Environmental Risk Assessment: Base Case

SYNOPSIS

DRAFT

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Executive Summary

The primary objective of this Environmental Risk Assessment (ERA) Report is to present the North Coast LRMP Base Case risk assessments for four environmental indicators: Coarse Filter Biodiversity, Marbled Murrelet, Mountain Goat, and Grizzly Bear. Environmental Risk Assessment (ERA) is a technical process intended to improve planning and decision-making by providing information on the potential implications to environmental values of land use decisions. This ERA has been produced by a team of government, private sector, and university biologists and modellers. The primary assumption of this ERA is that industrial forest harvesting, as presently practiced, is the primary land use change that might put environmental values and indicators at risk. To model changes in forest condition over time we used results of a spatial timber supply simulator known as Spatially Explicit Landscape Event Simulator (SELES). Experts on each of the indicators used outputs from SELES to run static models and Bayesian Belief Network models projecting changes to the indicator, and associated risks, from time 0 to time 250 years. A Bayesian Belief Network allows the combination of documented data on functional relationships, plus expert opinion on likely relationships, plus a measure of the expert's confidence in the likelihood of the relationships.

Coarse Filter Biodiversity

An Environmental Risk Assessment (ERA) was performed for the North Coast LRMP planning area, in order to assess the implications of the current Base Case forest management scenario on coarse filter biodiversity values.

ERA involves a number of steps, in particular

- identifying appropriate indicators for the environmental value
- identifying an ecological benchmark against which risk can be measured
- identifying risk relationships and thresholds
- and summarising trends through time

We used the abundance, extent of representation, and landscape patterning of old forest ecosystems as our basic indicators of the probability of maintaining coarse filter biological diversity, function and ultimately ecological integrity in the planning area over time. This was considered an appropriate set of indicators for this ecological value in this landscape because the natural disturbance patterns primarily result in old forest dominating the landscape.

In order to identify an ecological benchmark, we predict the mean and standard deviation in stand-replacing natural disturbance frequency based on the current seral stage frequency of BEC variants in the NC area. The results from this approach agreed with expert opinion regarding the likely frequency of stand-replacing disturbance intervals on the North Coast. The exponential equation was then used to predict the mean (and range) percent of old forest that would occur naturally in these ecosystems. Sensitivity analysis shows that predicted old forest abundance is relatively insensitive to variation in stand-replacing disturbance frequency within the range of estimates considered appropriate for these ecosystems.

Output from spatial timber supply modelling (from SELES) was used to provide data on the projected abundance and distribution of old forest within different ecosystems (defined by Analysis Units within biogeoclimatic variants), through time from 0 – 250 years. Comparing predicted natural abundance of old forest within ecosystems to that from the modelling scenario at each time period is our primary indicator of risk for each ecosystem. This 'base risk' level could then be modified (up or down) where appropriate by the Ecosystem Conservation Value (a combination of Ecosystem Biological Value and Ecosystem Influence), Percent in Protected Areas, Patch Metrics and the Percent Recovery of Harvested Ecosystems.

Overall, there was high divergence from the naturally predicted percent of old forest both currently, and into the future, for all high productivity ecosystems, and for most medium productivity ecosystems. There was little or no deviation from predicted natural abundance of old forest for low productivity ecosystems. We interpret the extent of the deviation from natural for the high and medium productivity systems to indicate that these units are mostly at high risk, and that the risk increases through time. Ecosystem Conservation Value resulted in a very small increase in risk for some ecosystems, though the model was relatively insensitive to this parameter. Patch metric analysis showed for all CWH variants (lower elevation) that considerably less forest is found in patches greater than 500m through time. This trend is also apparent but less dramatic for the MH zones (higher elevation). We suggest that although it is difficult to interpret landscape metric and fragmentation indices such as this for general biodiversity values, these trends may result in an increasing risk to some elements of biodiversity. The amount of younger forest existing in Protected Areas was too low provide a downward pressure on risk, as was recovery of harvested areas.

Identifying risk thresholds is a key element of any risk analysis. As a base set of thresholds, we interpreted percent deviation from natural (0 –100%) to correspond linearly to 5 equal risk classes from very low to very high (0-20% deviation is considered very low risk; 80-100% deviation is considered very high risk). Sensitivity analyses for this model showed that the risk outputs were quite insensitive to the risk categories used. This gives us increased confidence in the relative risk rankings estimated from the assessment model.

Modelling techniques used include direct assessment of trends of old forest abundance through time, in addition to more complicated modelling using a Bayesian Belief Network Model (BBN). The BBN allowed us to incorporate expert opinion and uncertainties into the model, and also presents output in terms of probabilities. This approach will be useful in assessing future scenarios.

Marbled Murrelet

The North Coast LRMP area represents roughly 10% of the BC population of marbled murrelets (*Brachyramphus marmoratus*).

Future nesting carrying capacity and risk to long-term persistence, along with uncertainty of those estimates, were estimated for the "base case" scenario. Present and future landscape condition was taken from the SELES simulations, and processed using 3 alternative assumptions of acceptable habitat. Results from the habitat models were then applied in a population model to examine potential future population size and risk to long-term persistence.

Under the most conservative habitat assumption, there was a 39% decline in nesting capacity, reached at about 200 years. The "best" estimate (weighted average of the models) was a 28% decline. The general distribution of habitat within the plan area was maintained, although some landscape units were more heavily impacted then others. Even with conservative habitat assumptions, and incorporating identified sources of uncertainty, there was little predicted increase in risk to murrelet persistence in the plan area as a result of reduced nesting habitat.

Mountain Goat

The mountain goat is a yellow-listed ungulate that occurs throughout the mountainous regions of British Columbia including the Coast Mountains of the North Coast Forest District. In other jurisdictions evidence is mounting that development has had, and continues to have, negative impacts on individuals and populations of mountain goats. In the past the primary habitat factor at risk was their winter range but expanding access to both summer and winter range is increasing the risk of disturbance and direct mortality.

This ERA uses three indicators: the loss of snow interception, the relative increase in road associated disturbance, and the population fragility to establish the risk to mountain goat population in 33 Landscape Units (LU). A natural range of variability is estimated for the proportion of forested cover in winter range units by ecosection to help quantify the risk of harvesting winter range areas. Data was originally derived from provincial databases and the forest modelling program SELES. Indicators were run through a Bayesian belief network to provide risk values with associated uncertainties.

The results indicate that the 15 of LU's have a very low risk and 16 have a low risk. Two landscape units, the Kitsault and the Pa-aat LU, were identified with a moderate risk rating. On a district scale there is less than 5% overlap between the timber harvesting landbase and identified winter range although individual landscape units, such as the Kitsault LU, had up to 25% overlap. In most landscape units the harvesting related forest cover loss will remain within the range of natural variability. The road disturbance indicator suggests that some landscape units, including the Pa-aat, Quottoon and Somerville, will incur significant increases in traffic and human access although the actual indicators should be interpreted with caution. Mitigation options to perceived impacts would include any measure that limits forest cover loss and increasing human access in winter range units. Possible options include extending rotation age in winter range, protecting the winter range with a no treatment buffer adjacent to confirmed winter ranges, or through strategic placement of retention areas associated with visual resource management, wildlife tree patches and wildlife habitat areas. Partial cut systems and enhanced stand tending could also be employed to reduce impacts.

Grizzly Bear

This summary, and the associated report, will be submitted at a later date.

Environmental Risk Assessment for the North Coast LRMP

1.0 Objectives

The primary objective of this Environmental Risk Assessment (ERA) Report is to present the Base Case risk assessments for four environmental indicators: Coarse Filter Biodiversity, Marbled Murrelet, Grizzly Bear and Mountain Goat. A secondary objective is to suggest potentially useful land use and management scenarios that might be modeled later in the North Coast LRMP process so as to minimize or mitigate some of the risk identified for each indicator

2.0 Structure of the Report

This report is a compilation of four individual environmental risk analyses. An introductory chapter outlining the scope and general approach of the ERA, is followed by four chapters, each of which deals with one of the indicators. Individual chapters are structured as stand-alone documents. They were authored as follows:

Coarse filter biodiversity: Rachel F. Holt (Veridian Ecological Consulting Ltd.) and Glenn Sutherland (Cortex Consultants Inc.)

Marbled Murrelet: Doug Steventon (Wildlife Habitat Ecologist, Research Branch, Ministry of Forests, Prince Rupert Forest Region)

Mountain Goat: Brad Pollard (Acer Resource Consulting Ltd.).

Grizzly Bear: Tony Hamilton (Large Carnivore Ecologist, Terrestrial Ecosystems Branch, Ministry of Water, Land and Air Protection).

The report was compiled and edited by Don Reid (Ministry of Sustainable Resource Management, Skeena Region) and Rachel Holt (Veridian Ecological Consulting Ltd).

Questions regarding approach should be directed to compilers, and questions regarding individual reports should be directed to primary authors of the chapters.

3.0 What is Environmental Risk Assessment?

Environmental Risk Assessment (ERA) is a technical process intended to improve planning and decision-making by providing information on the potential implications to environmental values of land use decisions. All such decisions result in some change to the continued abundance, distribution or persistence of one or other resources or ecological processes (i.e. values) through time. Some of these changes might pose a risk (i.e. some probability of an undesirable outcome) to a particular resource or process. ERA attempts to quantify such risk(s) so that society can make more explicit choices about what risks to accept, trade-off or mitigate.

ERA can provide two types of output:

– *estimate of relative* risks *to environmental values associated with different scenarios, and/ or*

– *estimate of absolute* risks *to environmental values associated with a particular scenario.*

Each of these approaches has merits. In ERA, considering absolute risks (i.e. is risk high or low, rather than higher or lower) can be crucial (Holt and Utzig 2002): a detailed analysis that determines scenario A is higher risk than scenario B may be meaningless if both options result in very high probability of species extinctions. Alternatively, lack of ecological knowledge often makes absolute risk assessments difficult. For example, it may be known that a given scenario results in a population size reducing to one half of the original. Yet re-interpreting the population change in terms of an absolute risk level (moderate, high, very high) can often be difficult. The following chapters deal with the ERA for individual indicators in relation to a single scenario – the Base Case. The outputs are therefore absolute because no comparisons are involved. As scenarios are developed by the table this absolute evaluation will be augmented by relative risk values associated with each scenario.

The Province has developed a methodology for ERA (Ministry of Environment 2000). We have followed this methodology in broad outline. There are five main components:

1. identify and characterize key environmental pressures.
2. identify appropriate environmental values (criteria) and indicators for the ERA.
3. define a benchmark / basecase[1] for comparison.
4. characterize environmental trends and indicator relationships to environmental change, and establish risk classes based on divergence from the ecological benchmark / basecase.
5. evaluate past and predicted changes to indicators and categorize environmental risks.

The key environmental pressure addressed is forest harvesting. The indicators reported in this ERA were selected through workshops (Daust 2001, and see below). The benchmark for these ERA analyses is either present condition (often as represented by habitat suitability) or range of natural variability in representation of forest stand types and ages. This report then encompasses much of steps 4 and 5.

[1] [1] The term 'base case' has been used to define the natural comparison against which indicators are measured (ERA document MELP). However, in order to prevent confusion with the timber supply 'base case' which defines current management, we here used the term benchmark to denote the natural condition. Benchmark, base case or baseline are considered synonymous here; similar to the "reference ecosystem" concept.

Other LRMPs in the Province have used different approaches for assessing risk to environmental values. Typically, staff or consultants have rated risk to an environmental value (account) within a number of risk classes based on expert opinion derived from personal knowledge of the value or its indicator under each of the potential land use scenarios. They have then employed Multiple Accounts Analysis (MAA) wherein risks to all environmental values (indicators) are summed under each scenario, and compared to the sum of risks to economic or social values (indicators) under the same scenario. The Table then makes the "social choice" regarding the costs and benefits of the risks to the various values. In this approach, the expert opinion may seem quite subjectively derived, and is sometimes not clearly articulated for others to understand. Also, the various factors affecting the value and its indicator have not often been explicitly modelled in relation to land use scenarios. Recent development of more sophisticated modelling techniques, in concert with the high ecological values and high public interest in the coastal region, led to a decision that the North Coast LRMP should include a more detailed approach to ERA. We provide details in the next section.

4.0 Conceptual Approach for the North Coast LRMP

Environmental values are complex and relatively difficult to define or measure, and therefore predicting future responses to land use decisions is relatively difficult. To deal with these problems an ERA requires the choice of indicators for each environmental value, or each identified criterion of environmental change

The utility of an ERA is based on how well the indicators chosen actually represent the environmental values at stake. The primary assumption of this ERA is that industrial forest harvesting is the primary land use change putting environmental values and indicators at risk. During a series of technical meetings in 2001 a list of potential indicators was developed (Daust 2001). Environmental indicators for the Base Case have been divided into (i) those for which we have sufficient information to warrant detailed modelling (i.e. the topics of this ERA), and (ii) a number of environmental accounts for which we have less confidence in our knowledge, and less time, to produce projections. Some of these will be reported on separately.

The indicators for this ERA are:

– Coarse filter biodiversity (CF). Here the indicator is actually the representation of all potential ecosystem (plant community) types by seral (age) class in the landscape. Since North Coast forests are relatively rarely subject to stand-initiating disturbances producing an early seral (young forest) condition, the primary risk is believed to be conversion of old forest to relatively young forest by harvesting. This indicator reflects the fact the a very large proportion of coastal forest biodiversity is in the form of plants and arthropods in old forests, and that old forest ecosystems on the coast of British Columbia are globally unique. Applying this indicator assumes that adequate management of old forest ecosystems will result in adequate management of the majority of species in the landscape.

– Marbled Murrelet (MaMu). Here the indicators are the amount of nesting habitat available, and population persistence. The Marbled Murrelet is a provincially red-listed (endangered) bird species nesting mostly in old forest stands, and foraging on the ocean. One potential threat to viability of this species is believed to be loss of nesting habitat through forest harvesting.

– Grizzly Bear (GB). Here the indicator is the quality of foraging and security habitat. The Grizzly Bear is provincially blue-listed (threatened), and exists on the North Coast in relatively high densities. The primary risk from forest development is increased hunting mortality due to enhanced human access to grizzly bear habitats via forest service roads. Forest harvesting may improve or decrease habitat quality at different times after harvesting, and road traffic may displace some bears from some habitats.

– Mountain Goat (MG). Here the indicator is the integrity of winter ranges. The Mountain Goat is limited to relatively small winter ranges due to heavy snow, and many of these are in the forest land base. Risk to population persistence may result from forest harvesting of some of this range, and from increased hunting mortality due to enhanced human access to goat habitats via forest service roads.

Separate Environmental Accounts, not addressed in this ERA, will be prepared for:

– Watershed ranking. This will be a compilation of indicators on a watershed basis. These will include some special elements such as diversity and abundance of rare ecosystems, and extent of rare bedrock (karst) types. The idea is to present some indication of which watersheds have particularly unique or unusual biodiversity.

– Black Bear. Here the indicator is black bear overall habitat suitability. This habitat is not believed to be at high risk, but the species is believed to be of high social value.

– Moose. Here the indicator is moose winter habitat suitability. This winter habitat is not believed to be at high risk, but the species is believed to be of high social value.

– Black-tailed Deer. Here the indicator is deer winter habitat suitability. This winter habitat may be reduced by forest harvesting in portions of the plan area where snow is relatively deep.

– Fish Habitat. Here the indicator is a compilation of habitat quality estimates for anadromous fish species. Habitat quality may be at risk from forest development activities that change flow regimes, water quality, and riparian vegetation. These fish resources are key to the productivity of the terrestrial forest ecosystems, and are of high social value.

For each indicator we take results of modelling of changes in the forest condition over time, and use those results to drive models of the effects of the changes on the indicator itself. To model changes in forest condition over time we used results from a spatial timber supply and landscape dynamics simulator known as Spatially Explicit Landscape Event Simulator (SELES). Details on the SELES model language, and its routines, are presented elsewhere (Morgan *et al.* 2002), and are not the subject of this ERA. The SELES outputs that drive the indicator risk assessment models varied from indicator to indicator, but included projections of forest condition through time for six time periods (Time 0, Time 20, Time 50, Time 100, Time 200 and Time 250 years). The SELES model was calibrated to ensure corroboration of results obtained from standard timber supply analysis using FS-SIM,-the Ministry of Forests timber supply model.

Each author(s) developing the individual indicator models used approaches relevant for that indicator. However, each team used one or both of these formats:

a) A static modelling summary. This uses a database tool (e.g. Excel) to summarize static data on the indicator, often at different time intervals.

b) A Bayesian Belief Network (BBN) approach. A Bayesian Belief Network is built by identifying and linking ecological factors that are thought to influence a particular parameter in a functional relationship. The 'Bayesian' approach has become increasingly popular in the analysis of environmental indicators, because data are often relatively scant, making traditional statistics inappropriate (Marcot et al. 2002). A Bayesian network allows the combination of documented data on functional relationships, plus expert opinion on likely relationships, plus a measure of the expert's confidence in the likelihood of the relationships. Outputs can be presented in terms of the 'likelihood', or 'probability', or 'plausability' of a particular response. For this work, we used NETICA (Norsys Inc.) to build BBNs.

In addition, each team presents risk in five classes reflecting the probability of a risky outcome. These are Very Low (0-20%), Low (20-40%), Moderate (40-60%), High (60-80%), Very High (80-100%).

For each indicator the author(s) presents the details of the approach used. Some of the models are detailed so, where feasible, results are presented in the body of each chapter and necessary details are presented in appendices.

5.0 Team and Individual Modelling

For the North Coast LRMP process, a technical ERA team made up of government, private sector, and university biologists / modellers has worked together to produce the Base Case ERA. The full team participated in workshops to discuss and develop general approaches and work plans, and to deal with technical issues. The full team has included the topic experts (i.e. those developing the individual risk models), the SELES modellers, and some other knowledgeable technical staff (Table 1). Topic teams have developed the individual topic models. These topic teams have varied in size, but include the topic expert, modelling experts (particularly in Netica), and associated experts (e.g., government research biologists) to build risk curves.

Table 1. Members of the Environmental Risk Assessment Team (alphabetically).

Team Members	Task	Affiliation
Allen Banner	Ecologist: recovery tables for Coarse Filter ERA	Ministry of Forests Research, Smithers
Laura Bolster	Timber Supply Modelling	Ministry of Forests, Smithers
Hubert Burger	NC LRMP Technical Coordinator & Timber Supply Modelling	Ministry of Sustainable Resource Management, Smithers
Dave Daust	SELES modelling & data manipulation	Private consultant
Andrew Fall	SELES modelling	Simon Fraser University, Burnaby
Brian Fuhr	Biological adviser	Ministry of Sustainable Resource Management, Smithers
Tony Hamilton	Grizzly bear ERA	Ministry of Water, Land and Air Protection, Victoria
Rachel Holt	Coarse filter ERA	Veridian Ecological Consulting Ltd., Nelson
Hannah Horn	Coordinator before June 2002	Private Consultant
Sarma Liepins	Biological Adviser	Ministry of Sustainable Resource Management, Prince Rupert
Don Morgan	SELES modelling	Ministry of Forests Research, Smithers
Jim Pojar	Ecologist: recovery tables for Coarse Filter ERA	Ministry of Forests Research, Smithers
Brad Pollard	Mountain Goat ERA	Acer Resource Consulting Ltd., Terrace
Don Reid	Coordinator since June 2002	Ministry of Sustainable Resource Management, Smithers
Doug Steventon	Marbled Murrelet ERA & Netica guru	Ministry of Forests Research, Smithers
Glenn Sutherland	Coarse filter ERA	Cortex Consultants Inc., Vancouver

6.0 Management Assumptions

The modelling approach used for the Base Case follows the assumptions described by 'Current Management'. Principally these are the assumptions used in the timber supply analysis and presented in the North Coast Timber Supply Area Analysis Report (Ministry of Forests 1999. North Coast Timber Supply Area Analysis Report. B.C. Ministry of Forests. Victoria). A number of key assumptions relating to the Base Case are summarized in Table 2 of this document. Other details are presented in the report on SELES model development (Morgan *et al.* 2002), and in the individual chapters of this ERA.

One key assumption was changed for the Base Case analysis since it was accepted it would not influence timber supply (Hubert Burger pers. comm.). In the standard timber supply Base Case, the inoperable land base (i.e. the forested area not part of the harvestable land base) is allowed to "grow or age forever" and is never changed to younger stand types by simulated natural disturbances. This assumption has a large impact on environmental analyses, because it incorrectly assumes that all forest continues to age when in reality natural disturbances continue to disturb some proportion of the area. In this Base Case we assume that the inoperable land base does not continue to age indefinitely (Morgan *et al.* 2002)[2].

Table 2. The principal management assumptions used in the Base Case ERA.

Resource impacts	Current management assumptions for ERA analyses
Forestry	• 100% of harvesting as clearcut. • Within block retention as per Landscape Unit Guidebook. • Forest Practices Code riparian mgmt. • Replanting as per Species Selection Guidelines. • Ungulate winter range does not have designated management plans, and is not recognized by written order. • Current forest development plan road layout simulated in SELES.
Natural disturbances	• Seral stage distribution capped at current, assuming current age class distribution is at 'equilibrium' (see footnote 2).
Recreation/tourism	• Not addressed by ERA.

[2] Note: in three landscape units, the current seral stage distribution showed large areas of young forest, arising from a fume kill earlier this century. In these units we allowed the forest to continue to age.

Heliskiing/ hiking	• Not addressed by ERA.
Mining	• Not addressed by ERA.

7.0 References

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Norsys Inc. www.norsys.com Information on the Netica software.

Acknowledgements

The process of producing this report rests on a great deal of technical and process-oriented background work undertaken by the staff working for the North Coast LRMP. Many are noted as team members above (Table 1). In addition we would like to specifically acknowledge the hard work of Hannah Horn, who coordinated this work and the ERA team through its first year; Trisha Jarrett, William Elliot, James Warren and Johanna Pfalz of the Ministry of Sustainable Resource Management (MSRM) in Smithers who did a great deal of GIS mapping work to provide the background map layers for the modelling; and Eamon O'Donoghue who, as process coordinator for the NC LRMP, helped keep the work focussed.