: 1. Ecosystem representation in protected areas and habitat diversity. 2. Presence of threatened and endangered species. 3. Sensitivity to forest development.	The assessment process is described in the 1996 Biodiversity Strategy for the CCLUP, pages 15-18.
% M+O>250ha	The area of mature plus old (M+O) forest in patches greater than 250ha as a percentage of the total Crown forest area classified as mature and/or old.	The process used for spatial analysis is described in CCLUP Biodiversity Strategy Update #4 entitled *An Approach for Patch Size Assessments in the Cariboo Forest Region*. Interior forest is the area that is buffered from the physical and biological influences of adjacent non-forest and younger forest. *The reference condition for comparison of spatial indicator values has not yet been finalized*.
% M+O Interior	The percentage of the current M+O forest (as defined by the 1996 Biodiversity Guidebook) that is defined as interior forest.	
M+O seral: Divergence from natural average landscape	Calculated in three steps: 1. Determine the area of M+O seral forest on Crown forest land. 2. Calculate the percentage difference from the average M+O seral natural reference condition for each landscape unit and biogeoclimatic subzone unit. 3. Express this difference in units of range of natural variation (RNV) as explained in the appendix. The analysis includes Crown forest land, parks and protected areas but excludes private land and First Nations reserves. Seral class definitions are from the Biodiversity Guidebook and CCLUP Biodiversity Strategy.	The natural forest reference condition used for these two indicators are calculated from natural disturbance models designed to predict the average seral condition in each biogeoclimatic subzone in the absence of forest harvesting and fire control. The same process was used to develop the seral targets for the provincial biodiversity guidebook. The relationship between the natural forest seral condition and the biodiversity guidelines is included in Appendix 2 and 4 of the 1996 Biodiversity Guidebook. Note: In many instances the forest inventory has not reclassified the age of forest stands impacted by recent intense natural disturbances including mountain pine beetle, Douglas-fir bark beetle and wildfires, so these disturbances are not well reflected in the seral analysis. In some cases the analysis will therefore over-estimate M+O seral proportions.
Early seral: Divergence from natural average landscape	Same as for M+O seral using data for early seral forest as defined in the Biodiversity Guidebook and CCLUP Biodiversity Strategy.	
Ha>M+O CCLUP target	The number of hectares of M+O forest above the targets from the CCLUP Biodiversity Conservation.	These targets are based on the same analysis produced by the natural disturbance models described above but were systematically reduced to meet socio-economic timber flow objectives.
% No harvest	Area of overlap of forested area within CCLUP no-harvest designations as a percentage of the forested area of the assessment unit.	No-harvest designations in the analysis include: parks, protected areas, goal 2 protected areas, permanent old growth management areas, caribou no-harvest areas, and riparian reserves around streams, wetlands and lakes.
% No harvest plus modified harvest	Area of overlap of forested area within CCLUP no-harvest designations plus specified modified harvest designations as a percentage of the forested area of the assessment unit.	The modified harvest designations selected for this analysis are ones which leave significant forest structure on the site over time. They include mule deer winter ranges, special harvest areas for caribou, trail management zones, areas designated to meet visual quality objectives of preservation, retention and partial retention.

Table 6. Weightings for forest biodiversity hazard indicators. All others have no weightings.

Indicator type	Attribute evaluated	Indicator	Indicator weight*
Hazard	Early seral forest proportion	Early seral – divergence from average natural landscape condition	**.8**
	Mature plus old seral forest proportion	Mature plus old seral - divergence from average natural landscape condition	**1.2**

Table 7. Classification of indicators used for assessment of forest biodiversity.

Note that the indicator ranges for early seral and mature plus old seral are calculated as in units of the estimated Range of Natural Variability, which is further explained and referenced in the appendix.

Indicators	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Ecological importance					
Biodiversity conservation priority	1-2	3-4	5-6	7-8	9-10
Current Hazard					
% M+O>250ha: % of natural	**Data and ratings not currently available**				
% M+O Interior: % of natural					
M+O: Divergence from natural (in units of RNV)	>=1	-1 to 0.99	-1 to -1.9	-2 to -2.9	<-3
Early seral: Divergence from natural (in units of RNV)	<-1	-1 to 0.9	1 to 1.9	2 to 2.9	3+
Current Mitigation					
Ha>M+O CCLUP target	More than 1000 ha below	1-1000 ha below	0-3000 above	3001-6000 ha above	6001+ ha above
% No-harvest	0-15%	16-30%	31-60%	61-80%	>80%
% NH + Modified	0-15%	16-30%	31-60%	61-80%	>80%

Calculation of component ratings

The ratings provided for ecological importance, current hazard and current mitigation are each composite ratings derived from multiple indicators. The steps in calculating the ratings are:

- Apply the classification ranges in Table 7 to determine the rating for each indicator.
- Apply indicator weightings from Table 6.
- Average the individual indicator ratings that make up each component. Round composite ratings up to the nearest whole number.

Evaluation of forest biodiversity assessment:

Strengths

- The land use designations which contribute to the mitigation ratings are legally established and so have a significant degree of security and clear definitions of management objectives.
- Analysis of seral condition by BEC within landscape units as directed by the 1996 Biodiversity Guidebook is relatively well understood by forestry practitioners and provides a framework that takes into account the major differences in intensity and frequency of natural difference across the province. The analysis methodology for assessment of current seral condition and patch size has been carefully developed and applied since the late 1990s in the Cariboo-Chilcotin.
- Use of the modelled natural landscape as a benchmark for comparison with current seral conditions provides a reasonable standard to assess the divergence from natural systems. This approach was well vetted among forest ecologists, and is an essential part of the foundation for the 1996 Biodiversity Guidebook. It could easily be modified based on better data on natural disturbance rate for specific BEC subzones.

Limitations

- Reliability of several aspects of the assessment is limited by the accuracy and currency of forest inventory data for forest age, logging and roads. In particular, the forest inventory has not reclassified the age of forest stands impacted by recent intense natural disturbances including mountain pine beetle, Douglas-fir bark beetle and wildfires so these are not reflected in the seral analysis. Therefore, the mature plus old seral forest in the assessment is likely over-estimated and the early seral forest under-estimated in some areas. This would also affect mature plus old patch size. The ministry has inventory projects underway that will improve the forest inventory data in the area covered by this report, and in the overall Cariboo-Chilcotin area. As the data improve, reanalysis may be warranted.
- Inclusion of quantitative data for natural disturbance such as pine mortality data could improve the analysis. However the coarse and imprecise nature of the current mortality estimates would also add uncertainty to seral estimates.
- Use of local or more up-to-date data, where available, to calibrate the modelling of the natural landscape for all of the BEC units could result in an improved natural benchmark. This was done for the Interior Douglas-fir in the 1996 CCLUP Biodiversity Strategy, and is used for assessments of this biogeoclimatic zone for this report. Doing this for all BEC zones would require additional research work.

- Other attributes important to landscape level forest biodiversity, such as access density and the presence and condition of rare and/or sensitive ecosystems, have not been included in this assessment.

Hydrological stability risk summary

Hydrological stability is a critical feature of watersheds, affecting the quality, amount and timing of water flows. These, in turn, affect fish and other aquatic organisms, human water use, built structures and the stability of watercourses. This assessment evaluates the factors that affect stream flow and sedimentation risk. Ecological importance is assessed in relation to the value of hydrological units for fish. The importance of water-related values other than fish is not evaluated here, but the hazard and mitigation information for geographically defined units could be used to assess the impacts on these other values. This assessment does not evaluate water quality factors except for sedimentation, and does not include riparian function.

The hydrological stability summary includes two sections. The first provides the results of the broad-scale assessment. The second provides more detailed information on the indicators. Two reports describing the updated 2013 assessment approach for hydrologic sensitivity and hazard for stream flow and sedimentation are included in the appendix. These reports provide a more comprehensive description of the assessment methodology.

The regional hydrology assessment includes all of the Cariboo-Chilcotin region that is within the Fraser watershed with the exception of small areas in the Quesnel and 100 Mile House forest districts.

Hydrological stability broad-scale assessment

Table 8. Indicators used to assess overall risk for hydrological stability.

Full indicator descriptions are included in Tables 11, 12 and 13.

Indicator type	Attribute evaluated	Indicator
Ecological importance	Importance for fish habitat.	Ratings based on fisheries criteria (see appendix).
Hazard	Sensitivity to stream flow.	**4 indicators** (non-forest area, BEC zone/ precipitation inputs, drainage density ruggedness, degree of lake/wetland buffering).
	Development impacts to stream flow.	**1 indicator** (equivalent clearcut area).
	Sensitivity to sedimentation.	**3 indicators** (soil erodibility, steep coupled slopes, degree of lake/wetland buffering).
	Development impacts to sedimentation.	**3 indicators** (roads close to water, roads on steep coupled slopes, and disturbance on gentle over steep).
Current mitigation	Level of no-harvest protection of forested land.	Overlap analysis using forested area within CCLUP no-harvest
	Level of protection of forested land from both CCLUP no-harvest and modified harvest designations.	Overlap analysis including forested area within both modified harvest and no-harvest designations.

Broad-scale assessment results

Table 9 summarizes ecological importance, hazard and current mitigation results. The current hazard shows ratings for both sensitivity and hazard. The sensitivity score evaluates the physical characteristics of a hydrological unit that makes it more or less prone to negative effects from development. The hazard rating combines the sensitivity rating with development factors to assess the likelihood of hydrological problems. Table 9 records the highest of the two sensitivity values for stream flow and sedimentation. The same is done for hazard. Hydrological stability assessments are included for three different scales of assessment unit (sub-basin, basin and watershed). The approach to delineating assessments units is described in the appendix.

Table 10 provides a more complete breakdown of results for stream flow and sediment sensitivity and hazard. It provides sensitivity and hazard ratings for sedimentation and stream flow separately. Indicator values are included for equivalent clearcut area (ECA), which is an input to stream flow hazard ratings and sediment impacting land use, which is an input to sediment hazard ratings.

Development impacts are human-related factors that affect both stream flow and sedimentation hazards. They include both forest harvesting and roads. In Table 10, the sediment impacting land use score incorporates two indicators related to roads (roads close to water and road density on steep slopes) and one related to forest disturbance above steep slopes. Higher values for ECA and the land use score result in higher hazard ratings.

The following three maps show the hydrological assessment units at the sub-basin, basin and watershed scales. For many study areas it will be useful to evaluate the results at the middle scale (basin), then look up to the larger watershed scale and down to the smaller sub-basin scale for areas where there is a particular interest. These maps show the results for hydrological sensitivity. The units are coloured to indicate the highest rating of the two sensitivity indicators.

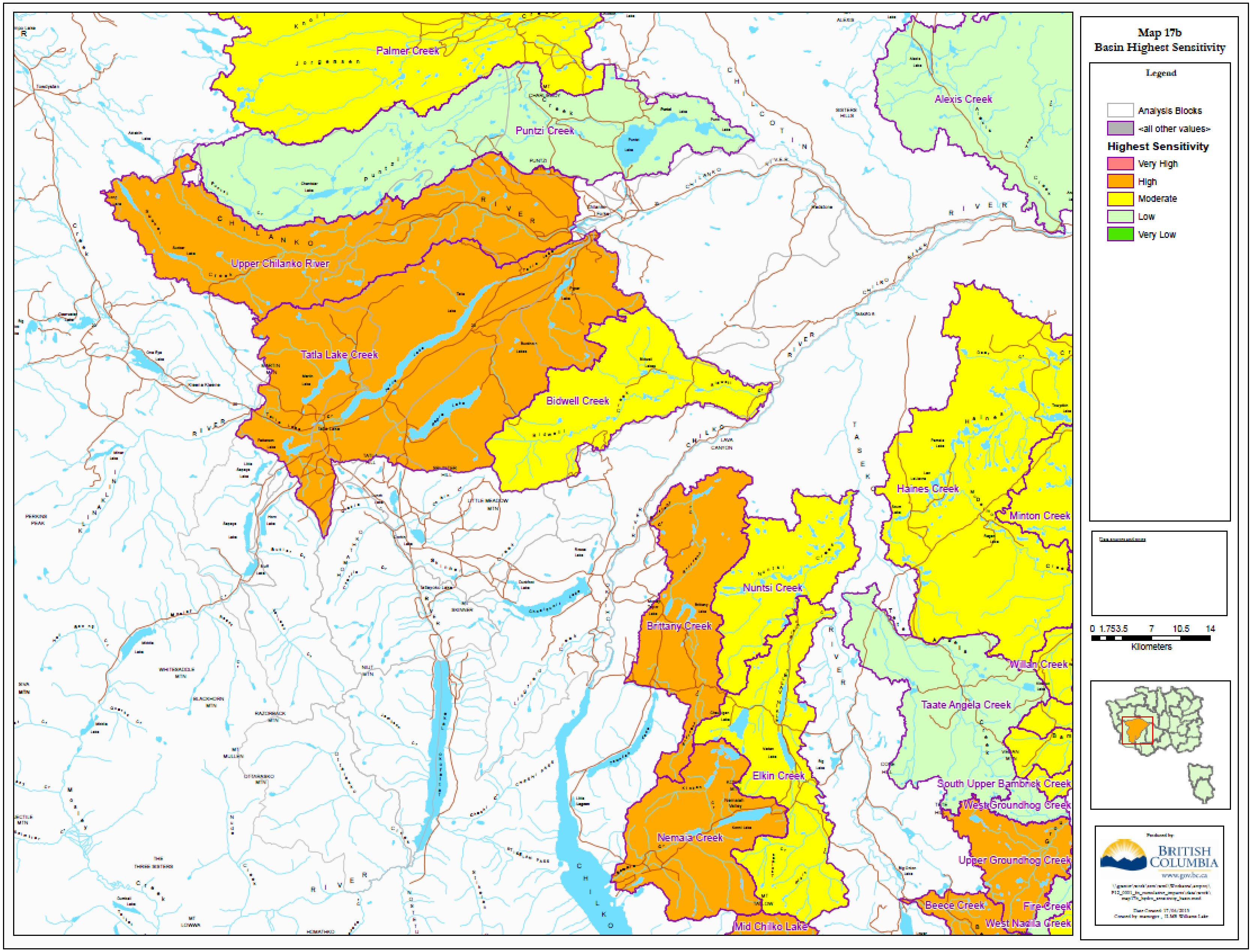


Figure 7: Map 17b – Basin highest sensitivity.

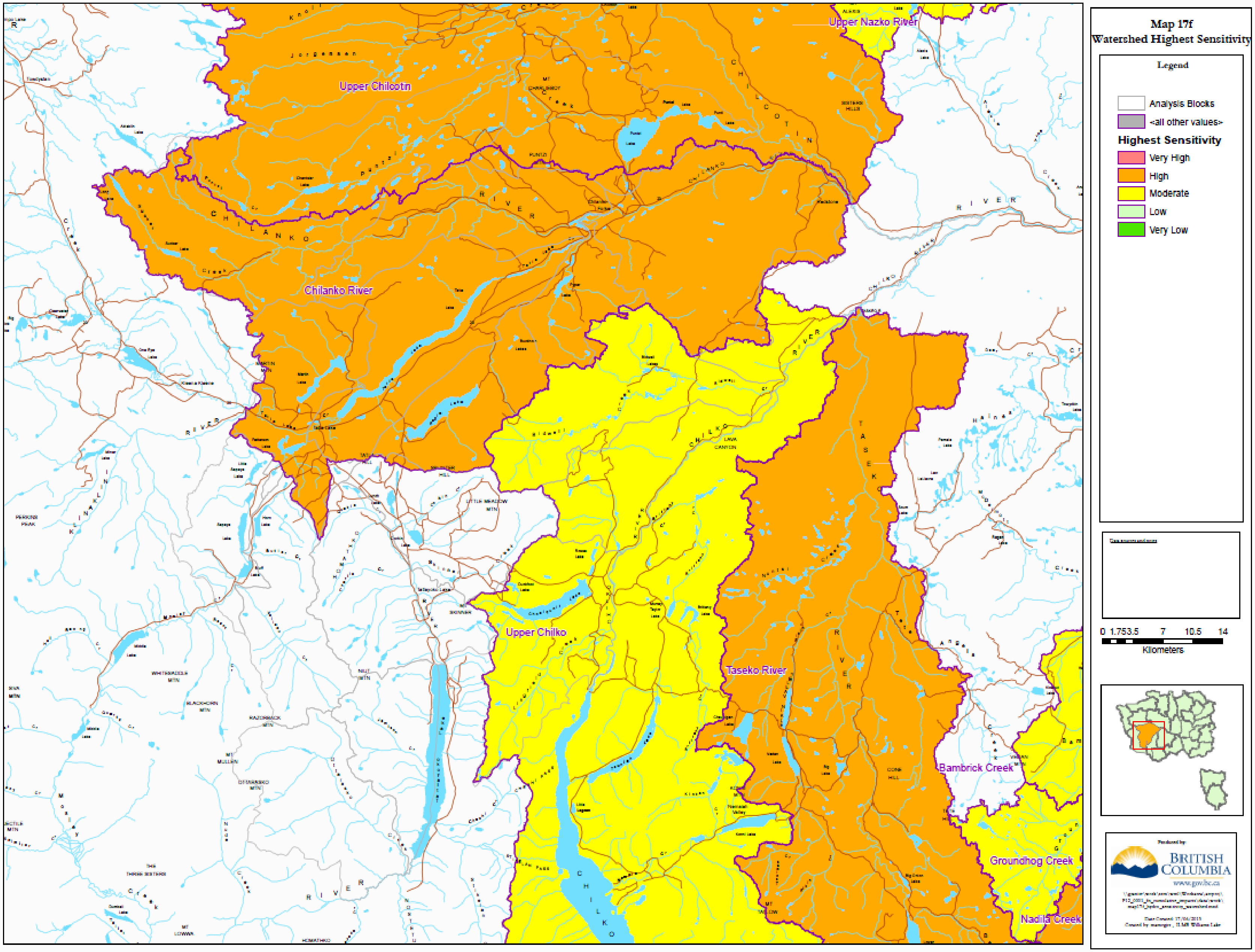


Figure 8. Map 17f – Watershed highest sensitivity.

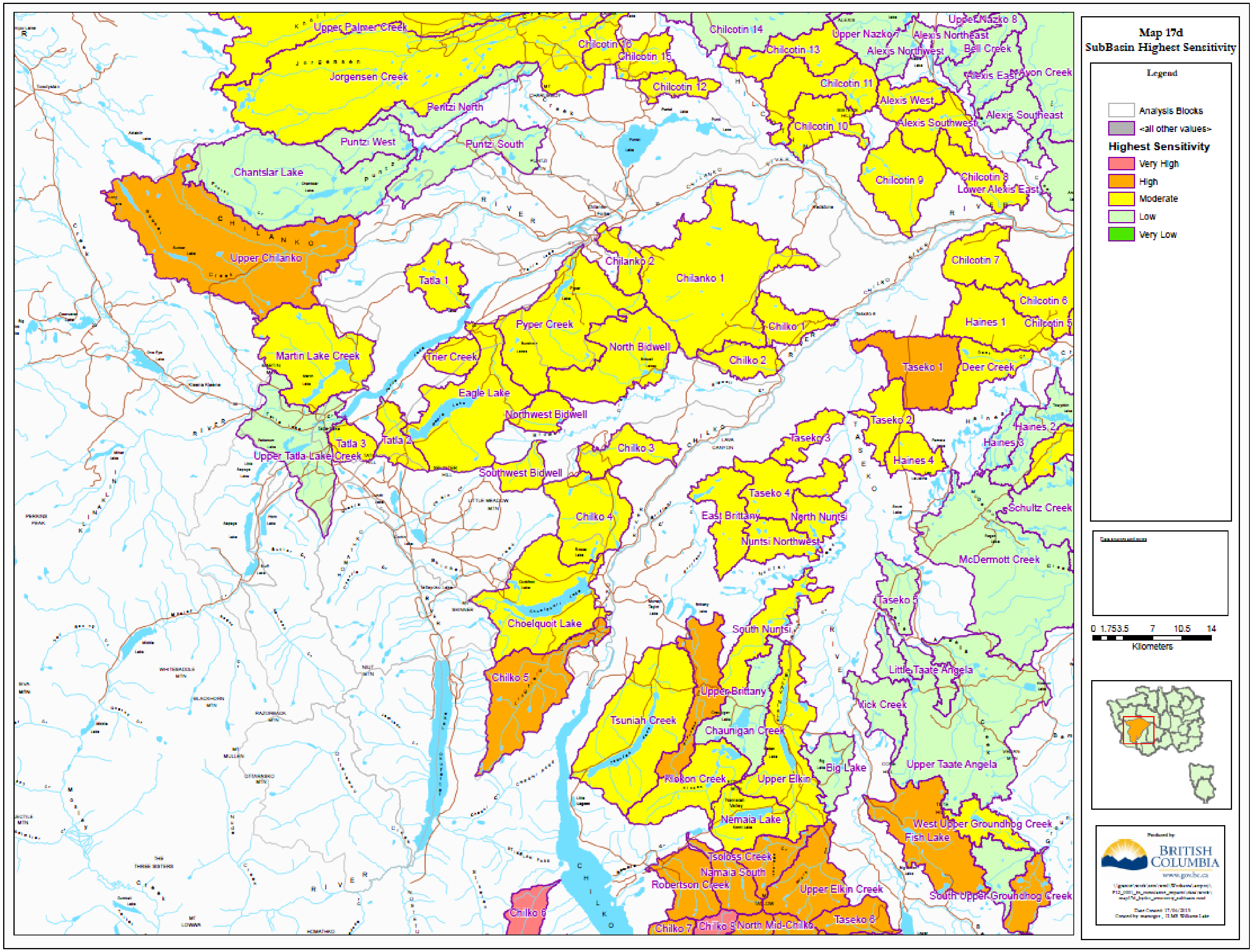


Figure 9. Map 17d – Sub-basin highest sensitivity.

Table 9. Summary of hydrological risk factors.

For simplicity, only the higher of the two sensitivity and hazard ratings are included. Colours reflect level of management concern: Very High (red), High, Moderate, Low, and Very Low (dark green). Note that colours for current mitigation are reversed because higher mitigation results in low management concerns which are coloured green.

Reporting Unit	Type	Fish Value Rating	Highest Sensitivity	Highest Hazard	Combined Mitigation Rating
Chantslar Lake	Sub-Basin	L	L	VL	L
Chilanko 1	Sub-Basin	VL	M	M	VL
Chilanko 2	Sub-Basin	VL	M	M	VL
Chilcotin 12	Sub-Basin	VL	M	H	L
Chilcotin 15	Sub-Basin	VL	M	L	VL
Chilcotin 16	Sub-Basin	VL	M	L	VL
Chilcotin 9	Sub-Basin	VL	M	L	L
Chilko 1	Sub-Basin	VL	M	L	L
Chilko 2	Sub-Basin	VL	M	M	VL
Chilko 3	Sub-Basin	VL	M	M	VL
Chilko 4	Sub-Basin	L	M	L	VL
Chilko 5	Sub-Basin	H	H	L	L
Choelquoit Lake	Sub-Basin	M	M	VL	M
Eagle Lake	Sub-Basin	L	M	VL	L
Jorgensen Creek	Sub-Basin	M	M	L	VL
Martin Lake Creek	Sub-Basin	VL	M	L	VL
North Bidwell	Sub-Basin	M	M	M	VL
Northwest Bidwell	Sub-Basin	VL	M	M	VL
Pentzi North	Sub-Basin	VL	L	VL	VL
Puntzi South	Sub-Basin	L	L	L	VL
Puntzi West	Sub-Basin	VL	L	VL	VL
Pyper Creek	Sub-Basin	L	M	L	L
Southwest Bidwell	Sub-Basin	L	M	M	VL
Tatla 1	Sub-Basin	VL	M	H	VL
Tatla 2	Sub-Basin	VL	M	VL	VL
Tatla 3	Sub-Basin	VL	M	L	VL
Trier Creek	Sub-Basin	VL	M	L	VL
Upper Chilanko	Sub-Basin	L	H	M	VL
Upper Tatla Lake Creek	Sub-Basin	L	L	L	VL
Bidwell Creek	Basin	M	M	L	VL
Palmer Creek	Basin	H	M	L	VL
Puntzi Creek	Basin	H	L	L	L
Tatla Lake Creek	Basin	M	H	L	VL
Upper Chilanko River	Basin	L	H	M	VL
Chilanko River	Watershed	H	H	L	VL
Upper Chilcotin	Watershed	VH	H	M	L
Upper Chilko	Watershed	VH	M	L	M

Table 10. Analysis of hydrological sensitivity and hazard for both stream-flow and sedimentation.

		Sensitivities		Hazards		Land Use	
Reporting Unit	Type	Steamflow	Sedimentation	Steamflow	Sediment-ation	ECA	Sediment impacting Land Use Score
Chantslar Lake	Sub-Basin	L	L	VL	VL	18	1
Chilanko 1	Sub-Basin	M	M	M	L	32	1
Chilanko 2	Sub-Basin	M	M	M	M	30	2
Chilcotin 12	Sub-Basin	M	M	H	M	39	2
Chilcotin 15	Sub-Basin	L	M	L	L	30	2
Chilcotin 16	Sub-Basin	L	M	L	L	26	2
Chilcotin 9	Sub-Basin	L	M	L	L	28	2
Chilko 1	Sub-Basin	M	M	L	L	17	1
Chilko 2	Sub-Basin	M	M	M	M	27	2
Chilko 3	Sub-Basin	M	M	M	L	24	1
Chilko 4	Sub-Basin	L	M	L	VL	24	1
Chilko 5	Sub-Basin	L	H	L	VL	3	0
Choelquoit Lake	Sub-Basin	L	M	VL	VL	13	1
Eagle Lake	Sub-Basin	L	M	VL	VL	18	1
Jorgensen Creek	Sub-Basin	L	M	L	VL	19	1
Martin Lake Creek	Sub-Basin	L	M	L	VL	20	1
North Bidwell	Sub-Basin	M	M	M	L	29	1
Northwest Bidwell	Sub-Basin	M	M	M	L	29	1
Pentzi North	Sub-Basin	L	L	VL	VL	16	1
Puntzi South	Sub-Basin	L	L	VL	L	17	2
Puntzi West	Sub-Basin	L	L	VL	VL	18	1
Pyper Creek	Sub-Basin	L	M	L	VL	19	1
Southwest Bidwell	Sub-Basin	M	M	M	VL	23	0
Tatla 1	Sub-Basin	M	M	H	L	37	1
Tatla 2	Sub-Basin	L	M	VL	VL	10	0
Tatla 3	Sub-Basin	L	M	L	VL	16	0
Trier Creek	Sub-Basin	M	M	L	VL	13	0
Upper Chilanko	Sub-Basin	L	H	L	M	18	2
Upper Tatla Lake Creek	Sub-Basin	L	L	L	VL	25	1
Bidwell Creek	Basin	L	M	L	VL	27	1
Palmer Creek	Basin	L	M	L	VL	21	1
Puntzi Creek	Basin	L	L	L	L	21	2

Tatla Lake Creek	Basin	L	H		L	VL		20	1
Upper Chilanko River	Basin	L	H		L	M		21	2
Chilanko River	Watershed	L	H		L	VL		22	1
Upper Chilcotin	Watershed	M	H		L	M		19	2
Upper Chilko	Watershed	L	M		L	L		9	2

Notes and highlights of hydrological stability assessment:

- Ecological importance for fish is rated very high for two of the three watersheds in the study area, and high for the third. Because the rating is additive, based on the presence of key fish species, the larger reporting units will usually have higher ratings than the smaller units. The lower ratings of the smaller hydrological units need to be interpreted with care because their water outputs feed into the larger units and affect the quality of fish habitat in the larger units. Because of the high or very high fish rating for all of the watersheds scale units, any serious hydrological problems in the study area could potentially have significant effects on fish.
- **Chilko 5 sub-basin** has a high fish rating even though it is a small unit indicating its significance for fish habitat.
- Overall, assessments for this study area indicate minimal hydrological concerns at present.
- The sensitivity to stream flow problems is rated as low or moderate for all hydrological units. The hydrological hazards for stream flow of all units are low and moderate with the exception of high ratings for two very small sub-basins: **Chilcotin 12 and Tatla 1.** In these two sub-basins, the high hazard results from elevated ECA (above 35%) associated with a moderate sensitivity and minimal buffering by lakes and wetlands.
- While several of the sub-basins, basins and watershed units were rated high sensitivity for sedimentation problems, no units rated a high hazard at present. The units rated as high sensitivity, would be more susceptible to increasing sedimentation hazards if road densities increase close to streams.
- Extensive overlap with intense wildfires and/or high bark beetle mortality can affect the ability of a watershed to slow runoff and protect from siltation until vegetation is restored. The 2010 wildfires are significantly overlapped with sub-basins **Chilko 1 and Chilko 2. Pyper creek sub-basin** is significantly overlapped with high pine mortality associated with mountain pine beetle. Further evaluation may be required to evaluate the hydrological risks imposed by these natural disturbances. However, none of these three sub-basins have high sensitivity ratings for hydrological problems.

Interpretation Cautions

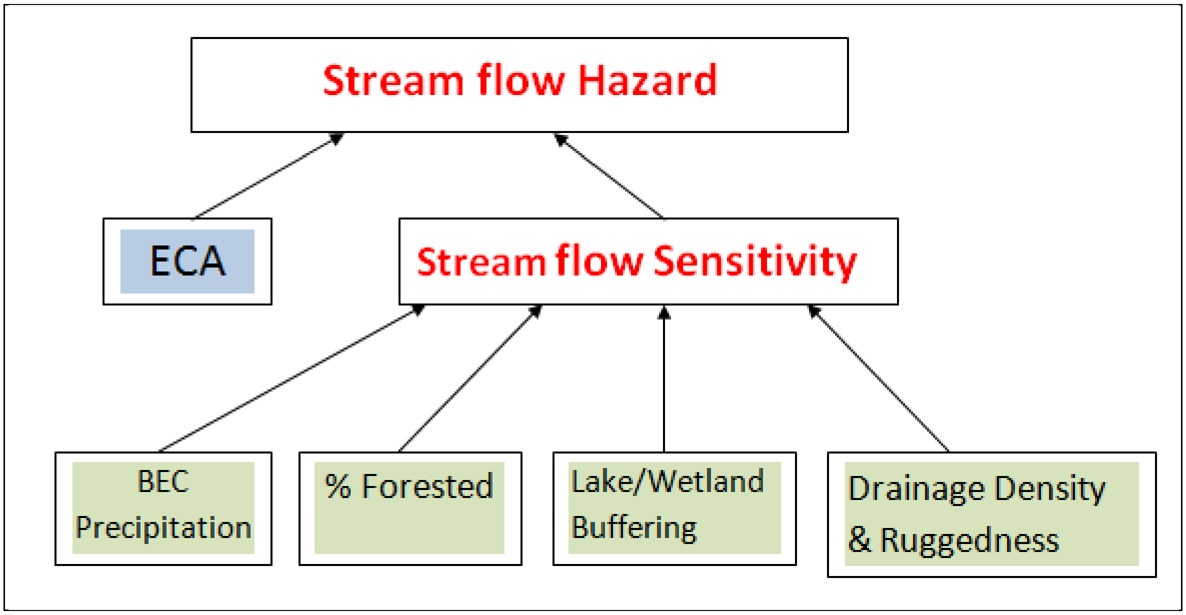
This assessment is a carefully structured GIS-based assessment designed to flag potential hydrological risk. It is best used as a screening device to identify units that may require additional, more detailed, hydrological assessment and potentially greater due diligence from development proponents.

The following section, from the methodology report for this assessment (full report included in an appendix), is instructive: "*Despite a high level of confidence in the indicators and approach used herein, we have only a moderate level of certainty that the hazard ratings reflect the hazard that may truly exist on the ground at any given time. This uncertainty is based on several factors; some of which are due to complex interactions between weather and biophysical environment that cannot be accounted for in the approach and others that are limited by the availability of GIS data and require field-based review by a qualified professional. While we feel strongly this approach provides a reasonable approximation of hazard, these factors may alter a hazard rating up or down one-hazard rating in a particular catchment.*" The report goes on to describe some of these factors.

A quote from a review of a similar project in 100 Mile House District by Kamloops hydrologist Rita Winkler provides a useful commentary on the use of equivalent clearcut area (ECA): *"It is important to understand that ECA only indicates the potential for change in stream flow and assumes that there is a proportionate increase in peak flow with increasing forest disturbance. In general, the larger the proportion of a watershed roaded and logged the greater the chance that some hydrologic variable of interest has been affected. However, the relationship between flow and the extent of forest cover, as well as the change with forest disturbance, is extremely variable - both from watershed to watershed and from year to year. Consequently, every watershed should be considered independently. Further, a small area of bad road, poor logging, riparian disturbance etc. may have a greater effect on downstream water-based resources (drinking water, fish) than extensive logging done well. The only way to evaluate this is in the field."*

The assessment approach used in this study refines the use of ECA in developing hazard ratings by using a sliding scale where hydrological units with lower inherent sensitivities are assumed to be able to absorb a higher ECA before hazard is rated as high.

Hydrological Stability Indicators



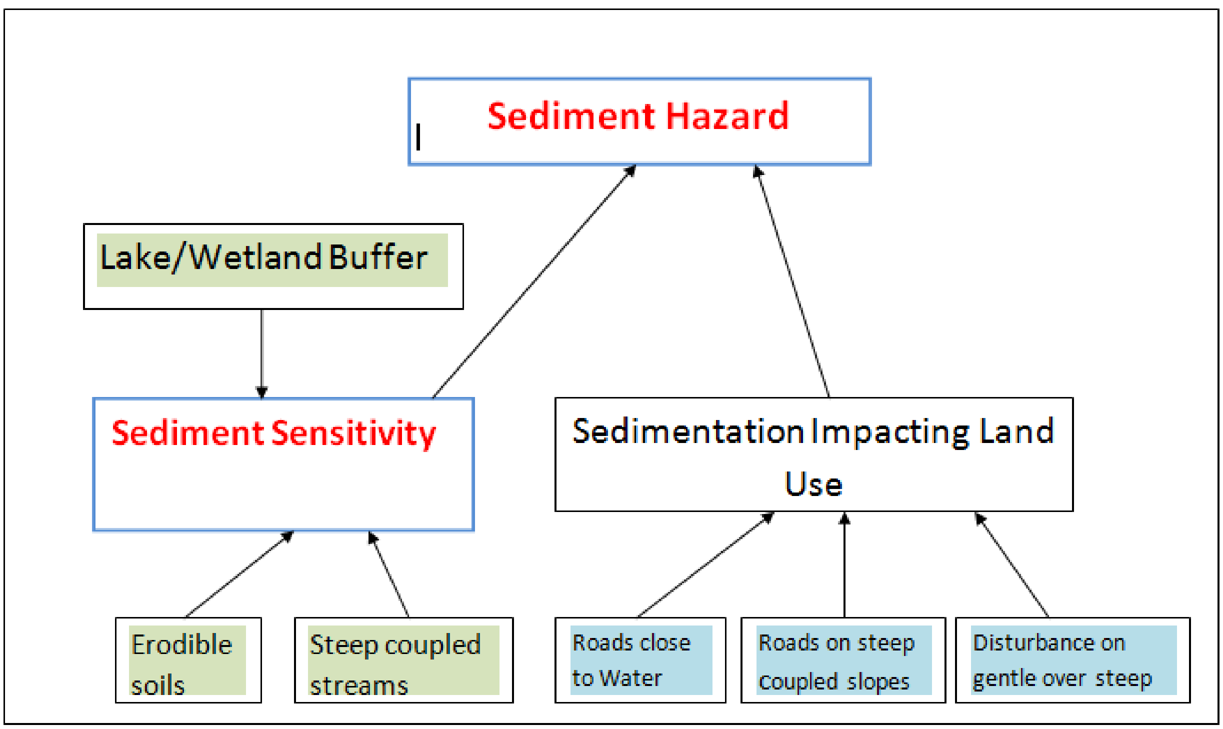


Figure 10. Conceptual diagrams for stream flow hazard and sediment hazard assessments.

Blue shading is for development influences and green shading is for biophysical factors influencing inherent sensitivity. The ratings for boxes in red text are included in Table 10 to summarize sensitivity and hazard for stream flow and sediment risks. More detailed tables published online show the ratings for all contributing indicators of sediment and stream flow hazard.

Table 11 below provides the full definition of all indicators used in the rating of hydrological sensitivity and hazards. For a more detailed description of the rating methodology, see the two draft reports in the appendix. Table 12 summarizes the indicators used for ecological importance and current mitigation.

Table 11. Indicators used for hydrological sensitivity and hazards.

Note that not all of these indicators were used in the current version of the assessment model.

Indicator	Measurement	Cariboo Chilcotin formula	Comments
Non-forested area	Portion of reporting unit covered by Alpine or Alpine Forest types.	(A + AF area) / (Reporting Unit Area) * 100%	It is easier to affect runoff and streamflow in reporting units that are fully forested, less so with increasing amounts of alpine (no trees) **Scores get inverted.** The areas with higher percentage of Alpine (A) and Alpine Forest (AF) become the lowest hazard scores.
BEC zone	Percent of watershed by BEC variant category. Score is the sum of BEC snow accumulation scores (0 – 2.5) times their areas.	(0.5*(Area of 0.5 Ranked BEC)/Total Area)) + (1*(Area or 1 Ranked BEC)/Total Area)) + (1.5*(Area of 1.5 Ranked BEC) + (2*(Area of 2 Ranked BEC) + (2.5*(Area of 2.5 Ranked BEC) + (3*(Area of 3 Ranked BEC) / Reporting Unit Area	Reductions in forest cover have a more significant affect on runoff + streamflow in units with high snow accumulation + good canopy closure. Low snow and limited closure = hard to affect. Many BEC zones are in between.
ECA (forest cover disturbance)	ECA as per 1999 Watershed Assessment Guidebook with full recovery at 12 m. Private land treated as clearcut with no recovery. MPB effects built into ECA calculation. Applies to the entire reporting unit.	ECA / Reporting Unit Area * 100%	MPB in Mature stands (Age ≥60): a) >70% PI = 80% ECA b) 30 – 70% PI = 50% ECA c) <30% PI = 0% ECA MPB in Openings (<60 years) > 50% PI in Spp1: Ages 20–30=8.2% mortality of the PI Ages 31–40=17.8% mortality of the PI Ages 41–50=21.7% mortality of the PI Ages 51–59=24.7% mortality of the PI
Drainage density ruggedness (DDR)	Stream density as a function of relief.	(km of streams / km^2 of reporting unit) *(reporting unit relief)	Steeper and better drained reporting units are more flashy and likely to respond in a negative way with land-use – roads and forest cover reduction.
Absence of lakes / wetlands	Percent of the watershed in open water (lake/wetland). Large lakes in lower portion of reporting unit have the greatest affect.	((1* Lake Wetland Area below H70 Line) + (0.75 Lake Wetland Area above H70 and below H40) + (0.25 * Lake Wetland Area above H40 line)) / Total Area	**Scores get inverted.** The areas with the lowest scores (i.e. the smaller percentage of lakes and wetlands) are considered more hazardous.
Extent of roading	Density of roads per square kilometer	Road km / Reporting unit area km^2	Increasing road density increases exposed surface materials to erosion.
Terrain stability	Percent of reporting unit area containing slopes >60%	((Area ESA 1 polygons within the reporting unit + Area of ESA 2 polygons within the reporting unit) / Total Area of the reporting unit)) * 100%	Steeper terrain is more likely to generate sediment with land-use activity and deliver sediment to streams.
Soil erodability	Percentage of the reporting unit in high erosion potential geological units – GSC quaternary deposits	(Area of reporting unit in high erosion / Total reporting unit area) * 100%	Quaternary deposits coverage from LRDW. Can be an issue for water quality and channel stability in steep terrain and where channels are incised into thick quaternary deposits. Does not work as well in gentle terrain.

Indicator	Measurement	Cariboo Chilcotin formula	Comments
Steep coupled slopes	Percentage of the reporting unit located in steep (>50%) coupled slopes. Coupled slopes have less then 50m of gentle terrain between the steep slope and stream.	(Area of steep coupled slopes / Total reporting unit area) * 100% Steep coupled area derived through GIS analysis – area directly upslope of intersection between 50m buffer on streams and 50% slope coverage.	A measure of slope steepness and the connection to streams. Steep and coupled = more likely to delivery sediment to channels.
Roads close to water	Total length of roads within 50 m of a stream by reporting unit.	Length of road within 50m of stream / total area of reporting unit (km/km^2)	Erodable surfaces in close proximity to streams.
Roads on steep coupled slopes	Density of roads located on steep coupled slope areas.	Length of road on steep coupled slopes / Total reporting unit area (km/km^2)	Development factor combining sediment generation on roads + their effect on drainage with the delivery aspect of steep coupled slopes.
Disturbance on gentle over steep (GOS)	Percentage of the reporting unit that is harvested with <50% slope upslope of steep coupled slope areas. Include all harvesting in the last 75 years.	(Harvested area in the last 75 years on GOS / Total reporting unit area) * 100%	Designed to capture development related effects on drainage within the gentle portion of GOS areas. Diversions in gentle terrain often result in erosion or slides on the steep portion with sediment input to streams. More of a factor for pre-Code development.
Logged riparian area	Percentage of the total stream length within or adjacent to cutblocks. Summarized/weighted by stream order classes, with higher order streams receiving a greater weighting.	(0.5* length of order 1 streams within 30m of logging / Total length of order 1 streams within the reporting unit) + (0.75 * length of order 2 - 4 streams within 30m of logging / Total length of order 2 – 4 streams within the reporting unit) + (1 * length of order 5 - 9 streams within 30m of logging / Total length of order 5 – 9 streams within the reporting unit) * 100%	Reductions in riparian function along lower order streams often leads to decreases in channel stability, decreases in in-stream wood supply and channel complexity, and increases in lateral movement with sediment generation.
Cattle / range use	Percentage of total stream length within active range unit (km/km). Summarized/weighted by stream order classes, with higher order streams receiving a greater weighting.	(0.5* length of order 1 streams within range tenure / Total length of order 1 streams within the reporting unit) + (0.75 * length of order 2 - 4 streams within range tenure / Total length of order 2 – 4 streams within the reporting unit) + (1 * Length of order 5 - 9 streams within range tenure / Total length of order 5 – 9 streams within the reporting unit) * 100%	Uncontrolled livestock access to streams can reduce riparian function and damage stream beds and banks resulting in increased sediment production, decreases in channel stability, and input of fecal matter to drinking water source areas.
Private land	Percentage of total stream length within or adjacent to private land (km/km). Private land buffered by 20m to capture private land areas "adjacent to" streams. Summarized/weighted by stream order classes, with higher order streams receiving a greater weighting.	(0.5* length of order 1 streams within private land tenure / Total length of order 1 streams within the reporting unit) + (0.75 * length of order 2 - 4 streams within private land / Total length of order 2 – 4 streams within the reporting unit) + (1 * length of order 5 - 9 streams within private land / Total length of order 5 – 9 streams within the reporting unit) * 100%	Private land is most often located along major streams in alluvial fan and floodplain environment. Reductions in forest cover along with road construction, ditching, and other instream work can result in destabilization, increased erosion, reduced fan and floodplain function, and direct effects on fish and fish habitat.
Placer mining	Percentage of area occupied by placer mine tenures adjacent to streams (ha/ha). Summarized/weighted by stream order classes, with higher order streams receiving a greater weighting.	(0.5* area of placer mine tenure within 500m of order 1 streams) + (0.75 * area of placer mine tenure within 500 m of order 2 - 4 streams) + (1 * area of placer mine tenure within 500 m of order 5 - 9 streams) / Total area of the reporting unit * 100%	Historic placer mining known to be a significant source of water quality impairment where present on a system. More recent activity can still pose a threat to channel bank, fan and floodplain stability where not undertaken properly. Most disturbance in fan and floodplain areas results in a reduction in function and stability over the long term.

Table 12. Indicators for ecological importance and current mitigation in the hydrological stability assessment.

Indicator	Measurement	Comments
Fish value	Rating on a six-level scale done by an experienced local fisheries biologist using the criteria in Table 7.	
% No harvest	Area of overlap of the forested area of CCLUP no-harvest designations as a percentage of the forested area of the assessment unit.	No-harvest designations in the analysis include: parks, protected areas, goal 2 protected areas, permanent old growth management areas, caribou no-harvest areas, and riparian reserves around streams wetlands and lakes.
% No harvest plus modified harvest	Area of overlap of the forested area of CCLUP no-harvest designations plus specified modified harvest designations as a percentage of the forested area of the assessment unit.	The modified harvest designations selected for this analysis are ones which leave significant forest structure on the site over time. They include mule deer winter ranges, special harvest areas for caribou and areas designated to meet visual quality objectives of preservation, retention and partial retention.

Table 13. Fish scoring criteria for watershed study.

Phase 2 Score	Criteria
0	Little or no known fish use; barrier present near mouth; low flow problems
1	1 or 2 species in parts - fish presence may be based on adjacent stream information, stream appearance on Google Earth, etc; possible low flow problems
2	1 or 2 species with at least 1 key species; fish use throughout or heavy use in parts
3	3-4 species; at least 2 key species or presence of sensitive species; fish use throughout the watershed
4	4-5 species; 2-3 key species; sensitive species; fish use throughout watershed; First Nations or commercial value of at least one stock; medium to large streams with diversity of fish habitat
5	5+ fish species; 3-4 key species; sensitive species present; fish use throughout watershed; First Nations or commercial value of at least one stock; presence of large streams with diversity of habitat

Key Species:	BT CO CH RB LT SO PK CM KO BB WF	bull trout coho chinook rainbow trout lake trout sockeye pink salmon chum salmon kokanee burbot whitefish	First Nations Use - fish stock used for sustenance/ceremonial Economic importance - angler use on lakes or rivers within the watershed; commercial salmon value

Listed/Sensitive Species	BT CO	bull trout coho

Table 14. Weightings for hydrology mitigation indicators.

Indicator type	Attribute evaluated	Indicator	Indicator weight*
Current mitigation	No-harvest protection	% forest area protected by no-harvest	**.8**
	No-harvest plus modified harvest protection	% forest area protected by no-harvest plus modified harvest	**1.2**

Table 15. Classification of indicators used for assessment of hydrological stability.

Indicators	Very low (1)	Low (2)	Moderate (3)	High (4)	Very high (5)
Ecological importance					
Fisheries value rating	0	1	2	3-4	5
Current hazards					
Stream flow sensitivity	Complex rating system designed by hydrologist and geomorphologist using numerous indicators as documented in Tables 8 and 11 and in original papers included in the appendix.				
Stream flow hazard					
Sedimentation sensitivity					
Sedimentation Hazard					
Current Mitigation					
% no Harvest	0-15%	16-30%	31-60%	61-80%	>80%
% NH + Modified	0-15%	16-30%	31-60%	61-80%	>80%

Evaluation of the Hydrological Stability Assessment:

Strengths

- Assessment is clearly focused on two major hydrological hazards: stream flow effects and sedimentation. The clear link to hydrological processes using well-tested indicators provides a transparent and well-understood approach.
- Identification of hydrological sensitivities for stream flow and sedimentation allows for better understanding by the decision-makers of the inherent biophysical factors affecting the hydrological stability of assessment unit prior to adding any resource development impacts.
- A sliding scale is used to calculate hazard. This takes into account the ability for less sensitive hydrological units to absorb more development impacts before hazard is increased.
- The land use designations which contribute to the mitigation ratings are legally established and so have a significant degree of security and clear definitions of management objectives.

Limitations

- Reliability of several aspects of the assessment is limited by the accuracy and currency of forest inventory data for forest age, logging and roads. In particular, the forest inventory has not reclassified the age of forest stands impacted by recent intense natural disturbances including mountain pine beetle, Douglas-fir bark beetle and wildfires so these are not reflected in the seral analysis. Therefore, the mature plus old seral forest in the assessment is likely over-estimated and the early seral forest under-estimated in some areas. This would also affect mature plus old patch size. The ministry has inventory projects underway that will improve the forest inventory data in the area covered by this report, and in the overall Cariboo-Chilcotin area. As the data improve, reanalysis may be warranted.
- The assessment reported here does not include an assessment of riparian function. While this is an important aspect of hydrological stability, it is difficult to assess riparian hazards from available broad-scale data.
- The assessment is done at a broad scale with GIS-based data. Individual hydrological units may have special features which change the hydrological hazards but are not captured by this level and type of data.
- The current data is only for the Fraser watershed. Therefore, some areas in the western Chilcotin are not assessed. Also small portions of the northern part of the Quesnel District have not been assessed.

Moose risk summary

Winter forage and shelter habitat are key life requisites used for this assessment because they are important limiting habitats for moose populations. Spring calving areas are also important and will often overlap with winter forage habitat in the plateau portions of the region. Moose will use some of the same habitats in spring, summer and fall, but they will range much more widely in those seasons allowing them to spread out to access more forage that was not available in the winter and to more effectively avoid predation.

Two types of forage habitat are identified:

1. **Dynamic** forage habitat is created by disturbances such as fire or harvesting which put forested sites back to an earlier, shrubby successional stage that lasts for a relatively short period of time at a specific location and then may be created in another location by further disturbance.
2. **Static** forage habitat does not move around the landscape and includes habitats such as wetlands, riparian areas and self-sustaining deciduous forests.

These two types of moose forage habitat have different management implications because of their different degrees of permanence on the landscape. Maps and assessment information that separate the two types therefore provide useful information for resource managers.

Forest cover for security, thermal protection and snow interception are important components of moose winter habitat. The requirements and relative importance of these three functions of cover vary across the region depending on factors such as snow depth and winter temperature.

The assessment procedure identifies high-suitability moose habitat of two types – dynamic feeding habitat plus adjacent shelter and static feeding habitat plus adjacent shelter. Two hazard indicators were developed to measure changes in the amounts of this high-suitability habitat as a result of development. The first measures change in the total high-suitability habitat (i.e., both dynamic and static types) and the second measures change in just the static high-suitability habitat.

Data sources for this assessment include Broad Ecosystem Inventory (BEI) capability mapping for moose. Habitat protection provided by the legally designated no-harvest areas in the CCLUP is assessed. The key moose wetlands from the CCLUP are included on the assessment maps, and as potential winter feeding areas in the habitat model developed for this assessment.

The moose risk summary includes three sections. The first provides the results of the broad-scale cumulative effects assessment. The second provides site-level considerations related to assessment of potential project impacts. The third provides more detailed information on the indicators. Appendix 3 includes additional background information and details of the analysis of moose winter habitat suitability.

Moose broad-scale assessment

Table 16 lists the eight indicators used to assess the ecological importance, hazards and current mitigation for moose winter habitat. Table 17 summarizes the overall results. Table 18 provides more detail on the results for individual indicators.

Table 16. Summary of the eight indicators used to assess moose winter habitat.

Indicator type	Attribute evaluated	Indicator
Ecological Importance	Abundance of all moose winter habitat	% moose winter habitat
	Quality of capable habitat	Weighted capability
Hazards	Shelter amount and distribution	% landscape without adequate shelter
	Road effects	% high-suitability habitat disturbed by roads
	Change in high-suitability habitat	% reduction in Total high-suitability habitat % reduction in Static high-suitability habitat
Current Mitigation	Protection of the all capable habitat	% capable habitat protected
	Protection of modelled static moose habitat	% high-suitability, static habitat protected

The following maps display relevant information including some of the factors used in the assessment:

- Figure 2 - Bing satellite image showing the general topography
- Figure 4 - no-harvest and modified harvest areas designated by the Cariboo-Chilcotin Land Use Plan.
- Four assessment maps currently under review as part of the technical values review process:
  - Show the location of recent wildfire and high stand mortality from mountain pine beetle.
  - Summarize the spatial data used in the moose assessment.
  - Show more detail on modelled winter forage areas.
  - Show the location of paved, gravel and undefined roads.

A **new map** will include five classes of shelter habitat proportion and indicates portions of the assessment unit with inadequate shelter for moose

Table 17. Summary of the risk components for moose winter habitat.

Colours reflect the appropriate level of management concern: Very High, High, Moderate, Low, Very Low. Note that colours for current mitigation are inverted. For example, if the mitigation level is very high, the colour is dark green indicating a very low level of management concern.

Assessment Unit	Ecological Importance	Hazard	Current Mitigation
DCC_Bidwell_Lava_A	H	L	L
DCC_Bidwell_Lava_B	H	M	M
DCC_Bidwell_Lava_C	H	L	M
DCC_Chilanko_A	H	L	L
DCC_Chilanko_B	H	L	VL
DCC_Ottarasko_A	L	VL	VH
DCC_Ottarasko_B	L	VL	VH
DCC_Puntzi_A	H	M	VL
DCC_Puntzi_B	H	L	L
DCC_Pyper_A	H	M	M
DCC_Pyper_B	H	M	VL
DCC_Pyper_C	H	M	M
DCC_Tatla_Little_Eagle_A	H	L	L
DCC_Tatla_Little_Eagle_B	H	M	L
DCC_Tatla_Little_Eagle_C	H	L	L
DCC_Upper_Tatlayoko_A	M	VL	H
DCC_Upper_Tatlayoko_B	H	L	L
DCC_Westbranch_A	M	L	M
DCC_Westbranch_B	H	L	M

Table 18. Summary of data and ratings for individual indicators and the three indicator types.

Assessment Unit	Ecological Importance			Hazard					Current Mitigation		
					% Optimal Habitat Reduced				% Protected		
	% winter moose habitat	Weighted Habitat Quality	Rating	% Capable Area Lacking Adequate Shelter	TOTAL	STATIC	% road disturbance of optimal habitat	Rating	All Moose winter habitat	Optimal static habitat	Rating
DCC_Bidwell_Lava_A	VH	M	H	VL	M	M	M	L	VL	L	L
DCC_Bidwell_Lava_B	VH	M	H	L	M	H	M	M	L	M	M
DCC_Bidwell_Lava_C	H	M	H	L	VL	M	M	L	M	M	M
DCC_Chilanko_A	VH	M	H	VL	L	L	M	L	VL	L	L
DCC_Chilanko_B	VH	M	H	VL	L	L	H	L	VL	VL	VL
DCC_Ottarasko_A	VL	L	L	VL	VL	L	VL	VL	VH	VH	VH
DCC_Ottarasko_B	L	L	L	VL	VL	L	VL	VL	VH	VH	VH
DCC_Puntzi_A	VH	M	H	VL	M	H	M	M	VL	VL	VL
DCC_Puntzi_B	VH	M	H	VL	L	L	M	L	L	L	L
DCC_Pyper_A	VH	M	H	VL	L	M	H	M	L	M	M
DCC_Pyper_B	VH	M	H	VL	H	H	H	M	VL	VL	VL
DCC_Pyper_C	VH	M	H	VL	M	M	H	M	L	M	M

Assessment Unit	Ecological Importance			Hazard					Current Mitigation		
					% Optimal Habitat Reduced				% Protected		
	% winter moose habitat	Weighted Habitat Quality	Rating	% Capable Area Lacking Adequate Shelter	TOTAL	STATIC	% road disturbance of optimal habitat	Rating	All Moose winter habitat	Optimal static habitat	Rating
DCC_Tatla_Little_Eagle_A	VH	M	H	VL	VL	L	M	L	L	L	L
DCC_Tatla_Little_Eagle_B	VH	M	H	VL	L	M	H	M	VL	L	L
DCC_Tatla_Little_Eagle_C	VH	M	H	VL	VL	L	M	L	L	L	L
DCC_Upper_Tatlayoko_A	M	M	M	VL	VL	VL	L	VL	H	H	H
DCC_Upper_Tatlayoko_B	VH	M	H	VL	VL	L	H	L	L	L	L
DCC_Westbranch_A	L	M	M	VL	VL	L	M	L	L	M	M
DCC_Westbranch_B	H	M	H	VL	VL	L	L	L	M	M	M

Notes and highlights of moose broad-scale assessment:

- The **Ottarasko** Landscape Unit has a very low overall risk because only a relatively small portion of the landscape unit is winter moose habitat, and it has very little current road or logging disturbance and it is extremely well protected.

- The **Bidwell-Lava**, **Chilanko, Puntzi and Pyper** and **Tatla–Little Eagle** landscape units all have high ecological importance ratings because they have a very high proportion of moderate capability habitat. The overall hazard rating for all of the subunits in these five areas is either low or moderate. Moderate hazard ratings in Tatla–Little Eagle B, Pyper (A-C) and Puntzi A are driven by high road disturbance in important habitat. Any additional road disturbance in these units should be carefully planned to minimize additional impact to moose habitat and to reduce current impact where possible. Pyper B, Puntzi A and Bidwell-Lava B also have high ratings for reduced static habitat, which means that significant forest cover has been lost adjacent to moose feeding areas such as riparian and wetland areas.

- The two parts of **Upper Tatlayoko** have quite different ratings and should be considered separately. **Subunit A** only has about half of the unit classified as moose winter habitat because the western half is higher elevation. However, a substantial part of the valley bottom north of Tatlayoko Lake is classified as high capability. This valley bottom is of high local importance. **Subunit A** has a low level of disturbance and a high level of protection. **Subunit B** is almost entirely classified as moose winter habitat and has a high level of road disturbance and low level of protection.

- **Westbranch A** has a small amount of winter moose habitat but the small areas it contains are locally important. Both **Westbranch** units have minimal current hazards to winter moose habitat and are moderately well mitigated.

Site-level considerations

Site-level impacts

Moose winter moose feeding habitat is sensitive to the following types of changes in habitat:

- reduction in shrub productivity in winter feeding areas;
- loss of shrub habitat or adjacent forested thermal cover due to land use changes;
- forest harvesting of the thermal cover near to the productive shrub habitats;
- development of roads within 1000 m of moose winter habitat areas;
- increased vehicle use of roads within 1000m moose winter habitat areas; and
- snow ploughing of roads within 1000m of moose winter habitat areas.

Important site-level habitat characteristics

The mapped information provided with this assessment can be used to roughly identify the relative site-level importance and sensitivity to development of specific locations in the landscape as shown in the following table.

Table 19. Relative site-level importance and sensitivity to development.

Highest Importance	○ Areas of mapped "High-Value Wetlands" for Moose, including the modelled high-suitability moose habitat surrounding them
	○ Areas with concentrations of static winter feeding habitat and adjacent shelter habitat especially where they overlap with high and moderate winter capability habitat.
	○ An assessment map showing concentrations of modelled high-suitability moose winter habitat overlapping high and moderate winter capability is currently under review as part of the technical values review process.
	○ Any other areas mapped as high winter capability.
	○ Any large concentrations of modelled moose winter habitat in other capability areas.
	○ Areas mapped as moderate capability that are not overlapped with areas of modelled moose winter habitat.
Lowest Importance	○ Areas mapped as low capability that are not overlapped with areas of modelled moose winter habitat.
	○ Areas with nil capability.

Moose indicators

Table 20. Indicator weightings for hazard indicators.

All other indicators have no weighting.

Indicator type	Attribute evaluated	Indicator	Indicator weight*
Hazards	Forest harvest effects	% reduction in total high-suitability habitat	0.5
		% reduction in static high-suitability habitat	0.5

Table 21. Description of moose winter habitat indicators.

Indicator	Measurement	Comments
% moose winter habitat	Percentage of the assessment unit classified as capability classes 1-5. Classes 1-5 includes all winter habitat from very high to very low capability.	Based on provincial Broad Ecosystem Inventory (BEI) moose winter habitat capability mapping. The weightings for the second indicator are based on the relative habitat quality estimates built into the provincial wildlife habitat capability ratings.
% weighted habitat capability	Weighted % of the total moose winter habitat classified as low, moderate and high capability: 100/75 X ((class 1-2 area X.75)+(Class 3 area X .37)+(class 4-5 area X .125)) The number is multiplied by 100/75 to standardize the maximum score to be 100.	
% of landscape without adequate shelter	Percentage of capability 1-5 habitat that does not meet shelter criteria. Shelter criteria: % thermal shelter of 30% in dry and moderate ecotypes and 40% in wet ecotypes, evaluated in all 10 km^2 cells in capable habitat.	
% reduction in total high-suitability habitat	Percentage reduction in total high-suitability moose winter habitat between undeveloped and current landscape.	Indicates the reduction in total modelled high-suitability moose winter habitat as a result of forest harvesting to date. It will usually be a positive number in the drier ecotypes, but it may be negative in some parts of the moist and wet ecotypes indicating an increase in foraging habitat from addition of 10-35 year old cutblocks or burns.

% reduction in static high-suitability habitat	Percent reduction in modelled static, high-suitability moose winter habitat between undeveloped and current landscape	Note that the high-suitability habitat is calculated in the model based adjacency of forage and shelter habitats and is not the same as high-suitability habitat as determined by provincial BEI mapping.
% road disturbed habitat	Percentage of the modelled high-suitability moose habitat in **all capability** classes that is within 1000m of a paved or gravel road.	This indicator assesses habitat disturbance resulting from paved and gravel roads as defined in the Digital Road Atlas. It does not include the many small roads and in-block roads referred to as undefined.
% habitat protected	Percentage of the modelled high-suitability moose habitat in **all capability** classes that is overlapped by no-harvest land use designations	No-harvest designations in the analysis include: Parks, protected areas, goal 2 protected areas, permanent old growth management areas, caribou no-harvest areas, and riparian reserves around streams, wetlands and lakes.
Static habitat protected	Percentage of the modelled static high-suitability habitat that is overlapped by no-harvest land use designations	

Table 22. Classification of indicators used for assessment of moose habitat.

Indicators	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Ecological Importance					
% moose habitat	0-16	17-33	34-66	67-84	85+
Weighted capability	0-16	17-33	34-66	67-84	85+
Hazard					
% landscape lacking adequate shelter	<7	8-15	16-30	31-50	51+
% reduction in total high-suitability habitat	<6	6-12	13-24	25-50	51+
% reduction in static high-suitability habitat	<5	5-9	10-19	20-29	30+
% road disturbance	0-10	11-25	26-50	51-75	76+
Current Mitigation					
% No-harvest of all capable habitat	0-15	16-30	31-60	61-80	>80
% No-harvest of static high-suitability habitat	0-15	16-30	31-60	61-80	>80

Calculation of component ratings

The ratings provided for ecological importance, current hazard and current mitigation are each composite ratings derived from multiple indicators. The steps in calculating the ratings are:

- Apply the classification ranges in Table 22 to determine the rating for each indicator.
- Apply any indicator weightings from Table 20.
- Average the individual indicator ratings that make up each component. Round composite ratings to the nearest whole number.

Strengths and limitations of moose assessment

Strengths

- Moose habitat capability mapping used in this assessment for ecological importance was completed by provincial experts with input from local biologists, is available for this area and was used in the assessment.
- Many research studies of moose winter habitat use are available including several from the Cariboo-Chilcotin. Information from these was used to develop the moose habitat model.
- Inventory work has been done in parts of the region to identify important wetlands heavily used by wintering moose and to evaluate general habitat use patterns. This information was used to develop and validate the assessment model.
- Broad-scale capability mapping, in combination with the finer scale modelling of high-suitability moose winter habitat, provides systematic and ecologically meaningful estimates of habitat abundance, distribution and quality.
- Ministry of Environment moose specialists from Williams Lake and Kamloops were consulted on the initial design of the model.
- Land use designations, which contribute to the mitigation ratings, are legally established and therefore have a significant degree of security and clear definitions of management objectives.
- Maps of winter feeding habitats and locally modelled high-suitability moose winter habitat provide useful site-specific information for planners within the limitations of the input data. The mapping can be used to distinguish static feeding habitat (e.g., wetland and riparian zones) from dynamic feeding habitat (e.g., cutblocks and burns which provide forage for a limited time period following disturbance and change position in the landscape over time). This version of the assessment includes numerical assessments of the two types of moose habitat and thus resolves the limitation from the previous version where changes in the static habitat were masked in the analysis by additions of dynamic habitat. Separate assessment of these two habitat types provides a more ecologically relevant analysis, and more refined management recommendations.
- A detailed peer review was conducted by a local biologist with extensive knowledge of the moose literature and experience with local winter census flights (Davis R.L., 2014). Much of his input is incorporated into refinements to this version of the assessment.
- Current radio-telemetry studies in two parts of the region will provide future high quality information for model validation and refinement.
- The assessment model is tailored to three moisture/snowpack related ecotypes to allow for differences in habitat and habitat use across the region.

- An additional indicator was added to help users understand the amount and distribution of shelter habitat in relation to requirements published in the literature.
- The assessment model has been modified to better capture the habitat value of large contiguous deciduous areas such as the area above Lac de Roche. Most of these areas incorporate small conifer patches large enough to provide useful thermal and security cover but which are too small to show up in the forest inventory data and were thus missed as cover by the previous assessment model. Census data confirm that these areas can have high moose winter use even at significant distances from mapped cover. Therefore, the model relaxes the cover requirements for these areas to better represent actual known moose use and include them as current high-suitability habitat.

Limitations

- Reliability of several aspects of the assessment is limited by the accuracy, currency and polygon size limitations of forest inventory data and by the quality of the data in the digital road atlas.
- Ratings for the landscape shelter indicator have not been peer reviewed.
- Pine mortality data were not used quantitatively in the model but were mapped for use in qualitative assessments. The relationship between various levels of stand mortality and its effectiveness for moose security and thermal cover is not known with any precision. Thermal and security cover values in high mortality pine stands would be reduced in relation to totally green stands, but would be significantly higher than in clearcut areas.
- The reduced habitat hazard indicator uses a very simple reference condition which does not explicitly reflect historic natural disturbance processes. However, this indicator has been retained because it provides a valuable, spatially explicit assessment of current habitat. Because of the nature of the reference condition, the indicator does not completely reflect the difference between the current landscape and a naturally disturbed landscape condition. However, since the same methodology is applied across the region the relative differences in indicator values are meaningful and can be rated to meaningfully estimate relative habitat change across the region.
- Current classification of digital road data is very coarse and classifies all roads into only three classes: paved, gravel, and undefined. The undefined class includes many roads to and through cutblocks that are relatively large and well-travelled which would ideally be included as roads that that reduce habitat effectiveness for moose. Because of the coarseness of the road classification, these roads had to be excluded from the moose analyses when ideally they would have been included. Future, more

refined road classifications may allow for a more refined treatment of roads with variable disturbance distances depending on road classifications that would reflect industrial and hunter traffic.

- Review by Davis, R.L. in 2014 suggested some potential limitations to the capability mapping results used in developing the ecological importance ratings.

Mule deer risk summary

The key life requisite used for this analysis is mule deer winter range. In the winter, deer move to traditional winter ranges centred on areas that can provide available food and reduced snow depths. Reduced snow pack conditions result from a combination of factors including lower elevation, warm aspect slopes and forests with good snow interception cover. These winter ranges are distributed throughout the shallow, moderate and deeper snow areas in the Cariboo-Chilcotin, often on the warm aspect sides of major valleys. They have been carefully mapped and designated for special management. Mature forest cover on winter ranges provides critical snow interception as well as thermal and security cover. Douglas-fir provides especially good cover attributes with mature stands reducing snowpack by more than 50% while providing important litter-fall forage and a good substrate for arboreal lichen forage.

Most Cariboo-Chilcotin winter ranges cover large contiguous areas, and deer can move freely throughout them to find required habitat attributes and minimize predation. However some winter ranges are relatively small and/or isolated from each other by distances that may be difficult or energetically costly to travel in the winter. Animals in these smaller, isolated winter ranges are more sensitive to negative changes in habitat.

Extensive research and planning efforts over many years have produced comprehensive landscape and stand-level direction, tailored to the different forest types across the region, to maintain or improve the condition of mule deer winter range habitat on approximately 100 mapped winter ranges.[5] The boundaries for each winter range were carefully drawn to encompass adequate habitat for the variety of winter conditions, and individual habitat plans for each winter range specify legal requirements for specialized forest management.

Because the comprehensive management framework in place for mule deer winter range is expected to significantly reduce habitat risk for this species in the Cariboo-Chilcotin, the cumulative effects assessment framework for this species is simplified.

The mule deer risk summary includes three sections: the broad-scale assessment, site-level considerations and detailed description of indicators. The appendix includes additional background information and analysis details.

[5] Management Strategy for Mule Deer Winter Ranges in the Cariboo-Chilcotin Part 1a: Management Plan for Shallow and Moderate Snowpack Zones. http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh60.htm

Mule deer broad- scale assessment

Table 23 summarizes the indicators used to assess the ecological importance, hazards and current mitigation for each mule deer winter range. Tables 24 and 25 summarize the assessment results for individual mule deer winter ranges.

The following maps display relevant information including some of the factors used in the assessment:

- **Figure 2** is a Bing satellite image showing the general topography.
- **Figure 4** shows the no-harvest and modified harvest areas designated by the Cariboo-Chilcotin Land Use Plan.
- **Map 6** shows the location of the 2009 and 2010 wildfires that overlapped with much of the West Chilko and West Chilcotin winter ranges.
- **Map 9** shows the shows the location of the mule deer winter ranges and their legal name and number.

Table 23. Indicators used to assess the current risk to mule deer winter ranges.

Indicator type	Attribute evaluated	Indicator
Ecological importance	Ecological value of winter range as a whole.	This is rated as high for all winter ranges because they have all been carefully selected and had careful boundary revisions.
	Degree of winter range isolation.	Based on size of mule deer winter range and distance to other winter ranges. Detailed criteria are described in the Indicator Details section.
Hazards	Forest structure required for snow interception, thermal cover and litter-fall forage.	% winter range habitat area meeting stand structure targets based on 2002 assessment. % of winter range impacted by 2009/10 wildfires.
Current mitigation	Mitigation through the application of special management.	Special management level rated as high for all winter ranges because of high level of legally required special management.
	Legal protection level of winter range habitat.	% of winter range overlapped by no-harvest designations .

Table 24. Summary of the risk components for mule deer winter ranges.

Colours reflect the appropriate level of management concern: Very High, High, Moderate, Low, Very Low. Note that colours for current mitigation are reversed. For example, if the mitigation level is very high, the colour is dark green indicating a very low level of management concern.

Winter range name	WR#	Ecological importance	Hazards	Current mitigation
Chilanko Creek	dwl_24	H	M	**M**
Choelquoit	dwl_28	H	NA	**M**
Mosley Creek	dwl_1	H	M	**M**
Puntzi Lake	dwl_69	H	H	**H**
Tatlayoko	dwl_78	H	H	**H**
West Chilcotin	dwl_85	H	VH	**M**
West Chilko	dwl_86	H	VH	**M**

Table 25. Detailed breakdown of the indicators for assessment of mule deer winter ranges.

Winter range name	Ecol. Import.		Hazards					Current Mitigation		
	Rating		Forest structure	Isolation	Percent recent wildfire overlap	Rating		Special manage	% No-harvest overlaps	Rating
Chilanko Creek	H		32	L	0	M		H	22	**M**
Choelquoit	H		No Data	H	0	NA		H	5	**M**
Mosley Creek	H		84	M	0	M		H	30	**M**
Puntzi Lake	H		14	L	0	H		H	43	**H**
Tatlayoko	H		32	M	0	H		H	53	**H**
West Chilcotin	H		28	L	32	VH		H	23	**M**
West Chilko	H		40	L	54	VH		H	24	**M**

Notes and highlights of mule deer broad-scale assessment:

- All winter ranges have high ecological importance, and have comprehensive, legally required special management direction in place to mitigate forestry development activities.
- Several of the winter ranges in this area have a high or very high hazard rating. Except for Mosely Creek, they are all far from meeting structural targets and will require time for forests to develop better forest structure. Two winter ranges experienced large, recent overlap with forest fires and three of them are isolated from other winter ranges. Many winter ranges in the Chilcotin have received significant damage from Douglas-fir beetle and budworm within the last decade.
- The overall hazard level for the **Choelquoit** winter range is not rated because stand structure data is not available. However, it is a small isolated winter range with very low levels of overlap with no-harvest designations. Because of these factors plus the uncertainty of its structural status, it should be very carefully and conservatively managed.
- Risks are well mitigated in **Puntzi** winter range by over 40% no-harvest overlaps and special management on the remainder. It is well connected to winter ranges that follow the warm aspects of the Chilcotin River all the way to Hanceville. The current forest structure assessment indicates that time is required to restore forest structure. An updated forest structure assessment would be useful to determine the how close the stands are to meeting stand structure targets and to evaluate the effects of Douglas-fir bark beetle mortality.
- **West Chilcotin** and **West Chilko** winter ranges are both well connected to other winter ranges and have approximately 25% overlap with no-harvest designations. However, both were subjected to intense wildfire in 2009/2010 over a large proportion of their areas. While a more current assessment of stand structure would be useful, these winter ranges are at high risk and need to be need to managed very carefully to maintain existing green Douglas-fir and to promote timely establishment of Douglas-fir stands in burned areas.
- **Mosely Creek** winter range has good forest structure and a reasonable level of mitigation with over 30% of the winter range overlapped with no-harvest protection. Its isolation rating is moderate because, even though it is somewhat isolated from other winter ranges, it is large enough to somewhat decrease ecological effects of this isolation.
- **Tatlayoko** winter range has over 50% protected by no-harvest areas and the remaining area is subject to special management direction for mule deer. With time and good management it will provide better forest structure for winter range.

- **Chilanko Creek** winter range will require time and good management to restore good forest structural attributes.

Site-level considerations

Site-level impacts

Within their winter ranges, mule deer in the Cariboo-Chilcotin would be negatively impacted by the following types of habitat change or development:

- Habitat loss from forest harvesting treatments which change forest cover beyond targeted stand structure by removing too many trees, the wrong types of trees or harvesting heavily on special habitats such as ridges and topographic breaks.
- Construction of roads, skid trails, or any development on or near ridge and topographic break features.
- Loss of mature and old forest habitat (especially mature Douglas-fir) from forest insects, disease and wildfire.
- Silviculture systems and/or reforestation approaches that reduce or do not promote Douglas-fir in the post-harvest stand.
- Significant increases in road density and/or winter road use.
- Stand treatments that decrease the effectiveness of visual and thermal cover over large areas at the same time.
- Any activity that significantly increases human use or access over the winter season.
- Alienation of winter range area from Crown ownership.

Important site-level habitat characteristics

All of the following are important site-level characteristics for habitat on mule deer winter ranges. On a winter range, a site with any one of these characteristics will be important winter habitat. The more of these characteristics a site has, the more valuable it is, and the greater potential impacts from development activities not designed to meet mule deer habitat objectives.

- Small- or large-scale ridges and topographic breaks;
- Warm aspect slopes (southeast to west facing);
- Lower elevation areas on a winter range;
- Areas with Douglas-fir dominated forests;
- Mature or old forest; and
- Areas with any feature which reduces snow pack. This would include adjacency to large lakes such as Horsefly Lake which produce a buffer of reduced snow.

Mule deer indicators

Table 26. Indicator weightings for mule deer indicators.

Indicator type	Attribute evaluated	Contribution to combined hazard rating	Indicator weight
Ecological importance	Ecological importance		1.0
Hazard	Forest structure	Basic rating	NA
	Degree of isolation	Add 1 class for moderate rating and 2 class for high rating	NA
	Wildfire impact	Add 1 class for moderate rating , 2 classes for high rating, 3 classes for very high rating	NA
Current* mitigation	Special management		1.2
	Degree of legal no-harvest protection		0.8

*The special management regime for mule deer winter ranges was given a higher weighting than legal protection because the management regime is designed to meet mule deer habitat requirements and balance them with compatible timber harvesting.

Table 27. Description of mule deer indicators.

Indicator	Measurement	Comments
% Importance	Qualitative assessment	The importance of all mule deer winter ranges was rated as high. They were all specifically delineated based on their importance and the boundaries underwent numerous reviews.
Forest structure	% of winter range which meets stand structure targets	This is based on a 2002 assessment. Note that very broad risk classes have been defined for this indicator because of the low precision of the quantitative assessment. High scores indicate more ideal forest structure for winter range habitat. More detail on stand structure targets and assessment methodology is included in the appendix.
2009/10 wildfire impact	Percent of the winter range impacted by fire: **Moderate** = 11-20%, **High** =21-40%, **Very high** =>40%.	The fires in 2009 and 2010 had very high impacts on some winter ranges, decreasing habitat quality for shelter and mid-winter forage.
Isolation	Rating based on winter range size and degree of isolation. **High**: WR <2000 ha & isolated from other WR >2000ha in size. **Mod**: WR > 2000 ha but isolated from other winter ranges >2000 ha. **Low**: any size but **not** isolated from other winter ranges >2000 ha in size.	Isolated is defined as either: • >5 km distance or • separated by habitat features that would result in very difficult winter travel to nearest winter range.
Special management	Qualitative assessment of the level of mitigation provided by legal direction for special management to maintain mule deer habitat requirement in managed forest stands on winter range.	This was rated as high for all winter ranges because of the comprehensiveness of the legal direction in place requiring management to maintain mule deer habitat in managed forest stands. This legal direction addresses how much and what type of forest structure must be maintained in logging operations, what silviculture system to use, protection of special features such as ridges, placement and density of skid roads and tree species requirements for reforestation.
% habitat protected	Percentage of the forested component of the winter range that is overlapped by land use designations that do not allow timber harvesting.	No-harvest designations in the analysis include: Parks, protected areas, goal 2 protected areas, permanent old growth management areas, caribou no-harvest areas, and riparian reserves around streams wetlands and lakes.

Table 28. Classification of indicators used for assessment of mule deer winter range in the Cariboo-Chilcotin.

Indicators	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Ecological Importance	All mule deer winter ranges are rated high for ecological importance				
Hazard					
Forest Structure Targets	71-100		31-70	0-30	
Isolation	Large or close to other MDWR		Large but not close to other MDWR	Small and not close to other MDWR	
2009/10 wildfire impact (% WR burned)	0-10		11-20	21-40	>40
Current Mitigation					
Special Management	All winter ranges are rated high for special management				
% No-harvest	0-15%	16-30%	31-60%	61-80%	>80%

Calculation of component ratings

The ratings provided for ecological importance and current mitigation are each composite ratings derived from multiple indicators. The steps in calculating the ratings are:

- Apply the classification ranges in Table 28 to determine the rating for each indicator
- Apply indicator weightings.
- For current mitigation, average the individual indicator ratings that make up each component. Round composite ratings to the nearest whole number.
- For hazard, follow the procedure outlined below:

The combined hazard rating for mule deer winter range is not calculated by weighting and averaging the multiple indicators. Rather, the isolation and fire impact ratings result in a step up in hazard from the primary forest structure rating. The step ups for the isolation and wildfire indicators are shown in Table 29. They are additive. For example, an assessment unit with both moderate isolation and moderate wildfire impact would step up two classes of hazard.

The composite hazard is assessed this way because the forest structure is the primary indicator of habitat suitability in relation to stand structure targets. The other two indicators measure situations can only increase the hazard associated with a given rating for the primary indicator but cannot act to decrease the hazard.

Table 29. Combined hazard calculation.

Isolation and wildfire ratings increase the primary hazard rating based on stand structure as shown in the table.

	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Isolation	No step up		1 class	2 classes	
2009/10 wildfire impact*	No step up		1 class	2 classes	3 classes

Evaluation of Mule Deer Habitat Assessment:

Strengths

- Comprehensive local research provides an excellent basis for understanding the winter requirements of deer in the Cariboo-Chilcotin, and ensuring that legally designated winter ranges are located in areas that provide important winter habitat. Therefore, the high importance rating given to all winter ranges is valid.
- Specialized management requirements that contribute to the high mitigation ratings for all winter ranges are well designed to maintain mule deer habitat and are legally established.
- The land use designations which contribute to the mitigation ratings are legally established, and therefore have a significant degree of security and clear definitions of management objectives.
- Inclusion of a hazard indicator for percent area burned within each winter range in 2009 and 2010 is very useful because of the large proportion of some winter ranges degraded by wildfire in those two years.

Limitations

- Reliability of forest structure assessment is limited by the accuracy and currency of forest inventory data. Throughout much of the province, keeping forest inventory data up to date can be a challenge, especially in the interior where large-scale natural disturbances such as mountain pine beetle, Douglas-fir bark beetle and wildfires are occurring on an increasingly regular basis. The ministry has inventory projects underway that will improve the forest inventory data in the area covered by this report, and in the overall Cariboo-Chilcotin area. As the data improve, reanalysis may be warranted.
- Assessment of forest structure was done in 2002, and could benefit from updating.
- No-harvest overlap analysis could be improved by only evaluating the areas with >20% Douglas-fir which are generally the more important areas for mule deer winter range.

Grizzly bear risk summary

Significant grizzly bear populations occur in eastern and western parts of the Cariboo Chilcotin region, but have been largely extirpated from the centre (Figure 11). In the west, grizzly bear populations in the South Chilcotin Ranges and Blackwater-West Chilcotin population units are classified as threatened, and have objectives to increase populations. In the east, populations are classified as viable. Grizzly bears may be still seasonally present in some parts of units classified as extirpated, but breeding females are rare and management objectives are not to restore previous grizzly bear populations at this time. The study area includes some areas classified as extirpated, and some classified as viable adjacent the threatened South Chilcotin Ranges population unit (Figure 12).

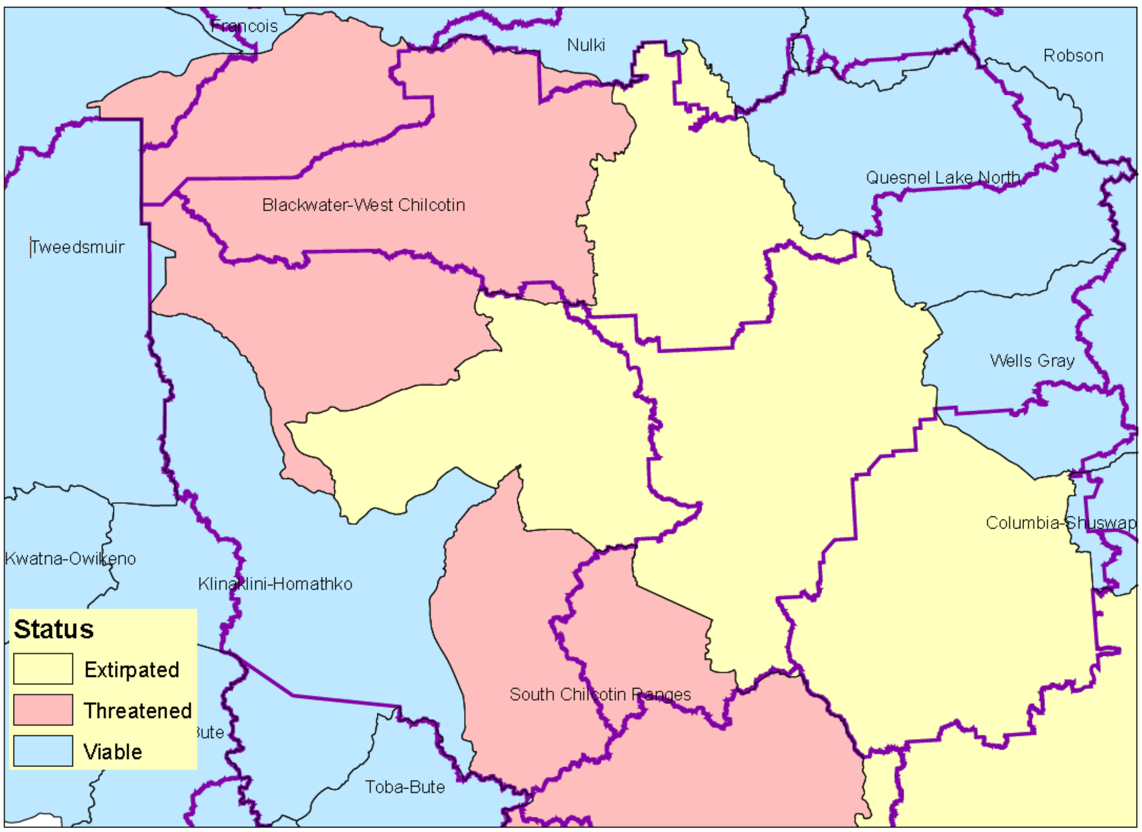


Figure 11. Status of grizzly bear population units in the Cariboo-Chilcotin

Grizzly bears require appropriate habitat over large areas. Appropriate habitat varies by season and geographic area. In spring they use lowland habitats and throughout the summer they disperse more widely. In the late summer and fall they start to key in on berries and will travel long distances to feed on spawning salmon. In addition to fish, ungulates are also a significant source of protein. In some parts of the region, sockeye and Chinook salmon provide a key resource in the important pre-hibernation period. Places where spawning salmon are abundant and accessible will draw bears from large distances, and are extremely important to regional populations. The Cariboo-Chilcotin has two of the largest sockeye salmon runs in the province; the Horsefly River/Quesnel Lake system and the Chilko/Chilcotin system.

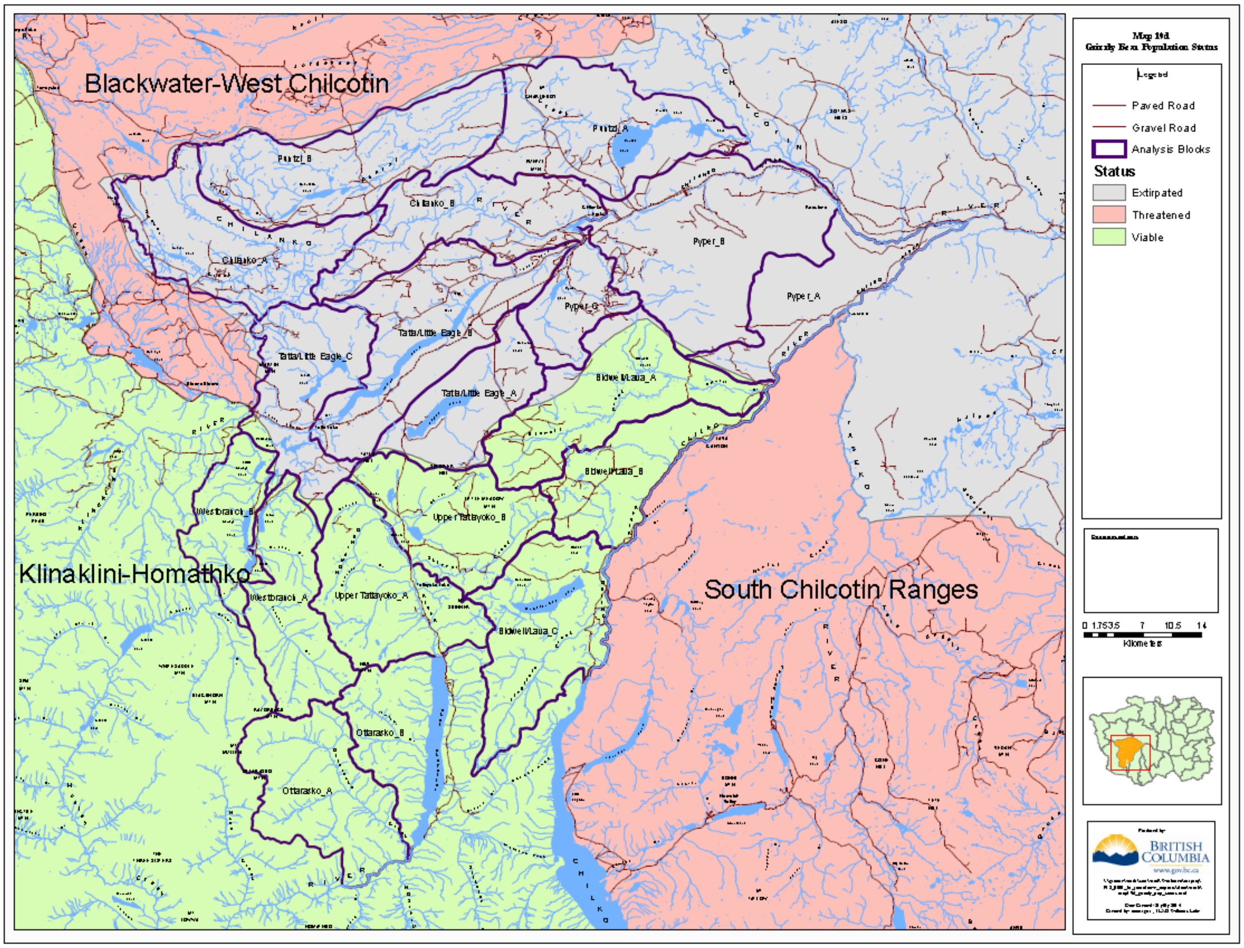


Figure 12. Grizzly bear population statuses.

Grizzly bears are negatively affected by both habitat loss and by patterns of human use which increase contact between humans and bears. Negative effects of contact with humans include displacement of bears from desirable habitat and increased mortality risk. Factors causing displacement include: roads, cattle ranching operations, industrial camps and recreational use. Mortality risks increase in relation to these same factors. Bears are shot as a result of poaching, mistaken identity by hunters and from conflicts with humans and livestock. Significant habitat disruptions such as major roads can also fracture the breeding connectivity of populations that is necessary to maintain gene flow.

Grizzly bear broad-scale assessment

The risk summary includes two sections:

1. Results of the broad-scale cumulative effects assessment, and
2. Detailed information on the indicators.

The appendix includes additional background information and analysis details.

Four aspects of grizzly bear ecology are included in this broad-scale assessment (Table 30):

- Current population viability status;
- Habitat quality including habitat capability and presence of significant salmon resources;
- Reductions in habitat effectiveness related to density of human access; and
- Proportion of capable habitat within roadless secure core areas. Secure core habitat is defined as roadless areas greater than 10 km^2.

The mitigation effect of current legal land protection is also assessed.

Table 30. Summary of the indicators used to assess grizzly bear habitat.

Capability classes 1-5 include all capable habitats, while classes 1-3 are moderate and better capability.

Indicator type	Attribute evaluated	Indicator
Ecological importance	Population unit status	Population status (extirpated, viable or threatened)
	Proportion of the land area classified as capability 1-5 grizzly bear habitat	% capable habitat: classes 1-5
	Proportion of the total capable habitat classified as capability 1-3	% capable habitat: classes 1-3
	Salmon abundance, consistency and availability for bear feeding	significant salmon resource
Hazard	Habitat effectiveness	% effective habitat: capability classes 1-5
		% effective habitat: capability classes 1-3
	Secure core habitat	% secure core: capability classes 1-5
		% secure core: capability classes 1-3
Current mitigation	Protection by designated no-harvest areas	% habitat protected: capability classes 1-5 % habitat protected: capability classes 1-3

The following maps supply useful spatial information to supplement the numerical assessment and aid planners in specific applications:

- Figure 2: Bing satellite image showing the general topography. Note that the satellite images are not up-to-date and therefore do not necessarily show all current roads and cutblocks.
- Figure 4: Current mitigation map showing no-harvest and selected modified harvest areas designated by the CCLUP.
- Map 19a: Habitat Capability and secure core areas map shows the secure core areas (roadless areas of greater than 10 km^2) and broad scale grizzly bear capability ratings.
- Map 19c: Road density for grizzly bear map shows road density in the five density classes meaningful for assessing grizzly bear habitat effectiveness.
- Map 19d: Grizzly bear population status shows the population status of grizzly bear population management units.

Table 31 provides an overview of the results while Tables 32 and 33 provide more detail.

Table 31. Summary of the risk components for grizzly bear habitat.

Colours reflect the appropriate level of management concern: Very High, High, Moderate, Low, Very Low. Note that colours for current mitigation are reversed. For example, if the mitigation level is very high, the colour is dark green indicating a very low level of concern.

Assessment unit	Ecological importance	Hazards	Current mitigation
Bidwell/Lava	VH	M	L
Ottarasko	H	L	VH
Upper Tatlayoko	H	L	L
Westbranch	H	L	M
Chilanko	These landscape units are in Grizzly Bear Population Units classified by Ministry of Environment as extirpated and were therefore not included in this summary.		
Puntzi			
Pyper			
Tatla/Little Eagle			
Puntzi			
Pyper			
Tatla/Little Eagle			

Table 32. Summary of the risk components for grizzly bear habitat including subunits

Assessment unit	Ecological importance	Hazard	Current mitigation
Bidwell/Lava_A	M	H	VL
Bidwell/Lava_B	M	H	L
Bidwell/Lava_C	VH	L	L
Bidwell/Lava	**VH**	**M**	**L**
Ottarasko_A	H	L	VH
Ottarasko_B	M	L	VH
Ottarasko	**H**	**L**	**VH**
Upper Tatlayoko_A	H	L	M
Upper Tatlayoko_B	H	H	VL
Upper Tatlayoko	**H**	**M**	**L**
Westbranch_A	H	L	M
Westbranch_B	H	L	M
Westbranch	**H**	**L**	**M**

Table 33. Summary of data and ratings for individual indicators.

Note that hazard indicators are rated using a three-class system.

Assessment Unit	Ecological importance					Hazard					Current mitigation		
						% Capable and Effective Habitat		% Secure Core			% Protected		
	Population Status	Capability 1-5	Capability 1-3	Salmon rating *	Overall Rating	Capability 1-5	Capability 1-3	Capability 1-5	Capability 1-3	Rating	Capability 1-5	Capability 1-3	Rating
Bidwell/Lava_A	viable	100	23	nr	M	44	48	6	1	H	7	13	VL
Bidwell/Lava_B	viable	100	21	nr	M	44	43	13	5	H	16	36	L
Bidwell/Lava_C	viable	100	42	VH	VH	76	89	62	83	L	29	17	L
Bidwell/Lava	**viable**	**100**	**29**	**VH**	**VH**	**56**	**68**	**28**	**44**	**M**	**17**	**19**	**L**
Ottarasko_A	viable	55	79	nr	H	100	100	100	100	L	96	96	VH
Ottarasko_B	viable	56	45	nr	M	96	100	93	100	L	98	98	VH
Ottarasko	**viable**	**55**	**66**	**nr**	**H**	**98**	**100**	**97**	**100**	**L**	**97**	**97**	**VH**
Upper Tatlayoko_A	viable	84	52	nr	H	71	86	59	81	L	48	36	M
Upper Tatlayoko_B	viable	100	37	nr	H	46	49	16	13	H	7	6	VL
Upper Tatlayoko	**viable**	**91**	**44**	**nr**	**H**	**59**	**70**	**37**	**52**	**M**	**27**	**23**	**L**
Westbranch_A	viable	63	67	nr	H	80	90	70	84	L	38	44	M
Westbranch_B	viable	98	43	nr	H	78	82	63	70	L	54	50	M
Westbranch	**viable**	**76**	**55**	**nr**	**H**	**79**	**87**	**66**	**79**	**L**	**46**	**46**	**M**

** "nr" for the salmon indicator means "not rated"*

Notes and highlights of grizzly bear broad-scale assessment:

- Known strengths and limitations of the assessment are summarized in the section on grizzly bear indicators.
- **Pyper, Tatla/Little Eagle Chilanko** and **Puntzi** landscape units are located in areas classified as unoccupied or extirpated for grizzly bear. These areas do have habitats capable of supporting grizzly bears, receive some level of grizzly bear use, and were likely occupied historically. However they are not known to currently support adult female bears with cubs and so are classified as extirpated habitat. Therefore, they are not included in this assessment.
- All landscape units in the study area, with the exception of those classified extirpated, are in the Klinaklini-Homathko population unit which is classified as viable. However the study area is adjacent to the South Chilcotin population unit where populations are threatened and recovery is the objective. Some interchanges of bears between the two units likely occur.
- **Salmon Spawning**: **Bidwell subunit C** incorporates a very important area along the Chilko River where high numbers of grizzly bears feed on spawning sockeye salmon. The most heavily used area stretches from Chilko Lake to Lingfield Creek but feeding also occurs farther downstream. This area also has significant numbers of spawning Chinook salmon which arrive three to five weeks before the sockeye. Much of the immediate area around the river is protected by areas designated as old growth management areas, critical habitat for fish, and community areas of special concern through the CCLUP. However, increased traffic on the existing roads through this area or any other nearby development can provide significant risks to bear habitat effectiveness. Also, the travel routes that bears use to get to this feeding site may also require attention when planning development. The maintenance of healthy spawning sockeye and Chinook salmon populations in the Chilko River is vitally important to bears throughout much of the study area and to the adjacent South Chilcotin grizzly bear population unit. The importance of this area for grizzly bear was documented in a 2009 study by Cedar Mueller.
- **Connectivity** is very important to grizzly bears. Because of the large home range size of grizzly and the importance of highly productive, site-specific habitats within that range, linear developments such as roads or extensive habitat alteration at the landscape level can disrupt connectivity. This disruption can affect population viability because the bears must be able to disperse to form a widespread, low density but connected sub-regional and regional population. In addition to road density, the existence of roads with significant traffic can disrupt the connectivity of bear habitat. It will be important to carefully consider developments, which will lead to significant increases to access or traffic volume.

Grizzly bear indicators

Table 34. Description of grizzly bear indicators.

Indicator	Measurement	Comments
Population status	Status from Ministry of Environment's Grizzly Bear Strategy	Population units classified as viable, extirpated or threatened.
% capable habitat class 1-5	% of the total land area in the assessment unit that is classified as weighted average capability 1-5	Based on 1:250,000 scale Broad Ecosystem Inventory (BEI) mapping updated in 2012. Classes 1-5 includes all habitat with any capability for grizzly bears. Classes 1-3 are the moderate–high capability habitat.
% capable habitat class 1-3	% of the 1-5 capability area that is classified as weighted average capability 1-3.	
Salmon availability	Three category ratings based on available quantitative data and qualitative information for sockeye and Chinook salmon. Rating combines salmon abundance, year-to-year consistency and availability of the fish to bears.	Ratings are based on quantitative spawning data for the Quesnel system and qualitative information from Department of Fisheries and Oceans experts for other areas.
% effective habitat classes 1-5	The area of all capable habitat (classes 1-5) is netted down based on degree of overlap with each of five road density classes. Net-downs increase with increasing road density. The indicator is the net down area as a percentage of the total area of capability 1-5 habitat.	This is primarily an indicator of displacement risk which can result in bears not being able to make full use of valuable habitat. It secondarily reflects a variety of grizzly bear mortality risks that go along with roads. Note that habitat effectiveness is usually calculated as a net down to habitat suitability. The net down was applied to capable habitat in this analysis to reflect the long term nature of the required planning horizon during which the suitability would be in flux.
% effective habitat classes 1-3	Same as above but the effectiveness net down is applied to moderate and high capability habitat (classes 1-3).	
Secure core: classes 1-5	Area of secure core habitat (roadless area >10 km^2) in capability classes 1-5 as a percentage of the total area in classes 1-5.	The proportion of capable habitat in road less areas > 10 km^2 reflects changes in mortality risk resulting from access.
Secure core: classes 1-3	Area of secure core habitat (roadless area >10 km^2) in capability classes 1-3 as a percentage of the total area in classes 1-3.	
% habitat protected: classes 1-5	The area of designated no-harvest area overlapped with capability classes 1-5 grizzly bear habitat as a percentage of the classes 1-5 habitat in the assessment unit.	No-harvest designations in the analysis include: Parks, protected areas, goal 2 protected areas, permanent old growth management areas, caribou no-harvest areas, and riparian reserves around streams wetlands and lakes. Assessment is based on all land, not just forested land.
% habitat protected: classes 1-3	The area of designated no-harvest area overlapped with classes 1-3 capability grizzly bear habitat as a percentage of the classes 1-3 habitat in the assessment unit.	

Table 35. Classification of indicators used for assessment of grizzly bear habitat.

<table>
<tr><th>Indicators</th><th>Very Low
(1)</th><th>Low
(2)</th><th>Moderate
(3)</th><th>High
(4)</th><th>Very High
(5)</th></tr>
<tr><td>Ecological importance</td><td colspan="5"></td></tr>
<tr><td>Population unit status</td><td colspan="2">Extirpated</td><td>Viable</td><td colspan="2">Threatened</td></tr>
<tr><td>Salmon availability*</td><td colspan="3">Not rated</td><td>significant and consistent</td><td>very significant and consistent</td></tr>
<tr><td>% Capable habitat class 1-5</td><td colspan="2" rowspan="2">0-33</td><td rowspan="2">34-66</td><td colspan="2" rowspan="2">67-100</td></tr>
<tr><td>% Capable habitat class 1-3</td></tr>
<tr><td>Hazard</td><td colspan="5"></td></tr>
<tr><td>% Effective habitat classes 1-5</td><td colspan="2" rowspan="2">66-100</td><td rowspan="2">34-65</td><td colspan="2" rowspan="2">0-33</td></tr>
<tr><td>% Effective habitat classes 1-3</td></tr>
<tr><td>% Capable habitat in secure core classes 1-3</td><td colspan="2" rowspan="2">46-100</td><td rowspan="2">18-45</td><td colspan="2" rowspan="2">0-17</td></tr>
<tr><td>% Capable habitat secure core classes 1-5</td></tr>
<tr><td>Current mitigation</td><td colspan="5"></td></tr>
<tr><td>% No-harvest in all bear capable habitat</td><td rowspan="2">0-15%</td><td rowspan="2">16-30%</td><td rowspan="2">31-60%</td><td rowspan="2">61-80%</td><td rowspan="2">>80%</td></tr>
<tr><td>% No-harvest in capability classes 1-3</td></tr>
</table>

*Only high and very high classes are rated. Where quantitative data on spawning numbers was available, it was used. Other significant and accessible salmon spawning areas were identified based on qualitative information from the literature or from expert input from fisheries and wildlife field staff. Where quantitative data were available for the Quesnel system, assessment units were rated very high for assessment units where highest spawner density exceeded 250,000 and most years had >10,000 spawners. Units were rated high where spawner estimates exceeded 10,000 in the best year and were >5000 for most years.

Combined ratings for risk components

Composite ratings for each of the three major assessment components (ecological importance, hazard and mitigation) are derived by combining the results from all of the indicators for each component.

Ecological importance rating - combines habitat quality and population status as shown in colour-coded table below.

Table 36. Ecological importance rating for grizzly bear.

Population status	Habitat quality				
	Very low (1)	Low (2)	Mod (3)	High (4)	Very high (5)
Extirpated	VL	VL	L	M	M
Viable	VL	L	M	H	VH
Threatened	L	M	H	VH	VH

The habitat quality is composed of habitat capability rating plus salmon rating as follows:

Habitat quality = combined habitat capability rating + salmon rating.

Combined habitat capability rating results (used above) combine capability ratings for the proportion of all bear habitat (capability 1-5) and the best bear habitat (capability 1-3). See Table 37 below.

Table 37. Combined habitat capability rating for grizzly bear.

Capability 1-3	Capability 1-5		
	Low	Mod	High
Low	L	L	M
Mod	L	M	H
High	M	H	H

Salmon ratings are given numerical values of: not rated =0, high=1, very high=2.

Hazard rating – combines the four indicators as follows:

Combined hazard rating = average of : a) effective habitat: classes 1 to 5, b)effective habitat: classes 1 to 3, c)secure core: classes 1 to 5 and d)secure core: classes 1 to 3)

Mitigation rating – combines the two indicators as follows**:**

Combined mitigation rating = average of: a) habitat protected: classes 1 to 5 and b) habitat protected: classes 1 to 3.

Evaluation of the grizzly bear assessment:

Strengths

- Broad-scale grizzly bear habitat capability mapping used in the analysis was done by a provincial expert with input from local biologists.
- Sockeye salmon inputs based on a decade of detailed quantitative data from the Department of Fisheries and Oceans for the Quesnel system was used to locate assessment units with significant inputs of salmon resources available to bears.
- Land use designations which contribute to the mitigation ratings are legally established and so have a significant degree of security, and clear definitions of management objectives.

Limitations

- Sockeye salmon ratings outside of the Quesnel watershed are based on qualitative knowledge of federal fisheries staff rather than quantitative estimates of spawning numbers. Chinook salmon locations and ratings were also based on qualitative information.
- Location of concentrated protein sources, other than sockeye and Chinook salmon, are not considered.
- Capability mapping does not incorporate the presence of significant concentrations of salmon available to bears. This means that the effectiveness and secure core hazard indicators have not integrated the habitat quality effects of the salmon inputs.
- Effectiveness assessments do not directly account for cattle ranching operations or density of recreational use, which are known to affect habitat displacement and mortality risk and therefore affect habitat effectiveness. In the assessment, road density serves as a surrogate for all of these sources of potential displacement and mortality risk.
- More work to identify important grizzly bear movement corridors could add another dimension to the assessment of habitat importance.
- A more complex roads model could be used to fine tune hazard assessments, but would not likely result in significant changes to broad-scale assessment results.

Marten risk summary

Marten occupy forests with higher levels of structural complexity. In the Cariboo-Chilcotin these forests are primarily mature and older forests. In the dry parts of the region, their highest capability habitat is found in moister forest sites near water. High-capability habitat is more widespread in parts of the region with a moister climate. Patch size, distribution and connectivity of mature/old conifer stands are important for marten. Habitat consisting of well-connected patches of moderate/high capability habitat within a matrix of poorer habitat can provide viable territories for marten, but research shows that home ranges with greater than 25% to 30% clearcut area are not used by marten (Hargis et al. 1998, Chapin et al. 1998).

Recent 1:40,000 scale mapping was used to define habitat capability for marten. A simple model based on forest age and type was used to define currently suitable habitat. Reductions in suitable habitat as a result of forest harvesting were calculated by comparing the current landscape with a simple reconstruction of an undeveloped landscape. Reductions in habitat effectiveness were modelled for suitable habitat within 200m of a paved or main gravel road.

The marten risk summary includes two sections. The first provides the results of the broad-scale cumulative effects assessment. The second provides more detailed information on the indicators. The appendix includes additional background information and analysis details.

Marten broad-scale assessment

Table 38 summarizes indicators used to assess the ecological importance, hazards and current mitigation. Table 39 provides overview results, while Tables 40 and 41 give more details of the assessment.

The following maps display relevant information including some of the factors used in the assessment:

- Figure 2 is a Bing satellite image showing the general topography and land cover.
- Figure 4 shows the no-harvest and modified harvest areas designated by the Cariboo-Chilcotin Land Use Plan.
- Map 6 shows location of recent wildfires and high stand mortality from mountain pine beetle.
- Map 10 indicates current suitable marten habitat colour colour-coded for road disturbance. Background colours show winter capability ratings.
- Map 13 shows the location of paved, gravel and undefined roads.

Table 38. Summary of the indicators used to assess marten habitat

Indicator type	Attribute evaluated	Indicator
Ecological importance	Potential marten winter habitat	% marten habitat (moderate + high capability)
		% marten habitat (high capability)
Hazards	Forest harvesting impact	% reduced habitat in M+H
		% reduced habitat in high
	Road impacts	% disturbed habitat in M+H
Current mitigation	Protection resulting from CCLUP modified harvest areas	% NH plus modified in M+H
		% NH plus modified in high

Table 39. Summary of the risk components for marten habitat.

Colours reflect the appropriate level of management concern: Very High, High, Moderate, Low, Very Low. Note that colours for current mitigation are reversed. For example, if the mitigation level is very high, the colour is dark green indicating a very low level of concern.

Assessment unit	Ecological importance	Hazard	Current mitigation
Bidwell/Lava	**M**	**M**	**L**
Chilanko	**M**	**L**	**L**
Ottarasko	**H**	**VL**	**VH**
Puntzi	**M**	**M**	**L**
Pyper	**M**	**M**	**L**
Tatla/Little Eagle	**M**	**L**	**VL**
Upper Tatlayoko	**M**	**VL**	**L**
Westbranch	**M**	**VL**	**H**

Table 40. Summary of risk components by landscape unit and subunit for marten and including natural disturbance information.

Assessment unit	Ecological importance	Hazard	Current mitigation	% Crown forest stand mortality >= 50%	% Crown forest burned since 1999
Bidwell/Lava_A	M	M	VL	3	12
Bidwell/Lava_B	M	M	L	4	9
Bidwell/Lava_C	M	VL	M	4	1
Bidwell/Lava	**M**	**M**	**L**	**4**	**8**
Chilanko_A	M	VL	L	21	0
Chilanko_B	M	M	VL	21	0
Chilanko	**M**	**L**	**L**	**21**	**0**
Ottarasko_A	H	VL	VH	0	0
Ottarasko_B	M	VL	VH	0	0
Ottarasko	**H**	**VL**	**VH**	**0**	**0**
Puntzi_A	M	M	L	21	0
Puntzi_B	M	L	L	20	0
Puntzi	**M**	**M**	**L**	**20**	**0**
Pyper_A	M	M	L	32	78
Pyper_B	M	H	L	14	9
Pyper_C	M	M	M	38	0
Pyper	**M**	**M**	**L**	**22**	**26**
Tatla/Little Eagle_A	M	L	VL	19	0
Tatla/Little Eagle_B	M	L	VL	8	6
Tatla/Little Eagle_C	M	L	VL	12	0
Tatla/Little Eagle	**M**	**L**	**VL**	**12**	**3**
Upper Tatlayoko_A	M	VL	H	6	0
Upper Tatlayoko_B	M	L	VL	10	0
Upper Tatlayoko	**M**	**VL**	**L**	**8**	**0**
Westbranch_A	H	VL	M	3	0
Westbranch_B	M	VL	H	7	0
Westbranch	**M**	**VL**	**H**	**5**	**0**

Table 41. Summary of data and rating for individual indicators and the three indicator types.

Assessment unit	Ecological importance: Marten habitat (%) M+H	Ecological importance: Marten habitat (%) High	Ecological importance: Rating	Hazard: Habitat reduced (%) M+H	Hazard: Habitat reduced (%) High	Hazard: Disturbed by road (%) M+H	Hazard: Rating	Current mitigation: % Modified plus no-harvest protection M+H	Current mitigation: % Modified plus no-harvest protection High	Current mitigation: Rating
Bidwell/Lava_A	99	20	M	20	21	7	M	10	12	VL
Bidwell/Lava_B	99	22	M	21	19	10	M	23	11	L
Bidwell/Lava_C	97	14	M	3	6	5	VL	39	48	M
Bidwell/Lava	**99**	**19**	**M**	**17**	**18**	**7**	**M**	**21**	**17**	**L**
Chilanko_A	99	17	M	5	4	10	VL	10	21	L
Chilanko_B	99	17	M	11	13	13	M	9	11	VL
Chilanko	**99**	**17**	**M**	**8**	**8**	**11**	**L**	**10**	**17**	**L**
Ottarasko_A	95	39	H	0	0	0	VL	100	100	VH
Ottarasko_B	93	26	M	0	0	0	VL	100	100	VH
Ottarasko	**95**	**34**	**H**	**0**	**0**	**0**	**VL**	**100**	**100**	**VH**
Puntzi_A	99	22	M	21	25	10	M	20	16	L
Puntzi_B	99	25	M	7	5	9	L	20	23	L
Puntzi	**99**	**24**	**M**	**14**	**14**	**10**	**M**	**20**	**20**	**L**
Pyper_A	84	14	M	17	23	7	M	23	14	L
Pyper_B	96	17	M	30	28	10	H	21	17	L
Pyper_C	98	14	M	17	19	12	M	33	46	M
Pyper	**93**	**16**	**M**	**24**	**26**	**10**	**M**	**24**	**22**	**L**

Assessment unit	Ecological importance				Hazard					Current mitigation		
	Marten habitat (%)				Habitat reduced (%)		Disturbed by road (%)			% Modified plus no-harvest protection		
	M+H	High	Rating		M+H	High	M+H	Rating		M+H	High	Rating
Tatla/Little Eagle_A	100	14	M		9	8	9	L		12	14	VL
Tatla/Little Eagle_B	99	22	M		11	11	15	L		7	5	VL
Tatla/Little Eagle_C	99	16	M		7	10	7	L		12	12	VL
Tatla/Little Eagle	**99**	**18**	**M**		**9**	**10**	**11**	**L**		**10**	**8**	**VL**
Upper Tatlayoko_A	96	12	M		1	2	2	VL		46	61	H
Upper Tatlayoko_B	98	19	M		7	7	10	L		10	13	VL
Upper Tatlayoko	**97**	**16**	**M**		**4**	**5**	**6**	**VL**		**28**	**29**	**L**
Westbranch_A	97	32	H		2	4	4	VL		57	58	M
Westbranch_B	98	11	M		2	4	3	VL		68	62	H
Westbranch	**97**	**22**	**M**		**2**	**4**	**3**	**VL**		**62**	**59**	**H**

Notes and highlights of marten broad-scale assessment:

- The quality of the assessment is greatly improved by the inclusion of the recently completed habitat capability information.
- These hazard assessments do not include natural disturbance. Intense fires would significantly degrade marten habitat. High bark beetle mortality can also reduce habitat suitability but not as strongly as intense forest fire. Numerical assessments of the overlaps with mountain pine beetle mortality are included in Table 39 and shown on Map 6.
- Hazards are very low to moderate throughout most of the study area. Exceptions include the **Pyper** landscape unit where higher ratings have resulted from a higher level of forest harvesting.
- The current hazard in **Pyper** is also significantly increased as a result of extensive stand mortality from bark beetle and wildfire. Recent wildfire has impacted 78% of the Crown forest in the **Pyper A** subunit.
- Ecological importance was moderate across the whole study area with the exception of the **Ottarasko** landscape unit, and the **Westbranch A** subunit which had greater proportions of high capability habitat resulting in high importance ratings. Very little of the forested land is classified as low capability habitat.
- High levels of mitigation are currently in place for marten habitat in the **Westbranch** and **Ottarasko** landscape units and the upper **Tatlayoko A** subunit.

Marten indicators

Table 42. Description of marten habitat indicators

Indicator	Measurement	Comments
% marten habitat	Percentage of the total marten habitat in the assessment unit mapped as moderate or better marten winter habitat: (classes 1-3/classes 1-5) as a %.	Based on 2012 1:40,000 scale marten capability mapping. Low and very low capability (classes 1+2) marten habitat was excluded from the analysis based on input about habitat quality from mapping expert Tony Button.
% high-capability habitat	Percentage of the total marten winter habitat classified as high capability: (classes 1 and 2/classes 1 to 5) as a %.	
% reduced habitat in moderate and better capability	Percentage change in modelled marten habitat overlapping moderate and high capability between undeveloped and current landscape.	This is an indicator of the change in the amount of marten habitat as a result of forest harvesting to date.
% reduced habitat in high capability	Percentage change in modelled marten habitat overlapping high capability between undeveloped and current landscape.	

Indicator	Measurement	Comments
% disturbed habitat in moderate and better capability	Percentage of the current modelled marten habitat in moderate or better winter capability that is within 200m of a paved or gravel road.	This analysis includes paved and gravel roads as defined in the Vegetation Resources Inventory. It does not include the many small roads and in block roads referred to as undefined in the Digital Road Atlas.
% No-harvest plus modified harvest in moderate and better capability	Percentage of the modelled marten habitat in moderate and high capability areas that is overlapped by no-harvest and selected modified harvest land use designations.	No-harvest designations in the analysis include: Parks, protected areas, goal 2 protected areas, permanent old growth management areas, caribou no-harvest areas, and riparian reserves around streams wetlands and lakes. The modified harvest designations selected for this analysis are ones which leave significant forest structure on the site over time. They include mule deer winter ranges, special harvest areas for caribou, trail management zones, and areas designated to meet visual quality objectives of preservation, retention and partial retention.
% No-harvest plus modified harvest in High Capability	Percentage of the modelled marten habitat in high capability areas that is overlapped by no-harvest and selected modified harvest land use designations.	

Table 43. Weighting factors used for marten indicators.

Indicator type	Attribute evaluated	Indicator	Indicator weight
Ecological importance	Abundance of capable marten habitat	% Moderate-high capability marten habitat	0.8
		% high capability marten habitat	1.2
Hazards*	Forest harvesting impacts to suitable habitat	% reduced habitat (M+H capability)	1.3
		% reduced habitat (High capability)	1.3
	Road impacts to suitable habitat	% habitat disturbed by roads	0.4

*Forest harvesting impacts were weighted much higher than road impacts based on discussions of the relative importance of the two types of impacts with furbearer biologist Larry Davis.

Table 44. Classification of indicators used for assessment of marten habitat.

Indicators	Very low (1)	Low (2)	Moderate (3)	High (4)	Very high (5)
Ecological importance					
% M+H capability as a percentage of total area	0-20	21-50	51-80	81-90	91-100
High capability as % of M+H	0-10	11-30	31-60	61-80	81-100
Hazard					
% reduced habitat (M+H)	0-6	7-12	13-24	25-35	36+
% reduced habitat (high)	0-6	7-12	13-24	25-35	36+
% road disturbance(M+H)	0-6	7-12	13-24	25-35	36+
Current mitigation					
% no harvest plus modified (M+H)	0-15	16-30	31-60	61-80	>80
% no harvest plus modified (high)	0-15	16-30	31-60	61-80	>80

Calculation of component ratings

The ratings provided for ecological importance, current hazard and current mitigation are each composite ratings derived from multiple indicators. The steps in calculating the ratings are:

- Apply the classification ranges in Table 44 to determine the rating for each indicator
- Apply indicator weightings from Table 43.
- Average the individual indicator ratings that make up each component. Round composite ratings to the nearest whole number.

Strengths and limitations of the marten assessment:

Strengths

- Many research studies of marten habitat use are available including two from the Cariboo-Chilcotin. Information from these was used to develop the model.
- Advice from two marten experts was used to define forest ages for high and moderate habitat suitability, and how it would change between ecosystems with different levels of productivity.
- New habitat capability (2012) mapping was incorporated into the analysis. This information allowed indicator assessments to be focussed on the highest capability habitat.
- The land use designations which contribute to the mitigation ratings are legally established and so have a significant degree of security and clear definitions of management objectives.
- Detailed peer review by a local furbearer expert has strengthened our understanding of the model and its outputs.

Limitations

- Reliability of several aspects of the assessment is limited by the accuracy, currency and polygon size limitations of forest inventory data for forest age, forest species, logging and roads. Throughout much of the province, keeping forest inventory data up to date can be a challenge, especially in the interior where large-scale natural disturbances such as mountain pine beetle, Douglas-fir bark beetle and wildfires are occurring on an increasingly regular basis. The ministry has inventory projects underway that will improve the forest inventory data in the area covered by this report, and in the overall Cariboo-Chilcotin area. As the data improve, reanalysis may be warranted.
- Natural disturbance was provided as a numerical summary but was not incorporated into the assessment ratings.
- The reduced habitat hazard indicator provides a valuable, spatially explicit assessment of current habitat but it does not explicitly reflect historic natural disturbance processes. Because of nature of the reference condition, the indicator does not completely reflect the difference between the current landscape and a naturally disturbed landscape condition. However, since the same methodology is applied across the region the relative differences in indicator values are meaningful and can be rated to meaningfully estimate relative habitat change across the region.
- The assessment uses a relatively simple model for habitat suitability which does not assess spatial distribution and connectivity of habitat. Adding a meaningful spatial component would improve the model's evaluation of habitat suitability. One

potential would be to assess the proportion of unsuitable early seral habitat in grid squares of a meaningful size for marten in relation to levels recommended in the literature.

- Current road classification in the digital road data is very coarse and classifies all roads into three classes: paved, gravel and undefined. The undefined class includes many roads to and through cutblocks that are relatively large and well-travelled. Because of the coarseness of the road classification, these roads were excluded from the moose and marten analyses when ideally they would have been included. Future road classifications should allow for a more refined treatment of roads.

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Appendix 1: Forest biodiversity

Landscape-level forest biodiversity is used in this assessment to measure the overall risks to forested land and all of the organisms that live on it. The biodiversity assessment is often described as a "coarse filter" because if the overall condition of the forest land is more or less similar to the landscape created by natural disturbance, then a majority of the native species and ecosystems should be maintained. The biodiversity assessment included here is limited by the fact that it only applies to forested lands, and that important factors such as roads, rare and sensitive ecosystems, invasive species and climate change are not included.

Hazard assessment

The assessment of hazard to forest biodiversity includes the factors of seral condition and the spatial distribution of mature and old forest. Seral condition represents the abundance and distribution of the developmental stages of forest ecosystems. The indicator of seral condition used in this assessment is age as described in the Biodiversity Guidebook (1995). Seral categories include: early, mid and mature plus old. Seral assessments are applied to NDT-BEC units as described in the Biodiversity Conservation Strategy for the CCLUP (1996).

Forest seral condition provides an indicator for a broad spectrum of forest dependent wildlife species. Although each individual species has its own particular key habitat requisites, assessment of seral representation and patch size distribution contributes to understanding general wildlife risks at the ecosystem level.

In the Cariboo Region an assessment of seral condition is done every few years, for all landscape units, based on the most up-to-date vegetation information. Patch size is assessed about every five years with the last review being 2007. Changes from year to year reflect logging, natural disturbance and aging of forest stands. Changes in seral condition related to recent natural disturbances, including wildfire and bark beetle, is not included unless the vegetation inventory reflects a revised, post-disturbance age. This results in an over-estimation of mature plus old forests in some areas. Methodology to incorporate this disturbance into the analysis will be considered for future assessments.

Where forest biodiversity assessment units are small they have been amalgamated to make larger assessment units that provide a more valid assessment of seral distribution. The goal is to provide assessment units generally of 5000 ha or greater. A relatively small number of assessment units between 1000 ha and 5000 ha are included to assess valley bottom units where amalgamation would result in a losing the ability to track seral distribution in these very ecologically significant topographic positions. The issue of assessment unit size is discussed on pages 42-46 of the 1996 Biodiversity Conservation Strategy for the Cariboo-Chilcotin. The seral composition and area-based targets for each of the components of an amalgamated unit are calculated before amalgamation and then combined in order to accurately reflect the contribution of each component in the resultant combined results and targets.

The current seral condition is compared to the modelled average seral distribution used as a basis for the 1996 Biodiversity Guidebook. The average seral condition is derived by applying the simple negative exponential model which assumes disturbance is spatially random, with no increase in hazard with stand age. This allows the estimation of the average percent area above a given age as exp(-a/b) where 'a' is age of interest, and 'b' is the mean return interval of stand destroying disturbances. The mean return intervals were taken directly from the Biodiversity Guidebook for all BEC units except in the IDF where the natural disturbance was calibrated using local data as described in the 1996 CCLUP Biodiversity Strategy. This strategy described how the Interior Douglas-fir was divided into the Douglas-fir group and the lodgepole pine group.

The concept of the range of natural variability (RNV) is commonly used to evaluate and describe the natural variation in the seral condition of forested landscapes through time (Delong. 2011 and 2007, Wong and Iverson. 2004, Landres, et.al. 1999). The Cariboo-Chilcotin cumulative effects assessment uses this concept in the rating of seral condition. RNV estimates from Table 3 of Delong 2011 for age classes >140 years and <40 years range from +/-4% to +/- 13% of the forested landscape for a group of natural disturbance units with broadly similar natural disturbance regimes to the NDTs 1, 2 and 3 in the Cariboo-Chilcotin. Delong's work does not include ecosystems in NDT 4 such as the Interior Douglas-fir and Bunchgrass ecosystems. For ease of application and because the range in estimates was relatively small, we chose to use a single estimate of RNV to represent all of the ecosystems for the current iteration of the assessment. A RNV value of 10% of the forested landscape was used for all ecosystems. A provincial group of forest and wildlife ecology experts will be reviewing biodiversity indicators, reference conditions and ecological benchmarks over the next year to provide consistent provincial direction and may recommend changes to this approach.

The divergence of the current seral state from the reference average natural condition was calibrated in terms of units of RNV. Assessment units within one RNV of the reference condition were given a low hazard rating. Ratings were increased or decreased by one classification for each additional RNV unit of divergence from the reference condition as show in Table 6 in the Forest Biodiversity Risk Summary. Refinements could be easily made in this approach to more specifically fine tune it to individual disturbance types, but for this broad-scale assessment a more generalized approach is currently being used.

Note also that the assessment system rates very high proportions of mature plus old seral and very low proportions of early seral as very low management concern. The current management regime on most forest lands in the region reduces mature and old seral and increases early seral compared to reference conditions. Therefore, the major landscape conditions usually requiring attention are areas with too little mature plus old or too much early. In management of areas such as protected areas, that have minimal forest harvesting but still control wildfire, it may also be useful to assess the potential impacts of too little forest disturbance.

Patch size and interior forest distribution will also be assessed. The emphasis of the assessment is on the availability of large patches of mature and old forest since forest development tends to reduce both of these. Methodology for this assessment is found in Cariboo-Chilcotin Biodiversity Strategy Committee. 2001. UPDATE NOTE #4: An Approach for Patch Size Assessments in the Cariboo Forest Region.

<u>Ecological importance assessment</u>

Conservation priority ratings were developed for all landscape units in the region as part of the process of assigning Biodiversity Emphasis Options as required to implement the region's Biodiversity Conservation Strategy.

The 1996 Biodiversity Conservation Strategy for the CCLUP (pages 15 to 18) set out ratings to be used to determine ecological importance for landscape units in the current Forest Biodiversity Cumulative Effects Assessment, as follows:

"*The first step in allocating interim biodiversity emphasis options to landscape units was to assign a conservation priority rating, from 1 to 10, to each landscape unit based on three primary criteria. These criteria are indices of the relative biodiversity attributes of the unit. The primary criteria for assigning a conservation priority to each landscape unit are ecosystem representation, presence of known threatened or endangered species and sensitivity to forest development.*

1. Ecosystem representation
Several factors are included within the overall ecosystem representation criterion. These factors are:

a) Representation in protected areas.
Habitat representation in protected areas is an important component of a strategy to maintain regional biodiversity. Biogeoclimatic units with a lower degree of representation in protected areas require greater attention in the managed landscape to maintain regional biodiversity.

***Biogeoclimatic subzones** within each landscape unit were assessed according to the proportion of that subzone currently in protected areas within the CCLUP region (Appendix 2). In some cases, biogeoclimatic subzones that are ecologically similar were combined prior to determining the proportion within protected areas. Where representation in protected areas is low (less than or equal to 5%) the need for representation is considered high. Where representation is high (greater than 10%) the need is considered low. Representation between these two extremes is considered moderate.*

b) Diversity of biogeoclimatic units (variant) and habitat types.

Landscape units containing a diverse mosaic of habitats will support a greater diversity of species than relatively uniform units. The number of biogeoclimatic (BGC) variants within a landscape unit is an indicator of relative climatic and broad level ecosystem diversity within a landscape unit. This broad level assessment of diversity is further developed by assessing the relative variety of habitat types across the entire landscape unit. The combination of the broad level and more detailed assessments were used to derive a diversity rating for each landscape unit according to the following relationship as shown in table 3. Only biogeoclimatic variants larger than 1000 ha were counted in this assessment.

Table 3. Definition of diversity ratings for landscape unit.

BGC Variants and Habitat Diversity	***Diversity Rating***
One BGC variant and low or moderate habitat diversity.	*Low*
One or two BGC variants and high habitat diversity ***or*** *Three BGC variants and low or moderate habitat diversity.*	*Moderate*
Three BGC variants and high habitat diversity ***or*** *Four or more BGC variants.*	*High*

*Habitat diversity was visually estimated from forest inventory maps and satellite imagery and assessed relative to other areas of the region. The diversity rating is then combined with the biogeoclimatic subzone representation need according to the relationship in the following table to arrive at the overall **ecosystem representation rating** (Table 4).*

Table 4. Overall ecosystem representation rating.

Representation Need		Ecosystem Diversity		
% of Total Area with Moderate or High Need	% of Total Area with High Need	LOW	MODERATE	HIGH
<25	<15 15-25	Low Low	Low Low	Low Intermediate
25-50	<25 25 or more	Low Intermediate	Intermediate Intermediate	Intermediate High
>50	<25 25 or more	Intermediate High	High High	High High

2. Presence of threatened and endangered species

Some threatened or endangered species (blue and red listed species) are more sensitive to intensive forestry development than others. Those that are easily displaced by road development or require old forest or landscapes with low fragmentation will be most affected. Red and blue listed species found in the Cariboo Forest Region that have life requisites likely to be significantly affected by forest development at the landscape level include: grizzly bear, eastern caribou, flammulated owl and some forest dwelling bats. Western caribou are a provincially significant herd but are not blue listed at this time. Landscape units were classified as having or not having importance to these species based on the extent and quality of habitat available and the relative importance of the landscape unit to the species in question. Many other species have dependencies on attributes such as old forest but proper stand level management such as riparian and wildlife tree protection and recommendations from the Managing Identified Wildlife Guidebook were assumed to meet their needs.

3. Sensitivity to forest development

Even when the biodiversity guidebook recommendations are fully applied, forestry development inevitably changes natural landscape attributes including patch size, amount and pattern of connectivity, seral stage distribution and amount of interior forest. The degree of change from natural landscape attributes resulting from forestry development is different in different natural disturbance types. Those landscapes which are more changed by development have a higher degree of risk to biodiversity and thus a higher sensitivity to development. The forested natural disturbance types used in the biodiversity guidelines can be ranked in order of this type of sensitivity to development as follows: NDTs 1 and 2 (highly sensitive), NDT 4 (moderately sensitive) and NDT 3 (least sensitive).

Biodiversity conservation rating

Ecosystem representation, presence of threatened or endangered species, and ecosystem sensitivity to disturbance were combined into an overall conservation priority rating through use of a decision tree (Figure 2). The conservation rating is relative, not absolute, and is useful only for helping to discriminate between groups of units with respect to emphasis. The conservation priority ranges from 1 to 10 (10 being the highest conservation priority). The decision tree used to determine the conservation priority is dynamic, meaning that different pathways through the tree can lead to the same conservation priority and that the relative weighting given to a criterion is dependent upon the condition of the other criteria in that landscape unit. This allows the relative weighting of any criterion to change as extreme conditions for that criterion are approached."

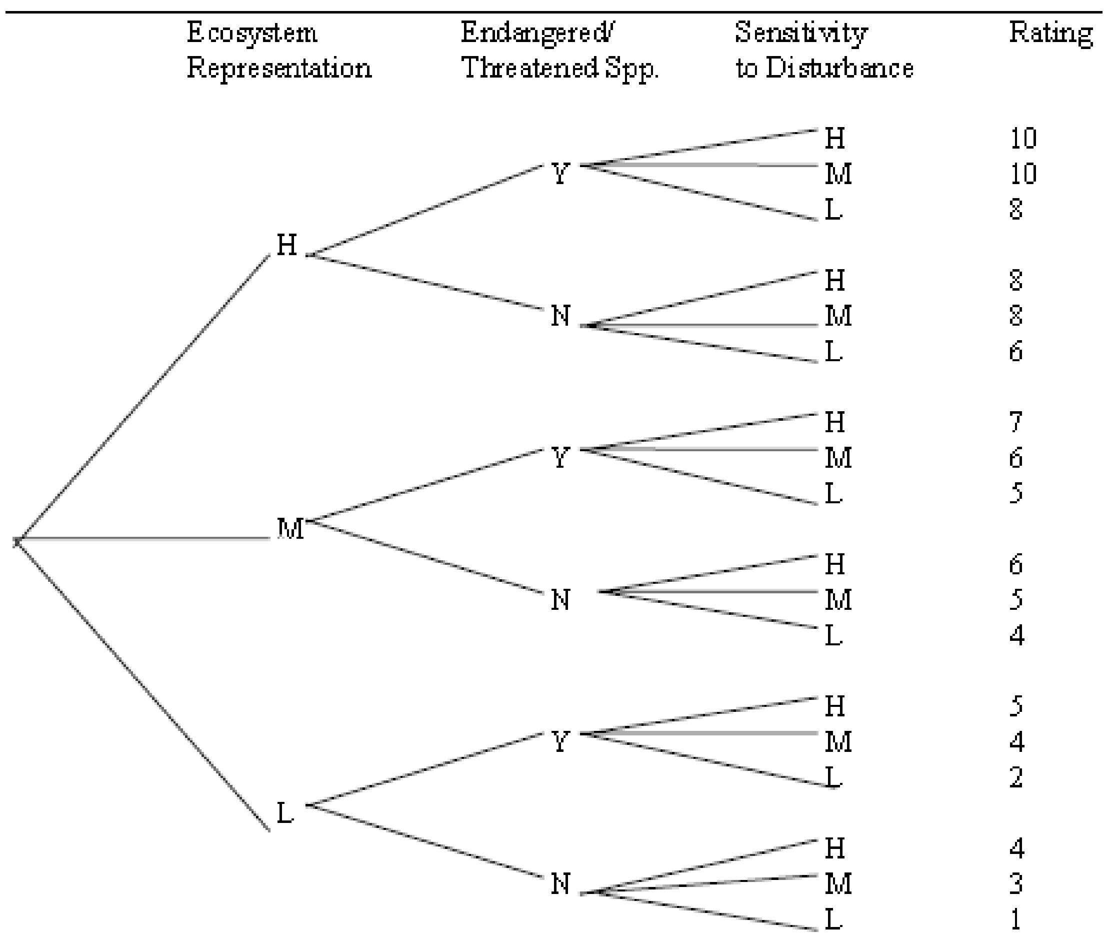


Figure 2. Decision tree used to determine landscape unit conservation rating from the three primary emphasis criteria

Appendix 2: Hydrology

The appendix includes:

- Description of the delineation of assessment unit boundaries;
- Detailed flow diagrams of the assessment variables used for the hydrological assessment;
- A version 2 report in two sections describing the updated assessment process for hydrological stability (1st section dated Oct, 2012, 2nd section date March 2013); and
- Fish value rating tables.

Delineation of hydrological assessment units

The following text and figure developed by Doug Lewis describes how six scales of watershed units were delineated for the original study on which the assessments documented in this report are based. Of these six scales only three (watersheds, basins and sub-basins) are included in this version of the Cariboo-Chilcotin cumulative effects assessment in order to simplify the results and provide scales that are the most useful for cumulative effects assessments. Future assessments could consider the potential value of including other units.

Assessment units

"We used BC Freshwater Atlas (FWA) 1:20,000 Watershed Assessment Unit (AU) boundaries (Carver and Gray, 2010) as the base units to build a hierarchical watershed structure for analysis and reporting hazard ratings. The hierarchical watershed structure consists of Super Watersheds, Large Watersheds, Watersheds, Basins, Sub-Basins and Residual Units, hereafter collectively referred to as Catchment Units. The levels in the Catchment Unit hierarchy were determined by using the 1:20,000 FWA stream network, with streams ranked by stream order to identify major drainage networks that flow into key systems (e.g., Thompson or Fraser Rivers) in each Assessment Area. Starting with the largest drainages in each Assessment Area, Super and Large Watersheds were delineated by amalgamating FWA AUs (Fig. H Append 1: A and B). This process continued down the hierarchy to delineate Watersheds, Basins and Sub-Basins (Fig. H Append 1: C, D and E). Once all of the true catchment units (defined as areas that drain down to a single point) are delineated, the remaining areas along major river systems or lakes are identified as residual areas (Fig. H Append 1: F). In some sub-basins, the smallest unit in the hierarchy that equate to individual FWA AUs, where the FWA AUs do not capture all tributaries of similar size, AUs were split along heights of land using 1:20,000 Terrestrial Resource Inventory Mapping (TRIM) contours to digitize new Sub-basin boundaries. Areas outside the revised Sub-basin boundary were assigned as residual units. Catchment units are named using gazetted names from the FWA AU file, or are assigned a name that suggests its general location (e.g., Upper Criss Creek basin resides in the upper portion of the Criss Creek watershed)."

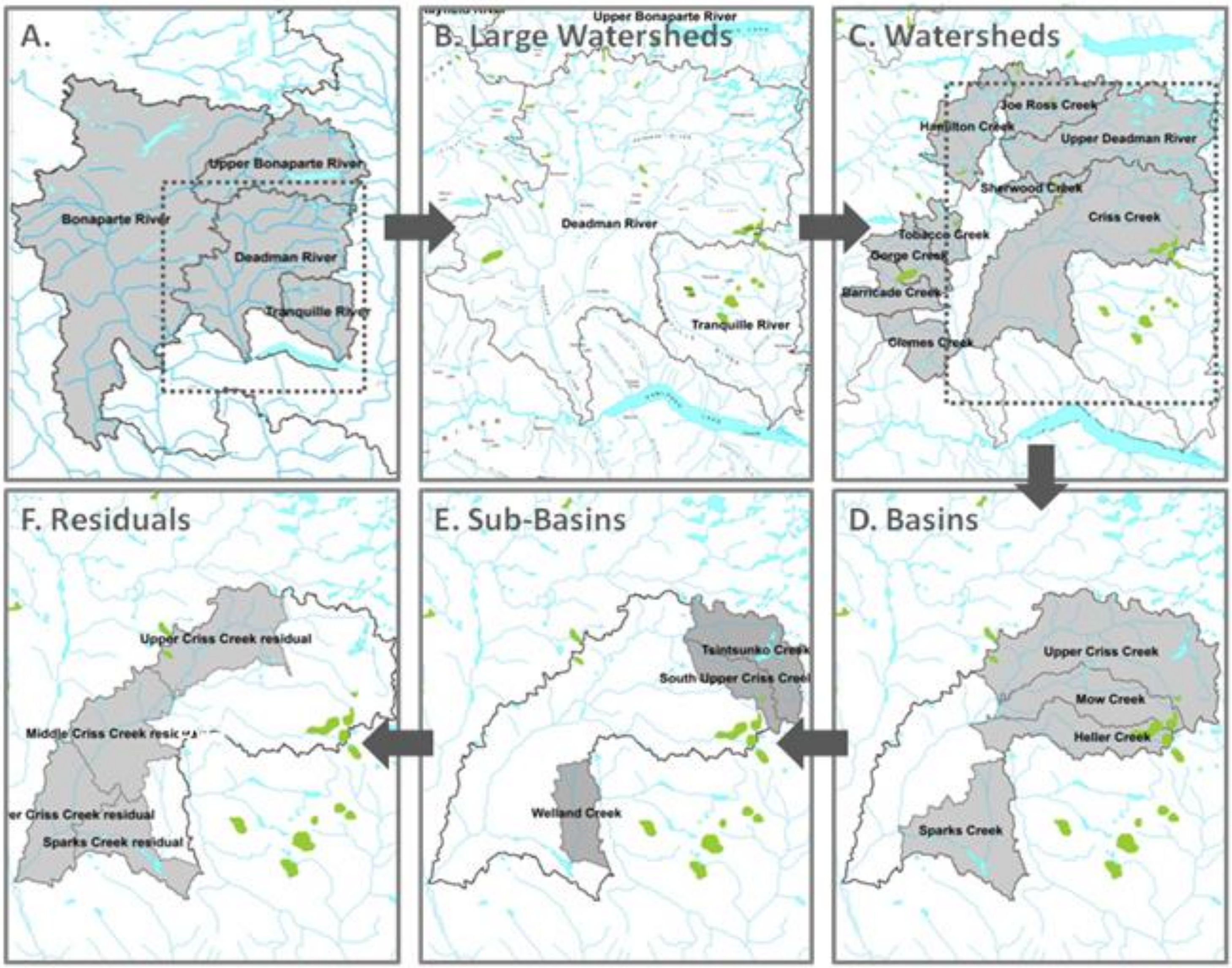
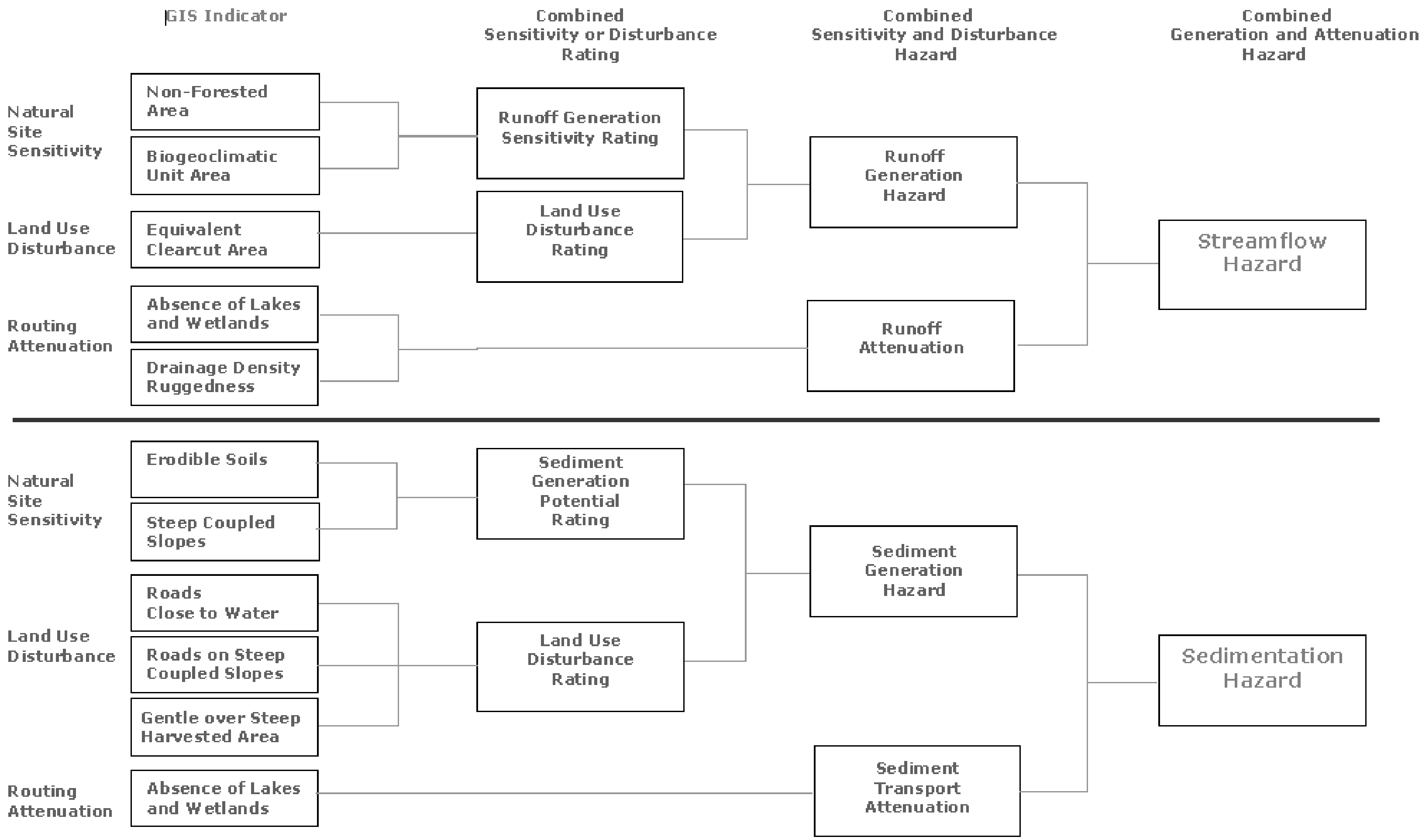


Fig. H Append 1. A.) Several large drainages (5th order or greater) that flow into the Thompson River west of Kamloops, BC, in the Kamloops Assessment Area. B) The 6th order Deadman River Large Watershed. C) Watersheds within the Deadman River Large Watershed. D) Basins within the Criss Creek Watershed, southeast portion of Deadman River Large Watershed. E) Sub-basins. And F) Residual Units within the Criss Creek watershed.

Detailed flow diagrams of variables used in the hydrological assessment

These diagrams are useful to refer to when interpreting detailed assessment tables for stream flow and sedimentation hazard. Note that the "stream flow sensitivity indicator" used in assessment tables combines the ratings for Runoff Generation Sensitivity and Runoff Attenuation. The "sedimentation sensitivity indicator" combines ratings for sediment generation potential and sediment transport attenuation.



A GIS-based Method for Describing Hydrologic Sensitivity and Hazards for use in Risk Assessments Associated with the Cumulative Effects on Water-Related Values in Individual Watersheds

D. Lewis, M. Milne, B. Grainger – Version 2 October, 2012

Stream Flow Hazard

Executive summary

The approach described herein focuses on the use of GIS-based indicators to characterize the effect of local climate, watershed topography, forest canopy cover and disturbance on streamflow. The approach is intended to be applied across multiple catchment units at a regional-sub-regional level to assist resource management practitioners to; 1) identify factors contributing to sensitivity and hazard and catchments that may be more sensitive to resource activities, and 2) guide further detailed assessments in those catchments with increased sensitivity and hazard. It is not intended to replace field -based assessments by qualified professionals that are recommended to confirm/deny hazard and risk.

Confidence

We have a high level of confidence that the approach and indicators used herein represent key hydrologic processes and watershed characteristics that strongly influence amount and timing of streamflow. Our level of confidence in these indicators is based on extensive published scientific literature, practical application of these measures by qualified professionals throughout the study area over the last two decades, and personal field experience and judgment applied in many of the example watersheds and other watersheds. These sources of information helped calibrate the breakpoints between scores for individual indicators used in this procedure.

Certainty

Despite a high level of confidence in the indicators and approach used herein, we have only a moderate level of certainty that the hazard ratings reflect the hazard that may truly exist on the ground at any given time. This uncertainty is based on several factors; some of which are due to complex interactions between weather and biophysical environment that cannot be accounted for in the approach and others that are limited by the availability of GIS data and require field-based review by a qualified professional. While we feel strongly this approach provides a reasonable approximation of hazard, these factors may alter a hazard rating up or down one-hazard rating in a particular catchment. Factors that contribute to this uncertainty include:

- Channel Sensitivity. A channels capacity to withstand depends on morphology and the extent of previous disturbances or alterations, (ref).

- Synchronization and De-synchronization of flows. Slope, aspect and the elevation and aspect of disturbance can affect the timing that runoff is delivered (Winkler et al. 2008, Winkler et al. 2010a).

- Effects of form of precipitation and antecedent conditions on hydrologic response (Winkler et al. 2010a). Form of precipitation refers to the timing, extent, intensity, duration and type (i.e., snow vs. rain), while antecedent conditions refer to forest canopy, forest floor and soil conditions prior to when new precipitation or snowmelt occurs. Complex interactions between both influence the interception and sublimation rates of forest vegetation and soil saturation and infiltration rates which all affect how rapidly new runoff is delivered.

Streamflow sensitivity and hazard

In this approach, the term streamflow refers to water flowing in, or discharging from, a natural surface stream (Winkler et al. 2010a). The term 'streamflow sensitivity' refers to how responsive or readily affected streamflow in a particular catchment is to land use activities and natural disturbances. Because the streamflow regime in B.C. is so heavily influenced by the interaction of climate and topography (Moore et al. 2010, Eaton and Moore 2010), streamflow sensitivity is a function of: 1) how much precipitation reaches the ground and is available for runoff, referred to in this text as the process of Runoff Generation and 2) how efficiently runoff is stored or transferred downstream within a drainage basin, referred to here as Routing Efficiency.

Runoff generation sensitivity

Runoff refers to the portion of precipitation that moves from the land to surface water bodies, either as surface or subsurface flow (Pike et al. 2010).In this approach, the processes by which runoff is generated is represented by two factors that can be determined with available GIS data coverage in B.C.; 1) Climate, and in particular the precipitation regime as it affects annual runoff and spring freshet or peak flows and, 2) vegetation cover, which affects the amount of precipitation that reaches the ground and is available for runoff (Winkler et al. 2010a). In B.C., forests form the dominant vegetation cover influencing watershed water balances and runoff; therefore the term 'runoff generation sensitivity' is used here to refer to how responsive or readily affected the amount of runoff in a catchment is due to loss or alteration of the forest canopy. In this approach, climate change effects on the amount of runoff can only be captured through forest canopy loss or alteration that may result from changes in the frequency or magnitude of severe natural disturbances events (e.g., wildfire, insects). Changes in temperature and precipitation regimes influencing the amount of precipitation generated are considered beyond the scope of this approach.

The influence of both climate and the presence or absence and type of forest canopy on runoff generation sensitivity is represented by two indicators; 1) Biogeoclimatic (BEC) unit, a vegetation classification system used in B.C. that reflects climatic and topographical influence on vegetation cover (Meidinger and Pojar 1991) and 2) area of a catchment unit that is non-forested (Non-Forested Area) which recognizes that although non-forested area contributes to runoff, in non-forested areas there is no forest canopy to be affected by land use or disturbance. Therefore catchments with a large proportion of non-forested area are less sensitive to changes in runoff due to forest canopy loss or alteration (Winkler et al. 2010a).

In the study area, BEC units were scored from 0-3.0 at the subzone level, based on total amount of precipitation regime and a generalized assessment of forest canopy closure[6] (Appendix 1). Essentially, heavily forested catchments in areas with high amounts of precipitation produce 5-10X the annual runoff and 10-year peak flow levels compared to drier and less forested areas in the study area (see Coulson and Obedkoff 1998, Eaton and Moore 2010, maps S-1, S-2). Hence, these catchments are expected see the greatest change in runoff generated following forest canopy loss or alteration. To generate a BEC score for each catchment unit, an area-weighted score was derived based on the proportion of different BEC units in the catchment. A Non-Forested Area score was calculated based on the proportion (%) of non-forested area in each catchment unit using Vegetation Resources Inventory (VRI) forest cover information. Appendix 2-A and 2-B show the distribution of BEC scores and Non-Forested Area within the Cariboo Region, Kamloops and Merritt-South Okanagan TSA's respectively.

To produce a Runoff Generation Sensitivity Score for each catchment, the raw BEC zone and non-forested area indicator values were binned into three categories, assigned a score of 1-3, equally weighted, and summed in a matrix (Table 3). Non-forested area values were inversely scored to more heavily weigh catchments with more forest area, and hence more sensitivity to change in forest cover. Based on this matrix, a runoff generation sensitivity score is derived for each catchment ranging from 2-6. These scores were broken into 5

[6] For example, dry BEC zones such as the IDF or PP have, in general, more open forest canopies that have less influence on precipitation so would be scored lower. Alpine or Grassland BEC zones with little forest cover received scores of 0.

sensitivity ratings , Very Low (VL)=2, Low (L) = 3, Moderate (M)=4, High(H)=5, and Very High (VH) = 6.

		BEC Rank Score		
Proportion of Non-Forested Area		**<100 (1)**	**101-200 (2)**	**>200 (3)**
	<30 (3)	M(4)	H(5)	VH(6)
	31-70 (2)	L(3)	M(4)	H(5)
	>70 (1)	VL(2)	L(3)	M(4)

Table 3. Watershed unit Runoff Sensitivity ratings base on raw watershed unit scores for melt rank and proportion of non-forested areas.

When the Runoff Generation Sensitivity Score was applied to all the catchments in the study area, the highest proportion of catchments with High and Very High rated runoff generation sensitivity occurred in the Columbia Mountains, Columbia Highlands and catchments within the Fraser and Thompson Okanagan Plateau Ecoregions that form part of the wetter transition to the Highland and Mountainous Ecoregions (Map S-3). Moderate runoff sensitive catchments generally occurred throughout the Fraser and Thompson Okanagan Plateaus (generally more forested, but lower precipitation), whereas the only Low and Very Low occurred in the Interior Transition and Chilcotin Range Ecoregions (moderate to low precipitation but mainly non-forested).

Runoff generation hazard

Runoff Generation Hazard refers to the potential for harm or a harmful event resulting from increased runoff, in particular the potential for increased frequency of spring freshet or peak flow events. Runoff Generation Hazard is the product of Runoff Generation Sensitivity and the extent of human or natural disturbances that impact forest cover. At coarse scales applicable to this GIS-based approach, the extent of human and natural disturbance effects on the relative loss, alteration and recovery of hydrologic function of a forest canopy is commonly measured through the use of the metric equivalent clearcut area (ECA) (BC Ministry of Forests 2001, Lewis and Huggard 2010). ECA is used quantify the area within a catchment that has experienced forest canopy loss due to disturbance (the hydrologic equivalency of a recent clearcut). ECA values also net-down this total area by factoring in the relative hydrologic function contributed by residual forest canopy and forest-growth following a disturbance. As an indicator, ECA provides a useful quantification of both loss and recovery of hydrologic function in disturbed forest stands, with values based on extensive research documenting differences in snow accumulation, ablation and melt rates between clearcut openings, regenerating, mature and mountain pine beetle

(MPB) attacked forest canopies (see Winkler et al. 2010b, Winkler and Boon 2010 and Lewis and Huggard 2010 for reviews).

A large body of research links increased forest canopy loss (represented by higher ECA values) with increased peak flows, and hence with the potential for harm or a harmful event (i.e., flood) to occur (Alila and Beckers 2001, Alila and Beckers 2004, Alila et al 2007, Alila et al 2009, Cheng 1989, Forest Practices Board 2007b, Schnorbus and Alila 2004, Schnorbus 2005, Schnorbus et al 2010, Thyer et al 2004, Whitaker et al 2002a, and Whitaker et al. 2002b). In general, increased peak flow resulting from increased runoff are observed at ECA values > 30%, whereas significant changes are almost always observed at ECA levels> 50% (Winkler pers. comm). The ECA concept has been commonly applied to derive peak flow hazard indices used in watershed assessments in B.C. (B.C. Ministry of Forests 2001). In common practice, ECA values of 20-30% have been used to identify levels of forest canopy disturbance that are more likely to produce increased peak flows (IWAP, Grainger examples). In this approach, ECA levels in the range of 20-50% distinguish the transition from low (Unlikely) to moderate hazard (About as Likely as not) to High and Very High (Likely-Highly Likely) hazard ratings. Catchments more sensitive to changes in runoff are assumed to be more likely to experience an increase in the frequency of higher peak flow events at lower disturbance levels, whereas less sensitive catchments may not experience changes unless at higher ECA levels (Figure 7).

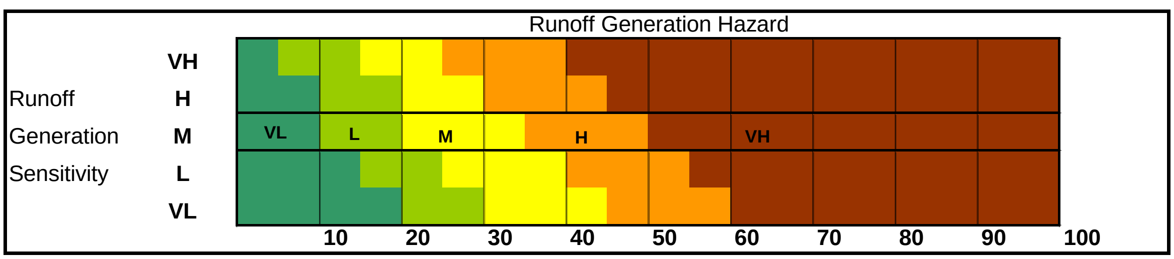


Figure 7. Runoff Hazard Ratings based on Runoff Sensitivity and Equivalent Clearcut Area (ECA) as a measure of forest disturbance.

In this approach, ECA values modify the runoff generation sensitivity ratings. For example, a catchment that is highly sensitive to changes in runoff, because it is largely forested and wetter climate, will have a low to very low runoff hazard if it is largely intact (<10-15% ECA). Likewise, catchments with low to very low sensitivity (drier and less forested) require higher ECA levels to increase Runoff Generation Hazard.

Routing sensitivity

In this procedure, Routing Sensitivity refers to how quickly or efficiently runoff is transported through the catchment. It considers two main indicators that can be determined from readily available GIS data covering most of B.C.: 1) drainage density ruggedness, which is the dimensionless product drainage density (stream length per unit area km/km^2) and total relief (the difference between the highest and lowest points in the watershed) and 2) the presence/absence, total amount and location of lakes and wetlands in the catchment that will attenuate or buffer stream runoff (Moore et al. 2010).

The greater the stream density in a catchment, the less distance there will be for slower hillslope runoff to travel before reaching a stream, where water velocities are much greater. The greater the relief in a basin, the greater the average stream gradient and streamflow velocity. Both these factors reduce the time of concentration for precipitation to reach lower channel reaches and increase the sensitivity of the basin to elevated peak flows (Winkler et al. 2010a; Pallard et al. 2009).

A Presence/Absence of Lakes and Wetlands score is generated for each catchment based on the proportion area (%) of a catchment covered by lakes and wetlands weighted by their location in the catchment. Larger lakes and wetlands contribute more to attenuating runoff, and lakes and wetlands lower in a watershed unit are weighted more heavily, as they attenuate flows from a larger proportion of the watershed. For example, a score of 10 could mean 10% of the watershed unit consisted of a lake/wetland in the lower 30% of the watershed (weighted 100%) or 33% of the watershed unit consisted of a lake/wetland in the upper 30% of the watershed unit (weighted 30%).

To develop a Routing Sensitivity Rating, raw scores for the drainage density ruggedness and percent of lakes and wetlands were assigned values of 1-3, weighted equally and summed in a matrix (Table 4). Percent of lakes/wetlands values was inversely scored to weigh catchments with less area of lakes and wetlands more heavily. Based on this matrix, each catchment was then given a Routing Sensitivity score ranging from 2-6. Scores were broken into 5 sensitivity classes, Very Low (VL) =2, Low (L) = 3, Moderate (M) =4, High (H) =5, and Very High (VH) = 6.

		Drainage Density Ruggedness		
Percent area of Lakes/ Wetlands		**<1500 (1)**	**1501-3000 (2)**	**>3000 (3)**
	0-3 (3)	M(4)	H(5)	VH(6)
	3.1-6.0 (2)	L(3)	M(4)	H(5)
	>6.1 (1)	VL(2)	L(3)	M(4)

Table 4. Watershed Unit Routing Sensitivity ratings based on raw watershed unit scores for drainage density ruggedness and absence of lakes and wetlands.

Results of the study for drainage density ruggedness showed the highest values in the more mountainous ecoregions (Appendix 2-D, Map S-4), whereas the Fraser and Thompson Okanagan Plateaus and Basins had generally lower drainage density ruggedness numbers. Lake and wetlands presence/absence scores were greatest in the Fraser Plateau of the Cariboo Region where larger lake and wetland systems better attenuate flows (Appendix 2-E, Map S-5).

When the Routing Sensitivity Score was applied to all the watershed units in the study area, catchments with High and Very High Routing Sensitivity occurred in the Highlands, Cariboo and Columbia Mountains and Transition Ranges from the Coast Mountains. Moderate Routing Sensitive catchments are evenly distributed on the flatter Fraser and Thompson Okanagan Plateau (See Map S-6).

Streamflow sensitivity and streamflow hazard ratings

As defined earlier, streamflow sensitivity refers to how responsive or readily affected streamflow in a particular catchment is to land use activities and natural disturbances. Streamflow hazard refers to an increase infrequency of harmful streamflow events due to forest canopy loss. In this approach, runoff generation sensitivity and hazard ratings are modified by the routing sensitivity ratings to derived streamflow sensitivity and hazard ratings for a particular catchment. Modifying both runoff sensitivity and hazard with routing sensitivity in this way assumes the potential hazard posed by increased runoff must consider the attenuating factors inherently characteristic of a catchment such as drainage density, basin relief and the buffering of lakes and wetlands. To generate streamflow sensitivity and hazard ratings, routing sensitivity scores were simply added to sensitivity or hazard scores as shown in the following matrix (Table 5).

		Routing Sensitivity Ratings & Scores				
		VL(2)	**L(3)**	**M(4)**	**H(5)**	**VH(6)**
	VL(2)	VL(4)	VL(5)	L(6)	L(7)	M(8)
	L(3)	VL(5)	L(6)	L(7)	M(8)	H(9)
Runoff Generation Sensitivity & Hazard Ratings & Scores	**M(4)**	L(6)	L(7)	M(8)	H(9)	H(10)
	H(5)	L(7)	M(8)	H(9)	H(10)	VH(11)
	VH(6)	M(8)	H(9)	H(10)	VH(11)	VH(12)

Table 5. Streamflow sensitivity and hazard matrix derived from runoff generation and routing hazard ratings.

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Sediment Analysis Section Version 2- March 8, 2013

Sediment hazard

Sediment hazard refers to the increased amount, frequency and duration of sediment generation from non-natural sources entering a stream and delivered downstream to elements at risk. Sediment hazard is a function of three factors:

1) The inherent sensitivity of a catchment to land use and disturbance based on erodible soils and terrain stability;
2) The amount and location of land use activities and their ability to generate and deliver sediment into streams; and
3) The attenuating capacity of lakes and wetlands to filter and settle sediment.

Sediment generation potential

Sediment generation potential considers how sensitive a catchment is to land use and disturbance based on steepness and amount of erodible soils. The rating is based on two GIS-based indicators; 1) Erodible soils – which uses the provincial 1:2m quaternary deposits layer and 2) Steep coupled slopes – a calculated metric of slope steepness and connection with streams that measures the percent of catchment with steep (>50%) slopes coupled to streams (base of slope is within 50m of stream).

A sediment generation potential rating is derived using the following matrix (Table 1x) by grouping percent area of a catchment with steep slopes and erodible soils. Catchments with neither steep slopes nor erodible soils have a rating of 2 (very low); relatively low amounts of one or the other = 3 (low); some of both or higher amounts of either indicator = 4 (moderate); high or moderate amounts of disturbance in both indicators = 5 (high), and relatively high amounts of both = 6 (very high).

Table 1x. Sediment generation potential matrix based on the proportion of erodible soils and steep coupled slopes (slopes >50% within 50m of a stream) in a catchment.

			Erodible Soils	
		0(1)	**<10% (2)**	**>10% (3)**
Steep Coupled Slopes	**0 (1)**	VL(2)	L(3)	M(4)
	<10% (2)	L(3)	M(4)	H(5)
	>10% (3)	M(4)	H(5)	VH(6)

Land use disturbance

Resource road construction and use can be a chronic source of fine sediment to streams depending on road location, construction methods, surface material type, amount and timing of use, maintenance regimes, and weather-related considerations (Gucinski et al., 2001). Roads in areas with steep slopes and erodible soils will generate more sediment. Road segment length, road and soil type are key factors that have been shown to generate more sediment (Luce and Black, 1999). Road-related effects on drainage are also linked closely with the occurrence of landslides on steep slopes, particularly where diversion and concentration occurs within gentle over steep areas (Jordan 2002, Grainger, 2002). Land use activities and their ability to generate and deliver sediment into streams are assessed through three indicators including:

1) roads close to water measured as the total road length (km) within 50m of a stream (includes crossings);
2) roads on steep coupled slopes measured as the density of roads (km/km^{2}) on steep coupled slopes ; and
3) disturbance on gentle over steep terrain measured as the percentage of a watershed unit harvested on a slope <50% upslope of a steep coupled slope.

Raw values from each of the three land use disturbance indicators were binned into three categories, assigned values of 0-2 (Table 2x).

Table 2x. Scoring matrix for land-use related sediment generation and delivery indicators

	Indicator measurement			
	0	**1**	**2**	
Roads close to water	0	<0.1	>0.1	length of road within 50m of stream/reporting unit total area (km/km^2)
Roads on steep coupled slopes	0	<0.01	>0.01	Length of roads on steep coupled slopes >50% (km/km^2)
Disturbance on gentle over steep	0	<0.05	>.05	Percentage of reporting unit with logged area above steep coupled slope

Individual indicator scores are summed for each catchment to derive an overall land use impact score and rating. Catchments with no disturbance are scored 0 (very low); some disturbance in one category = 1 (low); high disturbance in one category or lower levels in 2 categories = 2 (moderate); disturbance in all 3 categories = 3 (high); and high levels of land use in two categories or land use activities in all 3 categories = 4-6 (very high) (Table 3x).

Sediment generation hazard

Sediment generation hazard refers to an increase in the amount of sediment or number of sediment generation events from non-natural sources. A sediment generation hazard rating considers the probability that increased sediment will be generated from non-natural sources based on sediment generation potential and levels of land use impacts. A sediment generation hazard rating is derived by combining scores from sediment generation potential and land use impact ratings (Table 3x). No disturbance (score = 0) results in a low to very low rating under most conditions except high natural sensitivity. High levels of land use related impacts generally result in moderate to very high likelihood under most conditions.

Table 3x. Sediment Generation Hazard rating matrix based on sediment generation potential and land use impact scores.

		Land use Impact Rating and Score				
		Very Low (0)	**Low (1)**	**Moderate (2)**	**High (3)**	**Very High (4+)**
Sediment Generation Potential	**VL**	VL	VL	VL	L	M
	L	VL	VL	L	M	H
	M	VL	L	M	H	VH
	H	L	M	H	VH	VH
	VH	M	H	VH	VH	VH

A sediment hazard rating refers to that likelihood that increased amount, frequency and duration of sediment generation from non-natural sources will enter a stream and be delivered downstream to elements at risk. Sediment hazard ratings use the sediment generation hazard ratings modified by the lakes and wetland score to consider the attenuating effects of lakes and wetlands on the delivery of sediment downstream. To develop a sediment hazard rating, sediment generation hazard ratings and absence of lakes/wetlands are summed in a matrix (Table 4x). Percent of lakes/wetlands values were inversely scored to weigh catchments with an absence of lakes and wetlands more heavily.

Table 4x. Sediment hazard rating based on sediment generation hazard rating and sediment delivery attenuation.

		Sediment Delivery Attenuation		
Sediment Generation Hazard		**L (3)**	**M (2)**	**H (1)**
	VH (6)	VH	H	M
	H (5)	H	M	L
	M (4)	M	L	VL
	L (3)	L	VL	VL
	VL (2)	VL	VL	VL

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Fish value rating tables

The Ecological Importance for the hydrological stability assessment was based on importance for fish using the following criteria:

Fish scoring criteria for watershed assessments

Phase Score	Criteria
0	Little or no known fish use; barrier present near mouth; low flow problems
1	1 or 2 species in parts - fish presence may be based on adjacent stream information, stream appearance on Google Earth, etc, possible low flow problems
2	1 or 2 species with at least 1 key species; fish use throughout or heavy use in parts
3	3 -4 species; at least 2 key species or presence of sensitive species; fish use throughout the watershed
4	4 - 5 species; 2 -3 key species; sensitive species; fish use throughout watershed; First Nations or commercial value of at least one stock; medium to large streams with diversity of fish habitat
5	5+ fish species; 3 - 4 key species; sensitive species present; fish use throughout watershed; First Nations or commercial value of at least one stock; presence of large streams with diversity of habitat;

Key Species

Key Species:	BT CO CH RB LT SO PK CM KO BB WF	bull trout coho chinook rainbow trout lake trout sockeye pink salmon chum salmon kokanee burbot whitefish	First Nations Use - fish stock used for sustenance/ceremonial Economic importance - angler use on lakes or rivers within the watershed; commercial salmon value

Listed/Sensitive

Listed/Sensitive Species	BT CO	bull trout coho

Appendix 3: Moose

Moose background information

Moose are generally solitary animals that move about within familiar summer and winter home ranges. Females may also use specific areas for calving, and males use specific areas for rutting. A seasonal home range is usually under 5 to 10 km^2 (Blood 2000). Average annual home ranges of radio-collared moose in the Chilcotin ranged from 20 to 45 km^2 (Baker 1990). Movement corridors within seasonal home ranges may be important. Annual movement distances between seasonal use areas tend to be low in the Interior Douglas-fir (IDF), Sub-Boreal Pine-Spruce (SBPS), and Montane Spruce (MS) (Keystone Wildlife Research Ltd. 2006). Moose did not occur in the Chilcotin until sometime after 1900.

Moose commonly spend the winter in areas with deep snow that hinders the movement of predators such as wolves; 50 cm to 90 cm snow depth areas are commonly used. The majority of moose winter ranges in the Cariboo region are below 1700 m, as snow depths over 90 cm are limiting. In the west and south Chilcotin, lower elevation ecosystems like the IDFdk4, SBPSxc, and lower elevations of MSxv all have snow depths under 90 cm; higher elevation areas like the MSxv, ESSFxv1, ESSFxvp and BAFAun have deeper snow, up to over 180 cm. Moose select areas with abundant shrub forage. Suitable moose winter habitat may occur in deciduous and mixed forest, riparian willow thickets, and wetland areas in the IDFdk4 and SBPSxc; in the MSxv suitable winter habitat is primarily in lower elevation wetlands, especially large wetlands (Keystone Wildlife Research Ltd. 2006).

Spring calving areas are less abundant than winter living habitat, as cow moose seek out areas with high security cover values. Movement corridors are likely of secondary importance compared to the winter living and spring calving habitats, but are important in relation to road density and location. In plateau portions of the Cariboo-Chilcotin there is significant overlap between winter and calving habitat. In the more mountainous areas, some moose will remain in low elevation areas for calving but significant proportion of the calving will take place in higher elevation locations to reduce predation risk.

Wetlands provide a high density of forage shrubs during the winter. Moose that forage in shrubby wetlands obtain the maximum amount of energy (food) while limiting energetic costs of exposure to the elements, minimizing the effort required to search for food, and reducing the risk of mortality through predation. Adjacent stands of conifers are required for moose winter thermal cover, security cover, snow interception shelter, and travel corridors. Thermal shelter provides protection from cold resulting from wind and heat radiation to the sky during cold weather, and from excess heat from the sun on warm days; security cover provides visual screening from predators (including humans); and snow interception cover provides lower snow depths for living and travel. Studies in the west Chilcotin show that moose spend much of their time in feeding areas within 100m of forest cover (Baker 1990). Recent moose winter census data show significant moose use as much as 250m from foraging areas in the Chilcotin.

Hiding cover is ≥ 3 m high live conifer, and thermal cover is ≥ 19 m high live conifer (Intrepid Biological Contracting 2004). The tree ages at which the height thresholds are reached will vary with growing conditions. For the IDFdk4, SBPSxc and MSxv, approximate forest ages average ≥ 20 years old for ≥ 3 m height and ≥ 60 years old for ≥ 19 m height. In the deeper snow areas of the region snow interception cover also is important in deeper snow winters.

Roads or ATV trails within one kilometre of shrub wetland habitats may decrease moose populations through hunting, poaching, vehicle collisions and human avoidance. Roads in the area between wetlands that are within one kilometre of each other are likely to cross within-season movement corridors. Roads close to feeding areas may cause visual and noise disturbance that reduces or eliminates use of the feeding area by moose (Intrepid Biological Contracting 2004). Shanley and Pyare (2011) found that in Alaska, the disturbance effect of rural roads extended up to 1000 metres for female moose and 500 metres for males in the fall. Some other references in the literature find males to be more sensitive to road disturbance and find smaller disturbance distances of 250 to 500 metres. The current assessment assumes that major gravel roads and areas actively used for industrial activity may equal or exceed the disturbance caused by the roads found by these studies. Since the assessment only analyses the impact of major roads, the disturbance distance is set at 1000 metres. More sophisticated road data and a more complex road model could provide the basis for refinements in the disturbance distance based on type of road.

Moose assessment details

The land base used for assessment excludes federal land, private land and lakes. It is restricted to the portion of the land base classified by provincial Broad Ecosystem Inventory mapping as having winter capability for moose (i.e., classes 1-5).

Assessment units are approximately 15,000 to 40,000 ha areas resulting from subdividing biodiversity landscape assessment units into 2-3 parts based largely on watershed boundaries. Note that the scale of assessment units is important. If very large areas are used, the results will be the average for this very large area which will often mask important variation within the unit. If units larger than 30,000 ha are used it will be very important to evaluate the variation across the assessment unit and take this into account when doing interpretations.

The critical habitat required to maintain moose populations is assumed to be winter feeding and associated thermal shelter habitat plus snow interception shelter in the deeper snow areas in the region. Several major components are combined to assess the importance of moose habitat, its current hazard level and the level of mitigation currently in place. These include:

1. Broad Ecosystem Inventory Moose Winter Capability mapping. The assessment of ecological value uses the "weighted average" compilation of moose habitat capability.
2. A geographic habitat model of moose winter feeding and shelter habitats and their adjacency is described below. This model defines areas described as modelled high suitability. Note that this definition is different than that used for defining habitat suitability in provincial habitat mapping.
3. A simulated landscape with cutblocks replaced by forests capable of providing moose thermal shelter is used as a baseline for assessing change in habitat availability.
4. Geographic databases include:
    a. Paved and gravel roads from the digital road database;
    b. Key wetlands for moose which cover a large part of the region;
    c. No-harvest land use designations currently in place through the CCLUP; and
    d. High mortality forest stands resulting from mountain pine beetle infestation from VRI are mapped but not used in the quantitative assessment.

Broad-scale moose capability mapping

Capability mapping is used in this assessment to delineate where winter moose habitat is located in the region. The capability mapping is also used to evaluate the "ecological importance" of each assessment unit for wintering moose.

See the following for more information on this capability mapping:

- Broad ecosystem mapping for moose http://www.env.gov.bc.ca/ecology/bei/
- Wildlife Habitat Ratings http://archive.ilmb.gov.bc.ca/risc/pubs/teecolo/whrs/assets/whrs.pdf

Modelling of high-suitability winter moose habitat

The habitat model developed for this project delineates the location of the best currently suitable moose winter habitat at a finer scale than the Broad-Scale Moose Capability Mapping. It is based on the rules described below and uses data from the current VRI and roads databases. The model does not identify all areas that may be used by moose in the winter, but focuses on areas where forage and shelter requirements are both met in close proximity.

The model uses the following key attributes to define moose **high-suitability winter habitat**:

- Wetlands, riparian shrub thickets, and other shrubby areas for feeding, with adjacent stands of conifers for winter shelter (thermal, security and snow) and travel corridors.
- Cutblocks or burns in the moist and wet ecotypes (defined below) between 10 and 35 years since disturbance, with adjacent stands of conifers for winter shelter (thermal, security and snow) and travel corridors. In the dry ecotype, significant moose forage is assumed to occur only on wetter than mesic sites that are captured by defining the riparian buffers adjacent to lake streams and wetlands as foraging habitats for all three ecotypes.
- Deciduous forests are defined as forest stands with 40% or more deciduous composition. Two types are defined based on their probable successional dynamics. One type, called "self-sustaining", is more likely to be persistent on the landscape in the absence of significant management intervention to move it towards conifer domination. The other type, called "transient", is assumed to be an early successional stage which will most often transition to a conifer-dominated stand over the span of a normal forestry rotation. Development of the definitions for the two deciduous types was facilitated by advice from Regional Ecologist Ray Coupe.
- **Self-sustaining deciduous forest** is defined as: forest stands of at least 60% deciduous and at least 60 years of age. It forms part of the "**static forage habitat"** along with wetlands, riparian areas and other shrubby area not resulting from fire or logging disturbance.
- **Transient deciduous forest** is defined as all forest with 40% or more deciduous composition that do not meet the definition for self-sustaining deciduous forest. It forms part of the **"dynamic forage habitat"** along with cutblock or burns in moist and wet ecotypes between 10 to 35 years since disturbance.
- The allowable distance between shelter and cover is 250 m in the dry and moist ecotypes in the region and 100 m in the wetter parts of the region. The shorter distance in the wet ecotype is related to the deeper snow and therefore the greater difficulty of travel without snow interception cover.

As shown in Table 1, the region is divided into three ecological strata to tailor the model output to ecological differences across the region. In the drier portion, the snow is shallower, thus providing less of an impediment to moose travel. Also, in the drier strata, the best forage is found mostly in wetlands and the moister sites adjacent to water. In the wetter zone, snow is deep but forage production is good on all open areas such as burns and cutblocks. The strata are defined based on climatic moisture and temperature. Regional ecologists from the Cariboo and Kamloops were consulted to inform the definition of the ecotypes. Note that while all biogeoclimatic zones were classified, optimal moose winter habitat is not modelled where capability mapping indicates that winter capability is nil. Therefore, the ESSF, PP, BG, CWH and MH zones will contain little or no optimal moose winter habitat in most assessment areas. The general characteristics of moose habitat attributes for the three ecotypes are shown in Table 2.

Table 1. Definition of three ecotypes for moose winter habitat in the Kamloops and Cariboo regions. Brown =dry ecotype, Yellow=moist ecotype, Green=wet ecotype.

BEC zone	**Ecotype Classification by BEC Unit**								
PP, BG	All								
IDF	xm	xh	xc	xw	dw	dm1	dk 1, 3, 4	dk2	mw
SBPS	xc	dc	mc	mk					
MS	xv	dv	xk	dc	dm	mw			
ESSF	xv	xc	dv	dc	mv	mc	mm	mw	wk
SBS	vk	dw	mc	mh	mw	mm	wk		
ICH	ICHdk	All others							
CWH	All								
MH	All								

Table 2. Generalized moose winter habitat attributes of the three defined ecotypes.

Attribute	Ecotype		
	Dry	Moist	Wet
Location of significant potential shrub forage in clearcuts and burns	Wetter than mesic sites	All moisture regimes	All moisture regimes
Need for thermal shelter	High	High	Moderate
Mid-winter snow depth	Usually <60cm	Usually <90cm Often >60 cm	Often >90 cm
Energy cost of movement through snow	Low	Moderate	High
Need for snow interception cover	Low	Moderate	High

How the model defines high-suitability winter habitat

The model first defines “Potential” habitat for winter feeding and winter thermal/snow interception cover as described below. It then applies a proximity constraint between the potential feed and cover habitats types to ensure that the habitat can be effectively used. The result is “Effective Winter Feeding Habitat” and “Effective Winter Shelter Habitat”. The sum of these two is defined as the “Modelled High-Suitability Moose Winter Habitat”. This modelling approach is designed to define the high-suitability habitat, but does not identify all habitat used by moose throughout the winter. Moose can make significant use of sub-optimal habitat for various reasons such as reducing predation risk.

Since high-suitability habitat is defined the same way in every assessment unit, this modelling approach allows for valid and consistent broad-scale assessment and comparisons between assessment units. However, care must be taken when using the maps of modelled habitat for planning at the stand level since GIS data is not always perfect and since not all details of habitat across the region are incorporated into the model.

Potential winter feeding habitat (ha) = The total area of the following:

- Wetlands from BC Freshwater Atlas + "NPBr"(NP code =11) from VRI + high value moose wetlands identified for the CCLUP+BCLVS non-productive: level 2=Non-treed, level 3=Wetland. Combined wetland plus NPbrush polygons less than 2.5 ha including 20 m buffer are dropped.
- Forest with ≥ 40% deciduous composition.
- A buffer area of 20 metres adjacent to lakes, rivers and streams from the BC Freshwater Atlas. For rivers and streams this is 20 metres on each side of the river or stream. This analysis includes narrow strips of shrub and deciduous tree habitat often associated with water features, but that are too small to appear on forest cover maps. Note that feeding habitat is not included on first order streams because it was assumed that these would usually not have significant shrubby areas adjacent to them.
- In the moist and wet ecotype, all cutblocks or burns between 10 and 35 years since disturbance.

Potential winter shelter habitat (ha) = conifer forest (≥40% conifer) ≥ 60 years old

Moose require both hiding and thermal shelter in all ecosystems. In the wetter ecotype, and sometimes in the moist ecotype, the shelter habitat must also function as snow interception habitat. Moose in the moist ecotype may also require snow interception cover in deep snow winters or parts of winters. Thermal and snow interception habitat are the most limiting types of conifer shelter for moose and hence are modelled here. Shelter habitat attributes develop more rapidly as you move from the dry to moist to wet ecotypes. At the same time, the need for snow interception cover also increases as you move from the dry to moist to wet ecotypes. Good snow interception cover requires the larger trees and higher crown closure provided by more developed stands. As a simplifying assumption, the forest age for shelter habitat is kept at 60 years for all ecotypes even though the rate of shelter attribute development increases from dry to wet ecotypes. This, in effect, provides for better snow interception shelter attributes in the wet ecotype.

The ability to provide shelter attributes declines with increasing stand mortality. The model does not take this into account when defining potential winter shelter because quantitative relationships between level of stand mortality and shelter quality are not precisely known and because VRI data on mortality are very coarse. However, the distribution of high mortality pine stands is mapped as part of the analysis (Map 6) and should be considered when making qualitative statements of risk for specific assessment units where pine mortality is high.

Effective winter feeding habitat (ha) = potential winter feeding habitat within 250m of potential winter shelter habitat in dry and moist ecotypes (100m in the wetter ecotype).

Effective winter shelter habitat (ha) = potential winter shelter habitat within 250m of potential winter feeding habitat in dry and moist ecotypes (100m in the wet ecotype).

High-suitability moose winter habitat (ha) = effective winter feeding habitat + effective winter shelter habitat.

Comparison to "undeveloped baseline"

Current modelled high-suitability moose winter habitat area is compared with the same area in a simulated "Undeveloped Landscape" which is used as a baseline. This undeveloped landscape is created by replacing logged areas with conifer stands capable of providing moose shelter habitat (>60years old). The model determines the area of "Total High-Suitability Moose Winter Habitat" in the undeveloped landscape and compares it with the current landscape to indicate change in available habitat. Getting a reliable and up-to–date cut-block layer is a perennial problem for GIS analyses. This analysis uses the 2012 "Salkeld" consolidated cut-block layer as the best available data source.

Using this undeveloped landscape as a reference point for the analysis is a simple approach to assessing landscape change which does not incorporate the potential landscape composition effects of natural disturbance. However, after examination of the options, this approach was selected because it provides a way of documenting how much habitat change has happened up to the present and because it does so spatially.

For moose, this spatially explicit analysis recognized the need to have current forest cover adjacent or close to important feeding areas. It also allowed habitat suitability (current patterns of winter habitat) to be assessed in relation to habitat capability. In addition, this assessment provides a baseline for evaluation of moose forage areas created by forest harvesting and wildfire.

An alternative method would compare non-spatial habitat proportions in the current landscape to habitat proportions in a modelled naturally disturbed landscape. While this approach would better reflect natural disturbance affects, it would lack the important spatial specificity related to adjacency of cover and forage.

The use of a simple reference landscape allows for meaningful, spatially explicit assessments. The possible errors resulting from the use of this method due to the omission of natural disturbance are acknowledged. Therefore the raw numbers for habitat reduction indicators are an approximate measure of divergence between a consistent reference landscape and current conditions. This comparison is intended to provide a meaningful indication of relative habitat conditions across the region.

Roads

The effectiveness of moose habitat is reduced by having well-used roads located within one kilometre of important habitat. The model recognizes this by calculating the proportion of "disturbed" moose habitat within the high-suitability areas.

Disturbed moose winter habitat (ha) = high-suitability moose winter habitat that is within one kilometre of a gravel or paved road or the footprint of a major development such as a mine.

High-value wetlands for moose – High-value wetlands for moose were identified in the CCLUP for application of special management. These areas are used in the current quantitative analysis of moose habitat even though the study in which they were identified did not cover the entire area of the region. They are included on the moose assessment maps in this report. They indicate important, field checked winter feeding habitat.

Landscape shelter indicator

Each moose winter home range requires both forage and adequate shelter to provide effective habitat. A potential home range area with lots of forage habitat will only function as fully effective habitat if it also has adequate shelter. Landscapes with a very high level of disturbance can sometimes have much forage habitat but not enough shelter. The landscape shelter indicator assesses the adequacy of cover for moose over all potential home range units in the assessment unit. As well as estimating the proportion of potential home ranges with adequate cover, it is also an index of the distribution of the amount and distribution of cover required for moose to travel across the unit.

This indicator is different than the other three hazard indicators in that it is assessed across all capable habitat rather than just over the best habitat, i.e., the modelled high-suitability habitat. It essentially measures if, or the extent to which, moose winter habitat values across the whole assessment unit have been compromised by very high levels of disturbance even if this disturbance has provided large areas of forage habitat.

The landscape shelter indicator is designed to estimate the proportion of the capable habitat area within each assessment unit that has an adequate amount and suitable distribution of thermal/snow interception cover to provide useful habitat for moose in winter. Since the distribution of this cover is important for moose, a simple measure of the percent area with cover in a 10,000 to 20,000-hectare assessment unit would often provide misleading information. For example, if the whole northern half of an assessment unit had cover with no cover in the southern half, then a simple assessment would provide a measure of 50% cover even though half of the area had no cover. However another area with a total cover of 50%, if well distributed in relation to capable habitat, may provide adequate cover for 90% or more of the capable habitat. The approach described below uses a "moving window approach" to assess available cover in units the size of a typical female moose home range size (10 km^2) across all capable habitat in the assessment unit. The proportion of the area with adequate cover in each home range unit is then compared to guidance on shelter requirements derived from Keystone (2006), Wall et.al. (2011) and advice from Larry Davis (2014) to determine the adequacy of the cover in each home range sized unit to determine whether it has adequate cover. The indicator is then calculated by determining the proportion of the home range areas in each assessment unit that have adequate cover.

The analysis steps are as follows:

- Develop a raster data set of cover (defined as forest cover > 60 years of age and ≥ 40% conifer).
- Measure the proportion of cover in 10 km^2 home range units using a "roving window" approach with the "Focal Statistics"[7] spatial analysis tool in Arc Info. A 1 ha. central pixel and 1784m neighborhood/search radius was used to provide a 10 km^2 neighbourhood area. In each neighbourhood, the area of cover is determined and then percent cover is calculated by dividing by the total area to calculate a percent cover. Each one-hectare pixel is then classified using the following classes of % cover for its surrounding neighbourhood: 0-19.9%, 20-29.9%, 30-39.9%, 40-49.9% and ≥50%.
- Determine the proportion of the pixels in each assessment unit that have adequate surrounding cover. "Adequate cover" is defined as 30% + for dry and moist ecotypes and 40+% for wet ecotypes.

[7] See Arc Info help for Focal Statistics at: http://resources.arcgis.com/en/help/main/10.1/index.html#/How_Focal_Statistics_works/009z000000r7000000/

- Note that only pixels that are in capable habitat (classes 1 to 5) will be classified but that the analysis will allow the neighbourhood search radius to go outside of the capability 1 to 5 classes area.

Appendix 4: Mule Deer

The key habitat requisite for mule deer in the Cariboo is winter range. Energy expenditure for mule deer increases during winter because of the extra energy they require to move through snow. At the same time, they must rely upon low quality forage compared to their diet in other seasons. Therefore, they need access to areas with low snowfall and/or good snow interception and accessible forage. Old Douglas-fir forests or uneven-aged Douglas-fir forests with a high component of older trees on warm aspects at low elevation provide for these needs and form the main part of most winter ranges. These areas provide snow interception, thermal cover and forage. The Cariboo-Chilcotin *Regional Mule Deer Winter Range Strategy* (1996) and Dawson *et al*. (2006 and 2007) identify the critical mule deer winter habitat in the region and updated direction for habitat management. The mule deer strategy is designed to coordinate the requirements for both habitat and timber, and is therefore a compromise from both ideal timber management and ideal habitat management.

Through the CCLUP, winter ranges have been mapped and management plans prepared complete with zones, long-term management objectives, harvest opportunities and harvest practices. Under the Forest and Range Practices Act, the winter ranges and objectives have been legally established as ungulate winter ranges under the Government Actions Regulation (GAR).

The current state of each mule deer winter range is assessed in relation to forest stand attributes and long-term objectives determined in individual winter range plans. These plans and the attribute targets were determined as part of the CCLUP Mule *Deer Winter Range Strategy* that is backed up by more than a decade of research and planning work. The strategy takes into account the varying snow and forage conditions across the region and applies the knowledge from extensive local research work to individual winter ranges.

Natural disturbances including Douglas-fir bark beetle, budworm and wildfire, have had a significant effect on mule deer winter range habitat in some parts of the region. Salvage logging for Douglas-fir bark beetle has been a major disturbance to forest cover in Mule Deer Winter Range (MDWR) over time. The effect of many of these disturbances, including the salvage harvesting, have not always been well reflected in the VRI data. Because of the large impact of the 2009 and 2010 wildfires, an indicator to assess the overlap of these fires with winter range habitat is included in the assessment.

Lands may be removed from time to time from winter ranges for the purpose of agricultural leases or other land developments. Where known, any such alienation of lands contributing to MDWR should also be considered in the assessment of current condition.

Roads or ATV trails within mule deer habitats may also impact deer populations. Some deer habituate to human activity and roads but populations are still affected through poaching, hunting and vehicle collisions.

The current standard for managing mule deer habitat in the Cariboo is adherence to the management plans as described under GAR. Assessment of future projects will be based on the assessment of any incursions or developments in the mapped winter range that are inconsistent with the management objectives.

Very large investments in research, planning and legal direction for mule deer winter range management have resulted in a relatively secure future for these habitats. The special management measures in place for these winter range areas also helps to protect many other ecological values including biodiversity and habitat for rare and endangered species.

Habitat model

Winter range isolation

A winter range that is adjacent to or very near to another winter range will allow for greater habitat options, especially if the other winter range is large and in good condition. Small, isolated winter ranges result in greater risk to deer if habitat is degraded. An isolation variable (described in the indicators section) has been developed to standardize assessment of winter range isolation.

Forest structure assessment

The forest structure was assessed in relation to targets developed for each winter range. The Cariboo Forest Region was divided into four snowpack zones (shallow, moderate, transition and deep) based on the average snow pack in each biogeoclimatic subzone. Deer wintering in the deep snowpack zone require good snow interception cover over the entire winter range. However, they require decreasing proportions of the best snow interception cover in the transition, moderate and shallow snowpack zones. The winter range strategy for the region defined what forest characteristics are required for three classes of forest structure in each of the snow pack zones and specified appropriate proportions of each of these structure classes required in each of the snow pack zones to meet mule deer habitat needs. The forest structure assessment in the report uses forest inventory data to evaluate what percentage of the targets for moderate and high stand structure habitat classes were met when the assessment was done in 2002.

This assessment does not provide precise estimates of current condition because the forest inventory database is not designed to provide precise data on a stand-by-stand basis for the variables used to define the stand structure classes. Therefore assessments using this data are only suitable for very broad classification of habitat suitability. This assessment is split into only three categories with very generous ranges in meeting targets. For actual management of any given forest stand, assessment is based on measurements derived from field sampling. The forest structure assessment in this report is based on a 2002 analysis, and therefore does not incorporate changes since that time.

In summary the forest structure analysis procedures were as follows:

- Calculate the MDWR land base for each winter range:
    - Include only Crown forest land and exclude grassland benchmark areas
    - In shallow/moderate snowpack zones include forest polygons with ≥ 20% Fd
    - In transition/deep snowpack zones include polygons that meet one of the following tests:
        - ≥ 40% Fd
        - Fd leading species even if FD <40%
        - Deciduous leading with Fd as 2nd species
- Calculate the area within each winter range that meets the following definition of moderate or higher stand structure class as described in the following table:

Snow pack zone	**Age class**	**% Fd**	**Conifer Crown Closure class**
Shallow/ moderate	≥6	≥60	4
Transition/Deep	≥5	≥50	4

- Calculate the desired area of moderate plus high stand structure class for each winter range based on the following habitat goals which come from the 1996 Mule Deer Winter Range handbook.

Snow pack zone	Desired Stand Structure Habitat Class Proportions		
	Low	Moderate	High
Shallow	40	40	20
Moderate	33	33	33
Transition	20	40	40
Deep	0	33	67

- Calculate the current (2002) risk value as follows:

Risk Value = (Current % moderate plus high/desired % moderate plus high) x100

Mitigation

Mitigation is provided by overlap with areas designated as no harvest in the CCLUP and through legally required forest practises. Significant amounts of old growth management area was overlapped in the CCLUP process with MDWR to reduce timber supply impacts and to provide further protection for a number of other wildlife species (including several rare and endangered species) that live in mule deer winter habitat. Legally required habitat management practises for mule deer winter ranges are included in Government Action Regulation Orders as “Approved Objectives.”

Appendix 5: Grizzly Bear

Grizzly bear are provincially blue-listed, and are included in the Identified Wildlife Management Strategy (2004). They are federally listed as *Special Concern* by the Committee on the Status of Wildlife in Canada (COSEWIC), but they are not currently listed under the *Species at Risk Act*. The South Chilcotin Ranges Grizzly Bear Population Unit, immediately to the east of Bidwell/Lava Landscape Unit, is provincially ranked as *Threatened*.

Grizzly inhabit all elevations from sea level estuaries to high alpine meadows. A large variety of plant, animal, fish and insect food sources can be regionally important; preferred foods are typically high in protein, soluble carbohydrates and fat, but relatively low in fibre to maximize their digestibility (Tony Hamilton, pers. comm.). Gyug et. al. (2004) provides a good general summary of grizzly bear habitat in B.C.

Grizzly show fidelity to seasonal food sources and will return to specific sites such as berry patches, fishing reaches and avalanche chutes within a much larger (sub-regional) home range. Natural post-fire habitats may remain high productivity foraging sites, particularly for berries. Production may persist for 35 to 70 years. In the south and west Chilcotin, bears are also known to seek out whitebark pine (*Pinus albicaulis*) seeds, which may be particularly important in years of poor berry production (Tony Hamilton, pers. comm.)

Adjacent to foraging sites, bears require forested habitats to provide day beds and avoid heat stress. Hibernation habitats tend to be high elevation areas that are sloped, and have dry, stable soil conditions that remain frozen during the winter. However, lower elevation hibernation also occurs, especially in areas where late fall resources, such as late spawning salmon, occur (B.C. Ministry of Water, Land and Air Protection 2004).

Large-scale connectivity of habitat is very important for grizzly bear populations. Because of the large home range size and the importance of highly productive, site-specific habitats within that range, linear developments such as roads or extensive habitat alteration at the landscape level can disrupt connectivity. This disruption can affect population viability because, to form viable populations, bears must be able to disperse to form a widespread, low-density, but connected, sub-regional and regional population. Loss of a female bear has implications for the population not just from the loss of that bear but also the loss of her future offspring.

Roads can result in grizzly bear mortality both directly and indirectly. Direct mortality occurs through collisions with vehicles, hunting, poaching and food habituation leading to human-bear conflict. Indirect mortality occurs through social disruption when young bears or females with cubs seek out road corridors in an attempt to avoid adult males or through home range disruption when bears use less of the available habitat because of the disturbance factor caused by roads (B.C. Ministry of Water, Land and Air Protection 2004).

Road density is considered as a risk factor in the framework using the density of roads per square kilometre. Using a roving window approach, landscape is mapped into road density classes significant for grizzly bear (Tony Hamilton, pers. comm.). Where assessments are done in threatened grizzly bear population units like the South Chilcotin, where the objective is population recovery, there needs to be capable, suitable, effective and mortality-risk-limited habitat available for an expanding population (Tony Hamilton, pers. comm.).

Grizzly bear assessment model

The **assessment of ecological importance** includes habitat quality and current population status as determined by the Ministry of Environment. Habitat quality is assessed based on mapped habitat capability and a salmon rating based on abundance, consistency and availability of Sockeye and Chinook salmon to bears. Habitat capability assessments use 1:250,000 scale Broad Ecosystem Inventory mapping reinterpreted in 2012 by provincial grizzly bear biologist Tony Hamilton. The salmon rating is based on a combination of quantitative estimates where they were available, and qualitative ratings for other areas based on discussion with locally knowledgeable Department of Fisheries and Oceans staff. It considers both Sockeye and Chinook salmon.

The type of information used to develop salmon ratings for all rated assessment units is summarized in Table A.GB.1. Units with known significant salmon resources for bears were rated as high or very high while all other units were classified as not rated and not considered in the assessment. Where quantitative sockeye data was available, ratings were assessed as follows for each assessment subunit:

Very high = good availability, fish numbers > 250,000 in the best year and >10,000 in most years

High = good availability, fish numbers >10,000 in the best year and >5000 in most years

The only area without quantitative data that was rated as very high was the Chilko River immediately downstream from the Chilko Lake outlet (Bidwell/lava C assessment unit) that is well known for large concentrations of spawning Sockeye and Chinook salmon as well as large concentrations of grizzly bears feeding on the salmon.

Table A.GB.1. Salmon Info used to develop salmon ratings December 2013.

Note that two pairs of units (shaded) were each coupled for the purposes of rating because of the close proximity of their spawning habitats. Also note that two units, Bidwell/Lava C and Brittany B, have the same rating because they are just opposite sides of the Chilko River where the very productive spawning reaches are located.

Analysis_Unit	**Population Status**	**Salmon Rating**	**Data used for Salmon rating**	**High density locations**	**2001 Sockeye estimate (x1000)**
Baezaeko B	threatened	H	Qualitative chinook info	Baezaeko River from Coglistiko Jct to 3 km down stream	na
Cunningham A	viable	H	Qualitative chinook info	Cariboo River upstream of Cariboo Lake	na
Victoria A	viable	H	Qualitative chinook info	Swift River for 10 km upstream from Lightening Jct.	na
Bidwell/Lava_C	viable	VH	Qualitative sockeye and chinook info	see sockeye maps, Chinook location based on info from Shane Kaiyn (DFO)- At Lingfield, d/s of canoe crossing and between Henry's bridge and Brittany creek	*Approximately 2.5 million for the whole Chilko system in 2010*
Brittany_B	threatened	VH	Qualitative sockeye and chinook info		
Chilko_A	viable	H	Qualitative sockeye info	sockeye maps from DFO	?
Nemiah_B	threatened	H	Qualitative sockeye info	sockeye maps from DFO	?
Eastside A	viable	H	Quantitative sockeye data	sockeye maps from DFO	62
Eastside B	viable	H	Quantitative sockeye data	sockeye maps from DFO	13
Wasko/Lynx B	viable	H	Quantitative sockeye data	sockeye maps from DFO	82
Westside A	viable	H	Quantitative sockeye data	sockeye maps from DFO	
Westside B	viable	H	Quantitative sockeye data	sockeye maps from DFO	39
Black Creek B	viable	VH	Quantitative sockeye data	sockeye maps from DFO	908
Horsefly A	viable	VH	Quantitative sockeye data	sockeye maps from DFO	924
McKinley C	viable	VH	Quantitative sockeye data	sockeye maps from DFO	267
Mitchell Lake B	viable	VH	Quantitative sockeye data	sockeye maps from DFO	
Penfold B	viable	VH	Quantitative sockeye data	sockeye maps from DFO	1040

The **hazard assessment** includes two related indicators of human access effects on grizzly bears: 1) **Habitat Effectiveness** and 2) **Secure Core Area**. These indicators are well described in MacHutchon (2001) and are widely used for grizzly bear assessments in Western North America. Note that these two analyses are usually calculated based on suitable habitat. Capable habitat was used in this analysis to reflect the long term nature of the required planning horizon during which the suitability would be in flux.

"Habitat effectiveness models an area's actual ability to support bears given the quality of the habitat and the extent of human disturbance."[8] Habitat effectiveness is calculated in our model by applying a net-down of capable habitat based on access density in five classes as shown in Table A.GB.2. These classes and the net-downs were developed by Tony Hamilton, and are also used for hazard assessments in the Kamloops Region. The access data was carefully assembled to be as complete and accurate as possible. The road layer was compiled as a composite of three sources of roads data: the digital road atlas, the FTEN road layer and the TRIM roads layer. Access from the following was also included in the access layer: power transmission lines, pipelines and railways. Road density was spatially determined with a roving window approach using the line density tool in Arc Info. A 30m pixel and 500m neighborhood/search radius was used for line density tool application. The % habitat effectiveness is calculated first on all capable habitat (classes 1 to 5) and then on the best capability habitat (classes 1 to 3). Note that the areas described by all capable habitat and all suitable habitat are the same and therefore the analysis results using all capable habitat would be exactly the same as for all suitable habitat.

Table A.GB.2. Net-downs for estimating habitat effectiveness based on road density. Pers comm. Tony Hamilton.

Road density class	Road density (km/km^2)	Habitat effectiveness (%)
1	0	100
2	>0 <=.6	75
3	>.6 <=1.2	50
4	>1.2 <=2.4	25
5	>2.4	0

Secure core areas are "...areas where grizzly bears will be relatively secure from encounters with humans; where bears can meet their energetic requirements while at the

[8] Herrero, S. and M. Gibeau. 1999. *Status of the Eastern Slopes Grizzly Bear Project (ESGBP): May 1999.* Eastern Slopes Grizzly Bear Project, University of Calgary, Calgary, Alberta. 5 pp.

same time choosing to avoid people." Secure core areas help to reduce the incidence of habituated bears, bears killed out of self defense and bears removed by management agencies because of unacceptable behaviour.[9] The proportion of habitat that is within secure core areas is considered by grizzly bear biologists to be a useful measure of mortality risk. Secure core areas were calculated for this study as roadless areas >10 km^2 excluding lakes and nil capability habitat. 10 km^2 is assumed to be the minimum average daily foraging radius for a female grizzly bear with cubs. Indicators assess the percent capable habitat within an assessment unit that is within a secure core area. The percent secure core habitat is calculated first on all capable habitat (classes 1 to 5) and then on the best capability habitat (classes 1 to 3). The more capable and high-quality habitat included within secure core areas, the better the overall habitat will be for long-term survival of grizzly bears. Table A.GB.3 shows the relationship used in the assessment between percent of capable habitat in secure core areas, the estimated probability of mortality and the resulting hazard class. These relationships were provided by provincial grizzly bear biologist Tony Hamilton based on his extensive knowledge of the use of these indicators in other assessment processes.

Table A.GB.3. Assumed relationships between secure core habitat, mortality risk and hazard rating.

% of capable habitat in secure core areas	% probability of mortality	Hazard class
0-17	67-100	High
18-45	34-66	Moderate
46-100	0-33	Low

[9] Gibeau, M. L., and S. Herrero. 1998. Managing for grizzly bear security areas in Banff National Park and the Central Canadian Rocky Mountains. *11th International Conference Bear Research and Management.*

Appendix 6: Marten

American marten usually use dense deciduous, mixed, or especially coniferous upland and lowland forest; late successional, mesic, coniferous forests are preferred. Forests associated with wetlands may be important in the West Chilcotin. Marten spend much of their time in trees, but mostly hunt on the ground. They den in holes in dead or live trees, abandoned squirrel nests, conifer crowns, rock piles, or burrows. Young are born in a den, usually in a hollow tree, sometimes in a rock den. In the winter they use subnivean (below snow) sites created by coarse woody debris piles or even active squirrel middens for both denning and hunting prey such as mice and voles (Hatler et al. 2003).

Ground level structural complexity, coarse woody debris and coniferous canopy cover represent high quality habitat components. During the summer months marten use exposed resting sites on the ground or on tree branches. Dens are often located in features characteristic of mature forest stands – large trees with existing cavities, logs, snags, etc. Home range size varies (2 to 8 km^2) and may be dependent on timber harvesting practices. Marten are omnivorous but mammalian prey dominates their diet, especially during the winter. They often hunt along the edges of disturbed habitat in search of small rodents, birds, insects and berries, often using subnivean and subterranean hunting strategies. They have low fat reserves, must eat frequently, and may undergo metabolic rate depression during cold weather (Hatler et al. 2003).

Marten are present throughout B.C. with the BWBS and SBS biogeoclimatic zones supporting the highest population densities. In the West Chilcotin, the SBPSmc has the best habitat (Davis 2003, 2004). Population densities range from 0.4 marten/km^2 in logged habitats to over two marten/km^2 in old forest habitats (A. Edie and Associates 2003). What are apparently the same density numbers are phrased by Hatler et al. (2003) as "measured population densities of martens over most of North America have been in the range of 0.4 to 2.4 animals per 1 km^2, the lower figure obtained in the spring during a year of prey scarcity and the higher in the fall during a year of relative prey abundance."

Because of their dependence on conifer forests, especially mature trees and coarse woody debris, the primary assessment criterion is conifer forest. Winter is the time of greatest environmental stress so the critical habitat is related to the habitat suitability during the winter for both hunting and shelter. In the dry ecosystems in the Chilcotin high-suitability winter habitat is considered to be conifer leading forest ≥ 120 years old, moderate winter habitat is conifer leading between 80 and 120 years old. Low winter habitat was not modelled. In wetter forests, the model used age classes of ≥100 and 70-100 for high and moderate suitability. Disturbance from major roads is generally considered to apply for 200m into adjacent habitat.

Marten habitat model

The most limiting habitat type for marten is assumed to be winter feeding and associated thermal shelter habitat plus snow interception shelter in the deepest snow areas in the region. The assessment model is a relatively simple assessment suitable for broad-scale assessments. Several major components are combined to assess the importance of marten habitat, its current hazard level and the level of mitigation currently in place. These include:

1. 1:40,000 Marten Winter Capability mapping from 2012 mid-term timber supply analysis.
2. A simple GIS definition of suitable winter marten habitat.
3. Maps of designated no-harvest and modified harvest areas.
4. A simulated undeveloped landscape with cutblocks replaced by forest conifer stands >80 years of age.
5. Geographic data bases of:
    a. paved and gravel roads from the digital road database; and
    b. no-harvest areas currently in place through the CCLUP.

Marten winter capability mapping

Capability mapping is used in this assessment to delineate the location of potential winter marten habitat and its relative long-term value. Only winter habitat was mapped because it is usually the most limiting habitat type. On the advice of a habitat mapping specialist, we assumed that capability classes 1 to 3 include all of the areas with reasonably adequate habitat potential, while classes 1 and 2 include high quality habitat potential.

Identification of suitable marten winter habitat

Suitable habitat is defined for this assessment based on forest age, and includes only stands with 50% or greater conifer composition. The identified suitable habitat is assumed to be moderate and higher suitability. Forest stands with less than 50% conifer or an age lower than the tabulated age for moderate habitat suitability are considered to have low habitat suitability and not included in the modelled marten habitat.

Table 1. Forest age used to define moderate and high-suitability classes in the Cariboo Region.

Ecological types	Conifer forest stand age range	
	Moderate Habitat Suitability	**High Habitat Suitability**
Drier/less productive BECs	80-119	>119
Moist and wet BECs	70-99	>99

Note that for the current assessment, moderate and high-suitability habitat was combined into a single category of suitable marten habitat. The definition of the ecotypes in the Cariboo Region is the same as used for moose and is shown in Table 1.

Table 2. Criteria for delineation of three ecological strata for the Kamloops and Cariboo regions. These strata are used to provide tailor the model to a range of ecological conditions. Peach=dry ecotype, Yellow=moist ecotype, Green=wet ecotype.

BEC zone	Ecotype Classification by BEC Unit								
PP, BG	All								
IDF	xm	xh	xc	xw	dw	dm1	dk 1, 3, 4	dk2	mw
SBPS	xc	dc	mc	mk					
MS	xv	dv	xk	dc	dm	mw			
ESSF	xv	xc	dv	dc	mv	mc	mm	mw	wk
SBS	vk	dw	mc	mh	mw	mm	wk		
ICH	ICHdk	All others							
CWH	All								
MH	All								

Habitat effectiveness

Habitat close to well-used roads is assumed to have reduced habitat effectiveness. These are referred to as areas with disturbance, defined as follows:

Area with disturbance = Suitable Marten Winter Habitat within 200 m of a road (gravel or paved) or disturbance area (e.g., mine site).

Assessment of reduced marten habitat

Current marten habitat area is compared with the area available in a simulated undeveloped landscape which is used as a baseline reference point. This undeveloped landscape is created in GIS by replacing logged areas with conifer stands >80 years of age. The area of suitable marten habitat in the undeveloped landscape is then compared with the current landscape to determine the degree of change.

Using this undeveloped landscape as a reference point for the analysis is a simple approach to assessing landscape change which does not incorporate the potential landscape composition effects of natural disturbance. However, after examination of the options, this approach was selected because it provides a way of documenting how much habitat change has happened up to the present and because it does so spatially.

For moose, this spatially explicit analysis recognized the need to have current forest cover adjacent or close to important feeding areas. It also allowed habitat suitability (current patterns of winter habitat) to be assessed in relation to habitat capability. In addition, this assessment provides a baseline for evaluation of moose forage areas created by forest harvesting and wildfire.

For marten, the spatially explicit analysis also allowed the patterns of currently suitable habitat to be assessed in relation to mapped habitat capability. The alternative method of comparing non-spatial habitat proportions to habitat proportions in a modelled naturally disturbed landscape would reflect rates of natural disturbance but would lack the critical spatial specificity.

The use of a simple reference landscape allows for very meaningful, spatially explicit assessments. The possible errors resulting from the use of this method due to the omission of natural disturbance are acknowledged. Therefore the raw numbers for habitat "reduction indicators are an approximate measure of divergence between a consistent reference landscape and current conditions. This comparison is intended to provide a meaningful indication of relative habitat conditions across the region.

Natural disturbance

Natural disturbance effects were not quantitatively included in the ratings. However, Map 6 shows estimated stand mortality from mountain pine beetle and the percent of stand with estimated stand mortality of 50%+ is included in the report for each assessment unit.

Based on a discussion with biologist, Larry Davis, specific natural disturbances would reduce estimated habitat suitability as follows:

- High-intensity fires would change habitat suitability from high to low; and
- Unlogged, high-mortality mountain beetle stands would likely be reduced from high suitability to moderate suitability.