Environmental Risk Assessment (ERA): An Approach for Assessing and Reporting Environmental Conditions

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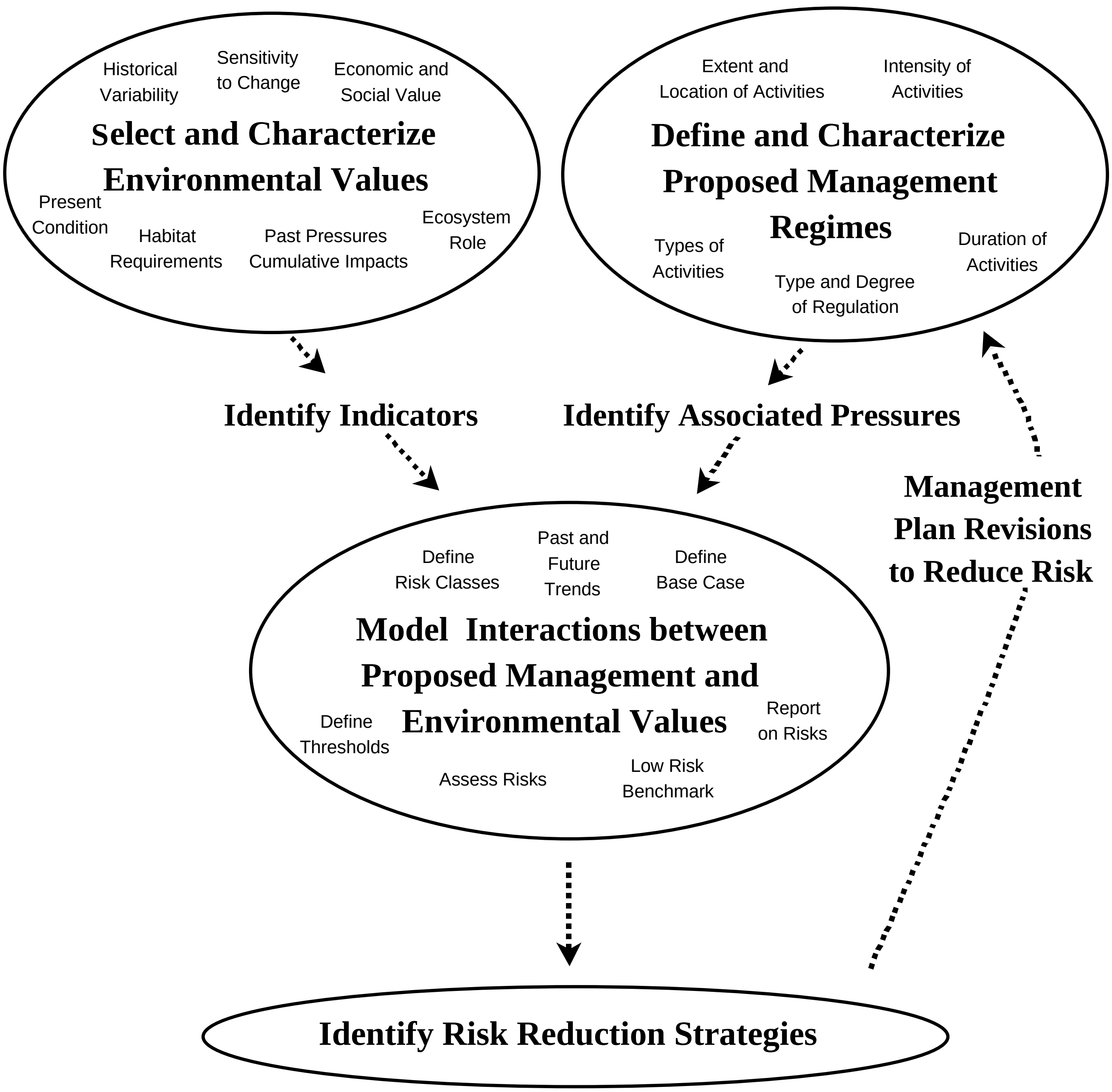
Acknowledgements

The material in this report has been drawn originally from a review of "environmental resource analysis" methods used in British Columbia strategic land use planning processes conducted in 1996. The review was managed by Marion Bernard of the Land Policy Branch, Ministry of Environment, Lands and Parks (MELP) and conducted by Colin Rankin, SALASAN Associates, Julian Griggs, Dovetail Consulting and Greg Utzig, Kutenai Nature Investigations. Many provincial government staff members involved with land use planning in BC provided information and advice to the review.

Following distribution of the review, MELP has been working to consolidate and coordinate approaches to environmental analysis used by the Ministry. Staff of Habitat Branch, including Rod Davis, Mike Fenger and Algis Janusauskas, have overseen development of this report. Review comments and consideration have been given by MELP staff across the province to various drafts and presentations. The report has been prepared by Greg Utzig of Kutenai Nature Investigations and Colin Rankin of SALASAN Associates and desktop and editorial assistance provided by Louise Beinhauer of Word Works. Many thanks to all who have been involved in its development and production.

It is our hope that the methods and examples provided in the report will be further refined and applied in support of consistent and effective environmental planning and management.

Exhibit 1: Role of Environmental Risk Assessment in Comparing Management Regimes and Revising Management Actions



Executive Summary

This report outlines an approach to Environmental Risk Assessment (ERA) with the aim of assisting government agency staff in assessing and reporting environmental conditions. The approach will also be of use to industry-based resource managers, First Nations, non-governmental organizations and others interested or currently participating in land use planning or the review of development proposals.

Environmental Risk Assessment is a process for estimating the likelihood or probability of an adverse outcome or event due to pressures or changes in environmental conditions resulting from human activities. ERA is complementary to methods used in State of Environment Reporting (SOE), Environmental Impact Assessment (EIA) and risk management. The approach involves identification, analysis and presentation of information in terms of risk to environmental values to inform planning and decision making processes — it does not presume to provide all social and economic information relevant to making decisions, nor is the approach intended to supplant planning and management processes.

ERA is a flexible tool that can be applied:

- at a variety of scales and levels of detail appropriate to those scales (e.g., provincial to site-specific);
- for a variety of environmental issues (e.g., from wildlife to water);
- at various levels of funding (i.e., for quick overviews to in-depth comprehensive studies); and,
- for short, medium or long-term time scales.

At the heart of ERA is an assessment of the interactions between management regimes and environmental values. The assessment and reporting of risk to environmental values can then be used to identify risk reduction strategies. Subsequent revisions to management plans and actions will then — hopefully — be undertaken to reduce risk. The process by which ERA can be used to model and assess management regimes is depicted in Exhibit 1.

Exhibit 2: Conceptual Framework for ERA

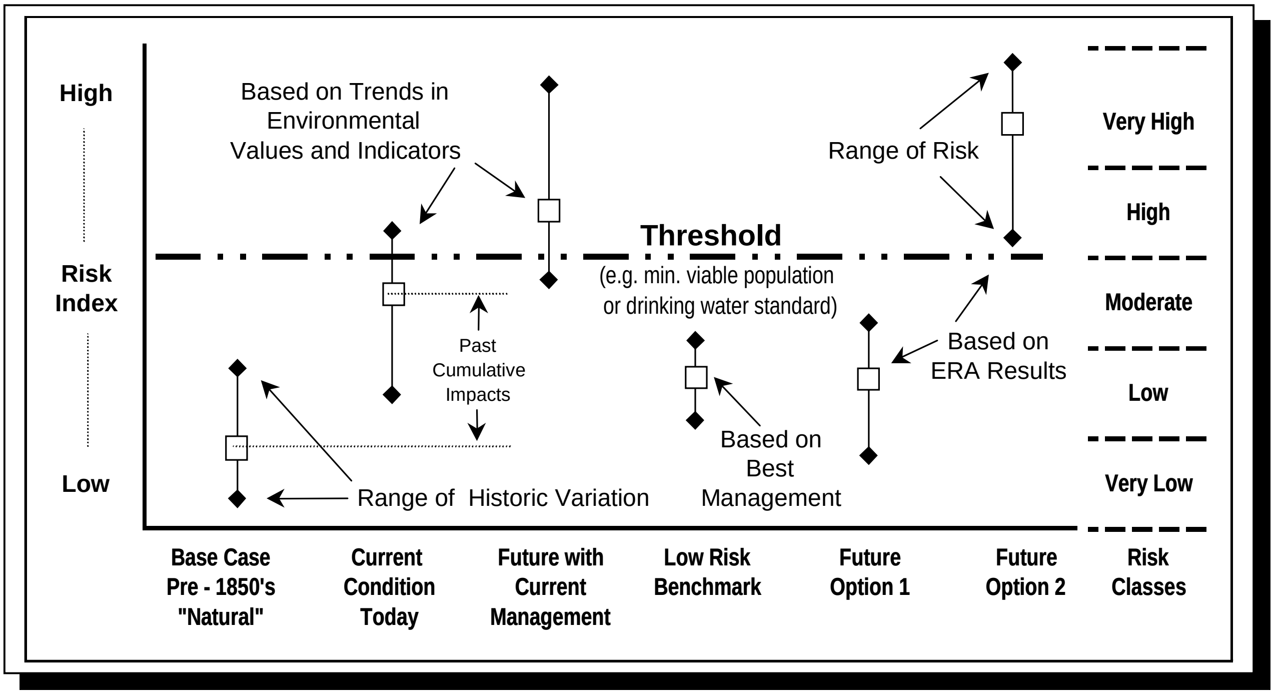


Exhibit 2 summarizes the conceptual framework for ERA — the assessment of risk to environmental values under past, present and predicted future conditions.

Environmental risk assessment is based on comparison of indicators of environmental values over time. Current conditions are compared against historic “natural” range of variation and predicted future ranges based on differing management scenarios. Assessment of environmental conditions and indicators is summarized in terms of a “risk index.”

The report outlines tasks and descriptions of six steps in the ERA approach:

1. Establish the context for ERA
2. Identify and characterize key environmental pressures
3. Specify environmental values and indicators for the ERA
4. Characterize environmental trends, indicator relationships and establish risk classes
5. Evaluate changes to indicators and risks
6. Report results and develop risk reduction strategies

These steps are summarized in Exhibit 8.

List of Abbreviations and Acronyms Used in this Report

AAC	Allowable Annual Cut
BEC	Biogeoclimatic Ecosystem Classification
CAP	Channel Assessment Procedure
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWD	Coarse Woody Debris
EA	Environmental Assessment
ECA	Equivalent Clearcut Area
EIA	Environmental Impact Assessment
ERA	Environmental Risk Assessment
FEN	Forest Ecosystem Network
FDP	Forest Development Plan
FPC	Forest Practices Code
FSSIM	Forest Service Simulator (Timber Supply Model)
GIS	Geographical Information System
HLP	Higher Level Plan
IWAP	Interior Watershed Assessment Procedures
IWMP	Integrated Watershed Management Plan
KBLUP	Kootenay/Boundary Land Use Plan
LRMP	Land and Resource Management Plan
LU	Landscape Unit
MAA	Multiple Accounts Analysis
MELP	Ministry of Environment, Lands and Parks
MoF	Ministry of Forests
MU	Management Units
MVP	Minimum Viable Population
NGO	Non-governmental Organization
OG	Old Growth
PA	Protected Area
PFA	Post Fledgling Area
SOE	State of Environment Reporting
TFL	Tree Farm License
TLMP	Tongass Land Management Plan
TSA	Timber Supply Area
TSR	Timber Supply Review
USDA	United States Department of Agriculture
USFS	United States Forest Service
WAP	Watershed Assessment Procedure
WHA	Wildlife Habitat Area
WMA	Wildlife Management Area

Glossary

Key terms and concepts central to the ERA approach include:

Environmental Risk Assessment An estimate of the likelihood or probability of an adverse impact on the environment resulting from human activities.

Environmental Value An aspect of the environment that is important because of its ecological, economic or social significance to an ecosystem, the potential consequences of its loss, and/or its economic or social importance. The term "value" is not used solely in its economic sense. Examples include old-growth dependent species, domestic water supplies, salmon or viewscapes.

Indicator A parameter that can be measured, observed or derived, and which provides information about patterns or trends in the environment. There are many different kinds of indicators, including both qualitative and quantitative information (e.g., percentage of protected areas, seral stage distribution, number of endangered species, single species distribution changes). Even quantitative indicators are often not free of qualitative judgements. In many cases qualitative information may provide adequate support for trend analysis. Any data uncertainty should be explicitly recognized.

Natural Conditions Environmental conditions within the range of historic variability prior to European settlement. In most cases, "natural conditions" should be described in terms of a long term average or norm, with accompanying ranges for specified conditions (e.g., mean seasonal stream flows with historic maximum and minimums; peak flows with mean return intervals).

Pressure A factor affecting ecosystem processes, functions or attributes, which are related to human actions. Impacts from past pressures have resulted in a variety of cumulative effects (e.g., land use decisions, dam construction, Workers Compensation Board-required snag removal, pulp markets and the loss of coarse woody debris).

Risk The likelihood or probability of an adverse outcome or event. In this report, risk refers to risk to the environment.

Risk Class A degree of risk (e.g., very high, high, moderate, low, very low) with "definable" limits for each class (e.g., "very low risk" is < x% change in a given suite of indicators, or < x% probability of an undesirable outcome over the next 100 years).

Environmental Risk Assessment (ERA): An Approach to Assessing and Reporting Environmental Conditions

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List of Exhibits and Figures

Exhibit 3: Environmental Principles Guiding Ministry Activities

The Ministry of Environment, Lands and Parks and the Ministry of Fisheries have a legislative mandate for the stewardship and appropriate management of BC's environment. This includes the conservation of biological diversity; stewardship of water, fish and wildlife; the protection of human health; and the regulation of activities affecting the environment. The eight environmental principles below are intended as guidance in a staged program of environmental action.

Stewardship	Taking a long-term and integrated view of resource management — air, water, land, plants and animals — recognising the dependent relationships of humans on the environment and that environmental health is fundamental to economic and human health.
Sustainability	Resources should not be used beyond their capacity to be naturally replenished, both in quality and quantity, for the well-being of future generations.
Precautionary Principle	The onus of proof should be on parties, undertaking actions which could cause serious or irreversible environmental damage, to prove beyond a reasonable doubt that no damage will be caused.
Pollution Prevention	Reduction or elimination of pollutants should be at their source. This contrasts with "end of pipe" controls on waste generated after the damage has been done.
User Pays	Users of the environment and resources should pay fair value for use of natural capital, and should exercise this privilege with care and consideration of other living beings. The user pay principle places the responsibility for sound environmental stewardship of products on industry, from the point of manufacturing to the point of final disposal.
Environmental Equity	All species — human, animal and plant — have an intrinsic right to a healthy environment and this right extends beyond the present generation to the future generations. No segment of these populations should bear disproportionately high adverse effects.
Shared Responsibility	Full participation and commitment of all societal groups fosters smoother transition to sustainability than if these groups work independently of one another.

Source: MELP 1996.

1. INTRODUCTION

This report outlines an approach to Environmental Risk Assessment (ERA) with the aim of assisting government agency staff in meeting their responsibilities (see Exhibit 3). It is intended to lead the Ministry toward a consistent method for assessing and reporting environmental risk. The report builds on earlier efforts in BC and elsewhere to develop environmental resource analyses (e.g., Land and Resource Management Planning (LRMP) environmental and multiple accounts analyses).

The report focuses on risk assessment within land use planning and development review, such as Land and Resource Management Planning (LRMPs) and Timber Supply Reviews (TSRs). This approach to ERA may also have application in other situations, both within and outside of provincial government programs.

The report is formatted with central text on the right (odd numbered) pages of the document and supplementary figures, tables and text on the left (even numbered) pages. The supplementary information is labelled with an “Exhibit number” — titled and tabulated in the Table of Contents along with text references.

Exhibit 4: Emerging Use of Risk Assessment in Canada and the United States

The presentation of environmental information in terms of risk is becoming increasingly common in various disciplines and jurisdictions. For example, several bills have been introduced in the U.S. Congress mandating that agencies use risk assessment to set priorities and budgets (e.g., *Environmental Risk Reduction Act*). Scientific panels, such as the National Research Council, have made similar recommendations, which have been echoed in many influential publications (see Lackey [1994]). From insurance brokerage to public health care, a body of procedures and tools has been developed to assess risk.

The most relevant risk assessment methods come from two distinct applications:

- assessment of environmental risks to human health (e.g., contaminated sites, pesticides); and,
- population viability assessments for rare or endangered species based on conservation biology.

Risk assessment is also being applied to increasingly complex issues. For example, the U.S. Forest Service has applied concepts of viable population to complex multi-resource analyses, such as assessing habitat management for the Northern Spotted Owl and in developing the 1997 management plan for the Tongass National Forest (see U.S.D.A. et al. 1993 or Everest et. al. [1997] and Soulé and Kohm [1989]).

The use of risk assessment in analyzing increasingly complex issues has prompted a refinement of methodologies. In particular, many of the methodologies are now incorporating both quantitative and qualitative information. This particular refinement has important implications for land managers, as it validates reliance on professional judgment and allows for the consideration of various aspects of the environment in natural resource management that have thus far been difficult or impossible to quantify.

2. BACKGROUND AND RATIONALE

2.1 The Need for Methods to Assess and Forecast Environmental Risk

As pressures on the environment increase, there is a need for understanding the resulting environmental risks. Forecasts of risk to the environment could provide basic information needed for sustainable resource development decisions — however, such information is often lacking. In response to this need, based on a review of methodologies used recently in BC and in other jurisdictions, the project team has developed an Environmental Risk Assessment (ERA) approach for assessing and reporting on environmental risk. The approach has application at a variety of scales or levels of detail.

2.2 What is Risk Assessment?

Environmental Risk Assessment (ERA) is a process that evaluates the likelihood or probability that adverse effects may occur to environmental values, as a result of human activities (i.e., a formal procedure for identifying and estimating the risk of environmental damage).

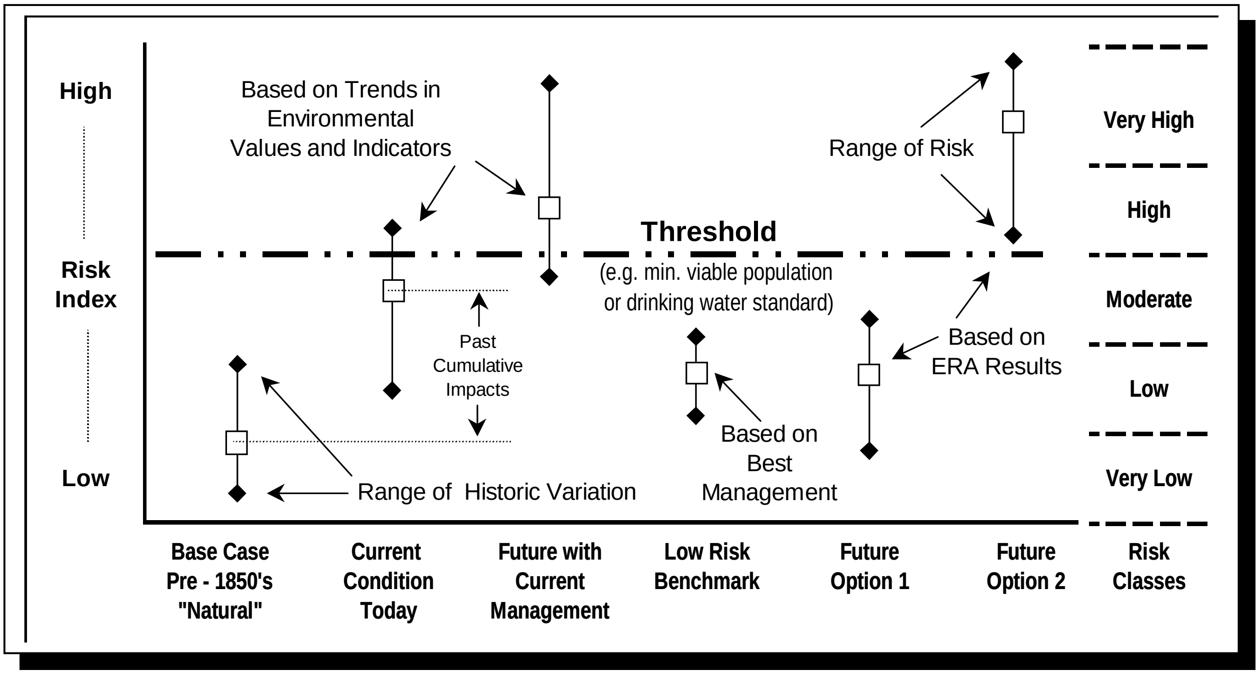
The ERA procedure is triggered prior to a significant decision affecting the environment. It can be broken into three broad stages:

- preparation, involving collecting and examining relevant background information, and establishing the focus for the assessment;
- conducting the assessment; and,
- interpreting, reporting and applying results of the assessment.

ERA is a support tool for policy evaluation, land use planning, and resource management decision making. It is systematic, and can be applied in a variety of situations, ranging from those with minimal available data and resources, to those with detailed inventories and complex systems modeling. ERA can be used on the back of an envelope while preparing for a meeting, or developed to provide risk information to a formal legislated process such as Timber Supply Review.

ERA provides information for making reasoned decisions by defining the range of risks associated with various options, but it does not dictate a specific outcome. ERA also provides a mechanism for managers to communicate forecasted risks associated with decisions, such that stakeholders and the public are informed of the implications for environmental values (e.g., Everest et. al. [1997]).

Exhibit 5: Conceptual Framework for ERA



2.3 Conceptual Framework for ERA

Environmental risk assessment is based on comparison of environmental indicators, as they change over time (see Exhibit 5). Current and predicted future ranges of conditions are compared against the historic range of variation for those conditions (i.e., "natural"). The base case, or the historic range of conditions, is determined by monitoring of undisturbed areas and analysis of natural disturbance regimes and historic records. The difference in risk between current and historic conditions is the result of cumulative impacts of past development and disturbance. Future conditions are based on the trends and long-term implications of continuing present management, or the predicted outcomes of potential alternative management options.

Assessment of environmental conditions and indicators is summarized in terms of a "risk index," and generally reported by means of a series of risk classes. As a part of the risk analysis, it may be useful to define specific thresholds, or a low risk benchmark based on best management practices.

A more detailed description and suggested procedures for describing the range of conditions for environmental values and establishing risk classes is provided in "Step 4" of this report.

2.4 Strengths of Environmental Risk Assessments

ERA is of particular value because it brings to the forefront the environmental consequences of decisions (see Exhibit 6). In doing so, ERA shifts the focus from justifying the merits of a particular action or strategy, and instead, illuminates likely outcomes and their desirability. By making explicit the factors that pose risks to the environment, ERA requires acknowledgement of risks to the environment before and after decisions are made. Awareness of risk encourages the distribution of accountability and a collective sharing of responsibility for managing that risk, and will hopefully lead to decisions that reduce risk.

ERA is also flexible, capable of being applied to complex in-depth analyses or in situations requiring rapid response answers (e.g., see Exhibit 10).

Exhibit 6: Strengths of ERA

ERA is a flexible tool that can be applied:

- at a variety of scales and levels of detail appropriate to those scales (e.g., provincial to site-specific);
- for a variety of environmental issues (e.g., from wildlife to water);
- at various levels of funding (i.e., from quick overviews to in-depth comprehensive studies); and,
- for short, medium or long-term time scales.

ERA has the following strengths:

- a concept (risk or threat) widely understood by the public, clearly illustrating the future consequences of choices;
- provision of explicit criteria for consideration in making decisions, encouraging transparency and accountability;
- creation of a framework for debate that clearly separates risk assessment from decision making, and can provide a vehicle for improving dialogue over highly contentious environmental management or development issues;
- providing reassurance to stakeholders that potential changes to the environment due to human activities are being considered;
- building understanding of the relationships between the environment and human activity;
- identification of the consequences of alternative management actions;
- acknowledgement of assumptions and information used; and,
- scientific validity, defensibility and replicability.

2.5 Limitations of Environmental Risk Assessment

ERA will clarify risk to the environment from a decision, but it will not be able to set an acceptable threshold of risk. Determining acceptable risk is an issue of risk management. Risk assessment is a basis for judgments about impacts but not for judgments on the acceptability of impacts. Decision-makers must choose a desired or acceptable level of risk.

ERA has the following limitations:

- risk tolerance is relative – individuals and institutions have differing perceptions, tolerance and acceptance of risk; and,
- isolating the risks associated with a decision can be difficult – there is a range of natural variability within ecosystems, differing tolerances to stress, and varying rates of recovery.

2.6 Relation to State of Environment Reporting, Environmental Impact Assessment and Risk Management

The approach to ERA outlined in this report complements existing assessment and reporting methodologies employed by MELP, including State of Environment Reporting (SOE) and Environmental Impact Assessment (EIA). ERA is also complementary to Forest Practices Code risk management framework used by the Compliance and Enforcement Branch of the Ministry of Forests (MoF).

State of Environmental Reporting

State of Environment Reporting (SOE) is a general approach used to report environmental conditions. SOE is often used to identify macro-scale trends of general relevance or interest to the public (see http://www.elp.gov.bc.ca/sppl/soerpt). It has become a key tool in establishing baseline conditions and trends, and can serve as an early warning system to identify key environmental issues and associated management challenges. The four fundamental questions generally addressed by a State of Environment Report are (MELP and Environment Canada, 1993, p. 1):

- What is happening in the environment?
- Why is it happening?
- Why is it significant?
- What are we doing about it?

Exhibit 7: Accommodating Uncertainty and Qualitative Information

"The sources of uncertainty include the complexity of natural systems, natural variability in space and time, random variation, errors of measurement, and lack of information. [It is generally recommended] that managers be conservative,… that they use adaptive environmental management (i.e., frequently test the effects of their management and be ready to modify it accordingly), that they use models, and that their models include error and sensitivity analyses… Ecologists must not retreat behind the shield of uncertainty… when asked for their advice. Someone is going to make the decision with or without their advice, and if ecologists' advice on ecological problems is not at least somewhat useful, then it is difficult to justify public support of their activities."

Source: Policansky (nd: p. 42)

"The trend toward narrow, single-purpose thinking is partially traceable to the growing emphasis on analysis as an end in itself. Precision and rigor are more accepted as methods of good research than holism and generality. Because only small and well-bounded problems can be rigorously analyzed, the tendency of science and analysis to reduce problems to their component parts has greatly contributed to and fostered narrow decision making.… There is, I believe, a good case to be made for being roughly right about an issue or problem of some substance and importance, rather than being precisely wrong about trivia. … This choice is not between analysis or synthesis but rather how to draw effectively on both methods of inquiry."

Source: Michael Goldberg (1989: pp. 7-8)

Quantitative analysis uses numerical measurements to describe conditions, relationships and trends. Qualitative analysis, on the other hand, involves describing conditions and relationships based on existing scientific research, experience and judgment. Qualitative analysis generally relies on words rather than numbers, although rating scales may be used (e.g. "very good" to "very poor" conditions can be translated into a +2 to -2 rating scale, while still being fundamentally qualitative). Both types of analysis have a role to play in environmental analysis, which often relies on professional judgment when dealing with complexities and uncertainties.

Most analysis is neither purely quantitative nor qualitative. For example, a qualitative analysis of biodiversity may be based in part on some numerical measurements (e.g., number of rare and endangered species). In general, a good qualitative assessment is better than a poor quantitative one. Experience suggests that strategic land and resource planning tables will accept the results of qualitative analysis if the reasons behind the assessment are explained. In fact, translating limited data into quantitative statements often faces serious criticism.

Expert opinion, expressed in an understandable format, is more valuable and more likely to be accepted than detailed quantitative analysis, which is not supported by explicit assumptions or rationale. It must be remembered that even "quantitative" analyses are based to varying degrees on assumptions and "expert opinion." Algorithms based on assumptions and extrapolated data are involved in habitat capability modeling and population assessments, just as they are in timber growth and yield modeling. Finally, one piece of summary advice from practitioners regarding choice and explanation of analysis methodology —"remember, it is better to be generally right than precisely wrong."

Source: MELP (1995)

ERA can also be used to report environmental conditions, addressing these fundamental questions. ERA differs from SOE, however, in that it uses risk to the environment as the basis for reporting. While SOE focuses on the present state of the environment and trends resulting from past management, ERA also looks ahead, forecasting potential future environmental risks resulting from today's decisions regarding proposed policies, practices or developments.

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is an assessment procedure with stages set out in government legislation and policy. EIA is most commonly used as a framework for investigating the effects or consequences of major proposed development projects such as mines, hydro-electric developments or manufacturing facilities.

ERA differs from EIA by focusing first on environmental conditions, then on the factors causing changes to these conditions. EIA generally focuses on a specific project and the nature of its impacts on the environment.

Risk Management

The primary objective of the MoF risk management framework (MoF 1998 and 1999) is to provide managers with a context for decision-making that will allow them to:

- "achieve optimal or at the very least acceptable levels of risk, where benefits flowing from a particular action or decision outweigh the potential loss or damage; and
- avoid unacceptable levels of risks, where the likelihood and magnitude of the potential loss or damage outweigh the expected benefits, or where the magnitude of the potential loss or damage, regardless of likelihood, is such that it cannot be reversed or mitigated."

The MoF risk management framework includes consideration of risks to environmental, social and economic values, as well as other factors such as the performance history of the development proponent. Within this framework, ERA provides a method for determination of the environmental risk aspect of the risk management process.

Exhibit 8: Summary of Steps in the ERA Approach

	Preparation	
1	**Establish the Context for ERA**	1. Identify decision processes that would benefit from ERA information (e.g., LRMPs, LU Plans, TSR or policy review). 2. Prepare a preliminary list of what may be at risk in the environment. 3. Confirm the scope and scale of the items for risk assessment. 4. Identify data inputs, assessment methods and presentation opportunities. 5. Identify resources required for ERA (expertise, personnel, time, funding, scheduling).
2	**Identify and Characterize Key Environmental Pressures**	1. Determine pressures causing changes in ecosystem processes, functions or attributes that may directly or indirectly impact the environment: - macro-scale (e.g., climate change, road density increases); and, - direct and indirect (e.g., point source pollution, fire suppression). 2. Review past and potential future management regimes that influence these pressures, and characterize the "cause-and-effect" relationships (to the extent possible).
3	**Specify Environmental Values and Indicators for the ERA**	1. Select environmental values from the preliminary list in Step 1 for risk assessment, based on consideration of: - significance of ecosystem role (e.g., keystone species, critical habitats); - economic or social value; - likelihood for increasing risk and strength of relationship to pressures identified; - feasibility (e.g., availability of data, understanding of habitat requirements); and, - scale appropriate to the level of reporting or decision-making. 2. Determine indicators that best link pressures to changes in risk based on: - strength of relationship between the indicator and risk to the environmental value; - sensitivity to change from human-caused management-related pressures; and, - availability of data. 3. Provide a rationale for the selected assessment items and indicators.
	Assessment	
4	**Characterize Environmental Trends, Indicator Relationships and Establish Risk Classes**	1. Describe the range of conditions for the selected environmental values, including: - the base case (i.e., the historic range of variability or "natural" conditions); - current condition, with a summary of cumulative impacts of past development; - predicted future status (mid/long term trends with current management); - low risk benchmark (i.e., conditions for sustained maintenance of the value); and, - predicted thresholds (e.g., minimum viable population, drinking water standards). 2. Choose methods for risk analysis based on ability to model relationships, track changes to indicators and describe risks to the environmental values being assessed. 3. Define risk classes (i.e., the types of risks and their specific ranges).
5	**Evaluate Changes to Indicators and Risks**	1. Assess the range of proposed development options. For each option identify: - the intensity, scale and duration of the various management activities; - predicted future pressures resulting from those activities; and, - consequent changes in selected indicators linked to the values being assessed. 2. Assess the degree of risk (by class), at various future times, for the range of management options (including cumulative impacts).
	Results	
6	**Report Results and Develop Risk Reduction Strategies**	1. Interpret the assessment results; identify low risk options and risk factors. 2. Identify risk reduction strategies: - identify actions to decrease pressures linked to high risks, and actions to support or enhance activities linked to low risks; and, - propose management strategies, policy options or development scenarios that could reduce or minimize risk. 3. Report the assessment results; including assumptions, limitations, uncertainty, and a full explanation of the consequences of risk levels.

3. CONDUCTING AN ENVIRONMENTAL RISK ASSESSMENT

ERA involves six basic steps:

PREPARATION

- **STEP 1 -** Establish the Context for ERA
- **STEP 2** - Identify and Characterize Key Environmental Pressures
- **STEP 3** - Specify Environmental Values and Indicators for the ERA

ASSESSMENT

- **STEP 4 -** Characterize Environmental Trends, Indicator Relationships and Establish Risk Classes
- **STEP 5** - Evaluate Changes to Indicators and Risks

RESULTS

- **STEP 6** - Report Results and Develop Risk Reduction Strategies

Exhibit 8 provides a summary of the steps. These tasks are discussed in more detail in this section.

The ERA process can be as complex, intensive and data oriented as the situation demands. In-depth or detailed ERAs will require sufficient lead time and resources. At the opposite extreme, there are situations where managers require assessments on a rapid response basis (see Exhibit 10). In these situations the ERA approach provides a framework for the specialist to apply expert opinion. Following the ERA steps ensures that risk information is timely, systematically compiled and appropriately qualified.

Exhibit 9: Risk Assessment and the Weather!

Risk assessment is used on a routine basis by all of us every time a decision is made whether to proceed with an outdoor event or activity. The weather forecaster completes a risk assessment based on available data and professional judgement. The results are presented as the probability of an undesirable outcome (e.g. 60% chance of thunderstorms). We, as the decision-makers, then decide whether the risk of rain and the severity of the consequences are acceptable or not. In the end, we may consider mitigative measures such as taking an umbrella.

Exhibit 10: Rapid Response ERA: "Back-of-the-Envelope" Risk Assessment

The following notes provide an example of a structured thought process to arrive at a rapid response assessment based on professional opinion.

Values: fish/aquatic habitat

Indicators: channel stability, equivalent clearcut area (ECA), road density

Range of Historic Conditions: 0-50% ECA based on fire history; estimated modal ECA of 10%; NO roads

Pressures: fishing, road construction, forest harvesting

Cumulative Impacts: over fishing, past mining disturbance, harvesting (25% ECA), roads as evidenced by channel erosion and increased bar activity

Risk Assessment and Risk Classes: Use quick evaluation tables, as shown in Appendix 1, Example 2, Figure 1. (e.g., ECA >30%+road density >1 km/km^2 = High risk)

Proposed Development: 35% ECA+more roads

ERA Results: High to Very High Risk

Risk Reduction: Road rehab, partial cut, green-up

PREPARATION

Step 1: Establish the Context for ERA

Step 1.1 Identify Decision Processes That Would Benefit from ERA

ERA can be used in a large number of applications where environmental risk information is lacking; however, each decision point or planning process will have its own inherent set of conditions that will likely affect many of the subsequent steps in the ERA. These will include such factors as timeframe for the assessment, available resources, and reporting requirements, which are discussed in more detail below.

The decision to undertake an ERA depends on gauging the potential impacts and the likelihood of improving the decision by providing environmental risk information. Having decided to undertake an ERA, it is important to develop a manageable analysis that delivers useable results.

Note that a distinct provincial environmental assessment review (commonly referred to as “Environmental Impact Assessment” or “EIA”) process is in place to review large-scale or intensive developments (e.g., resort or mine development proposals), as well as specific issues (e.g., coastal salmon aquaculture). Issues and developments under the purview of the EIA process have not been explicitly considered within this report.

Exhibit 11: Resource Planning and Management where ERA may be Effective

Strategic Land Use Planning

Land and Resource Management Plans (LRMP) and their implementation through designation as Higher Level Plans (HLP) under the Forest Practices Code are key decision-making tools at the strategic planning level in BC. LRMPs are mandated stakeholder processes that provide to government, land use recommendations for a specific region or subregion. Full implementation occurs when the plans are elevated into HLP objectives that guide land use practices on Crown lands. To ensure balanced consideration is given to the full range of values and resources, multiple accounts analysis (MAA) is often employed by LRMP tables. In most cases a number of options are developed for analysis, and differences in cost and benefits between accounts are noted for each option. Representing non-market environmental values poses a challenge, especially when these are compared to market values such as timber. ERA can help stakeholders to assess the likely outcome of the options being explored, and understand the current risk to the environment resulting from cumulative impacts. ERA is a tool that complements and refines MAA. The examples of ERA in this report for biodiversity and fish were developed during strategic land use planning processes. ERA can similarly be applied to Landscape Unit planning. Through the assessment of both existing (i.e., cumulative impacts) and anticipated future levels of environmental risk, ERA will support the process of defining appropriate combinations of landscape level objectives to adequately manage environmental values in each landscape unit.

Timber Supply Reviews

The allowable annual cut (AAC) for Tree Farm Licences (TFLs) and Timber Supply Areas (TSAs) must be determined every five years by the Chief Forester. A rationale supporting the determination is also provided by the Chief Forester as part of this process. The rationale addresses how the uncertainty in the timber supply forecasts has been factored into the decision, as well as how the short and long implications to the province of FDPs were considered. Current practices or the status quo are modeled in the base case timber supply forecast, with other options or uncertainty explored through sensitivity analyses. Proposed changes to current practices, such as anticipated land use decisions and new directions in forest policy are outside TSR process. However, the short and long term risks to the environment posed by a particular harvesting rate clearly do have implications for British Columbia, and therefore must be considered by the Chief Forester when setting the AAC. Consequently informing the process, and the decision, of potential risks to the environment are a legitimate part of TSRs. It is here that ERA should be applied to report on the levels of risk that the proposed rates of timber harvesting pose to the environment.

Forest Development Plans

There are approximately 200,000 hectares of forests harvested annually in B.C. There are potentially an infinite number spatial and temporal patterns that could be selected for harvest. Even within proposed cutblocks there are numerous possible boundary changes, levels of retention and scheduling regimes, each of which pose a greater or lesser risk to the environment. Forest licensees decide where to propose harvesting to meet their economic needs, while government staff and the public can review and comment on FDPs. The statutory decision maker must take into consideration all relevant information and comments provided. ERA can be used to better inform these decisions, and increase the accountability of the decision-maker, especially where risks to the environment are acknowledged in the rationale for a decision. Whether producing, reviewing or deciding to accept or reject a FDP, ERA offers a standard approach to clarifying risk to the environment.

Step 1.2 Prepare Preliminary List of What May Be at Risk in the Environment

It is necessary to prepare a preliminary list of potential environmental values for consideration in the assessment. This list should be comprehensive, and serves as the basis from which to narrow the assessment (see Exhibit 12).

Both the value itself and the rationale for choosing the value should be clearly noted in the assessment. Identifying environmental values, resources or specific indicators for ERA will inevitably include a degree of professional judgment and will rely on the field experience of Ministry staff. The preliminary values and potential indicators chosen for assessment will be further refined at Step 3 of the ERA.

Step 1.3 Confirm the Scope and Scale of the Assessment

The scope for assessment may be broad, including a number of environmental factors (e.g., biodiversity, old growth dependent species), or narrow (e.g., individual species or populations, single watersheds). It will be necessary to select a scale for the assessment as this determines the level of detail, the amount of data required and geographic limits.

In situations where information is unavailable, or lacking in detail or precision, it may be appropriate to broaden the scope of the assessment to include data collection and/or reworking of existing data sets. Often, however, the timeframe or available resources do not allow for further data collection or intensive data analysis. In these situations, the environmental risk analysis must employ the best available information, even if restricted to expert opinion or qualitative sources. It is better to provide a decision maker or decision making process with such information appropriately framed, than with no information at all. Where uncertainty exists, the reporting phase of the assessment should include ample discussion of the sources of uncertainty, and identify information gaps that would reduce the uncertainty.

Exhibit 12: Considerations in Identifying Important Environmental Values

Questions to consider when making the preliminary list of what may be at risk in the environment include:

- What values or resources are important to sustain, and therefore, to examine?
- Why are these values or resources important?
- Why might these values or resources be at risk?
- What values have the highest potential or strongest sensitivity to change (impact)?

Government agencies with conservation responsibility for fish, wildlife, habitat, biodiversity and water need to be able to report on these aspects of the environment when reviewing or assessing development or resource use. Environmental values to be included in the ERA should be chosen on the basis of mandate (e.g., MELP legislation and strategic priorities), in concert with area and situation-specific considerations. For example, important environmental values could involve:

- individual species (e.g., red or blue listed species, regionally-important management species);
- ecosystem diversity (e.g., rare or endangered ecosystems);
- guilds or groups of species (e.g., species dependent on particular habitats such as old growth, wetlands, snags or coarse woody debris);
- water quantity and quality (e.g., domestic water supply, fish requirements with respect to temperature, peak and low flows, flooding potential); or,
- broad scale habitat supply (e.g., seral stage distribution, cover/forage ratios through time).

Step 1.4 Identify Data Inputs, Assessment Methods and Presentation Opportunities

Review the status and availability of data and ERA methods for the identified environmental values and indicators. Data assembly and assessment can be the most time consuming or limiting portion of an ERA. A review of previous projects, available data and methods, expected complexity, timing, and expertise can assist in framing the approach to the ERA project.

Exhibit 17 provides an overview of potential analysis methods and indicators for consideration while developing the focus for an ERA. Potential applications range from the provincial scale to site-specific locations.

Step 1.5 Identify Resources Required for the Assessment (expertise, personnel, time, funding, scheduling)

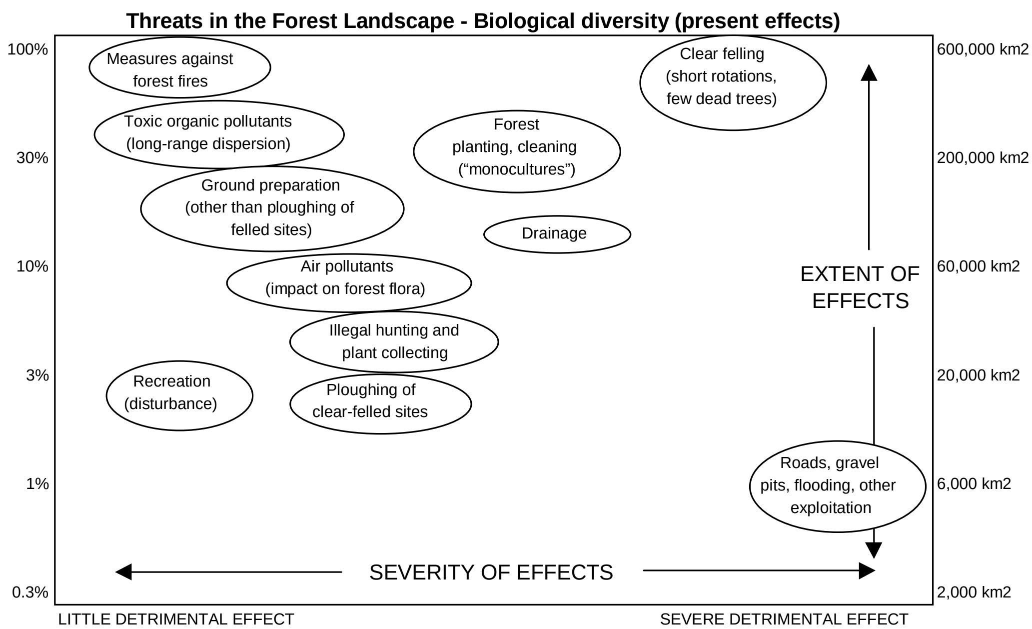
The length of time available for the assessment and the magnitude of the decision involved will also influence the effort that may be needed. For larger complex assessments a workplan outlining required expertise, proposed personnel, timing, funding, and proposed schedule should be prepared. In contrast, rapid-response assessments may only require the assembly of immediately available information, and systematic application of professional expertise (see Exhibit 10). It is important also to remember the intended audience for the ERA and associated presentation needs of assessment information at this early stage.

Step 1: Summary of Key Questions and Tasks

Key Questions	Tasks
• What decision, planning or assessment process is the ERA intended for? • What environmental values may be at risk? • What potential data (e.g., indicators of valued environmental components), assessment methods and resources are available to apply to the ERA?	1. Identify decision processes that would benefit from ERA information (e.g., LRMPs, TSR or policy review). 2. Prepare a preliminary list of what may be at risk in the environment. 3. Confirm the scope and scale of the items for risk assessment. 4. Identify data inputs, assessment methods and presentation opportunities. 5. Identify resources required for ERA (expertise, personnel, time, funding, scheduling).

Exhibit 13: Identifying Pressures: A Nordic Example

This study of environmental conditions in the Nordic landscape adopted a visual format to assist in assessment of the severity and scale of pressures on the environment. The assessment is outlined in a series of diagrams that indicate the effects of various environmental disturbances on: biological diversity, sustainable use of natural resources, landscape attractiveness and human health. An example of one of these diagrams — threats to biodiversity in the forest landscape — is shown below. The vertical position in which a particular disturbance is placed on the diagram indicates how **widespread** it is, and the horizontal position indicates how severe its **detrimental effects** are when it does occur. The baseline for this assessment was the situation existing in the early decades of the present century (when the dispersion of pollutants was still on a relatively moderate scale, but major changes in land use had occurred).



Source: Nordic Environment Report Group (1993)

Step 2: Identify and Characterize Key Environmental Pressures

Step 2.1 Determine the Nature of Development Pressures Effecting Environmental Change

A key element of ERA is identification of the pressures that result in identifiable changes in ecosystem processes, functions or attributes. These pressures impact environmental values either directly or indirectly. This information builds understanding of the source of risks, helps to direct and refine the ERA, and supports the final step in the ERA – presentation of results and, where appropriate, development of alternative actions to reduce risks.

While it is reasonable to be cautious in attributing causes to changes in environmental values in the face of scientific uncertainties or complex causal relationships, every effort should be made to identify:

- at a minimum, key pressures that contribute to measurable change; and,
- where possible, the linkages and cause-and-effect relationships between these pressures and observed effects on environmental values and indicators.

Identification and characterization of pressures on environmental values should be based on available information, including local or expert knowledge. Pressures may be:

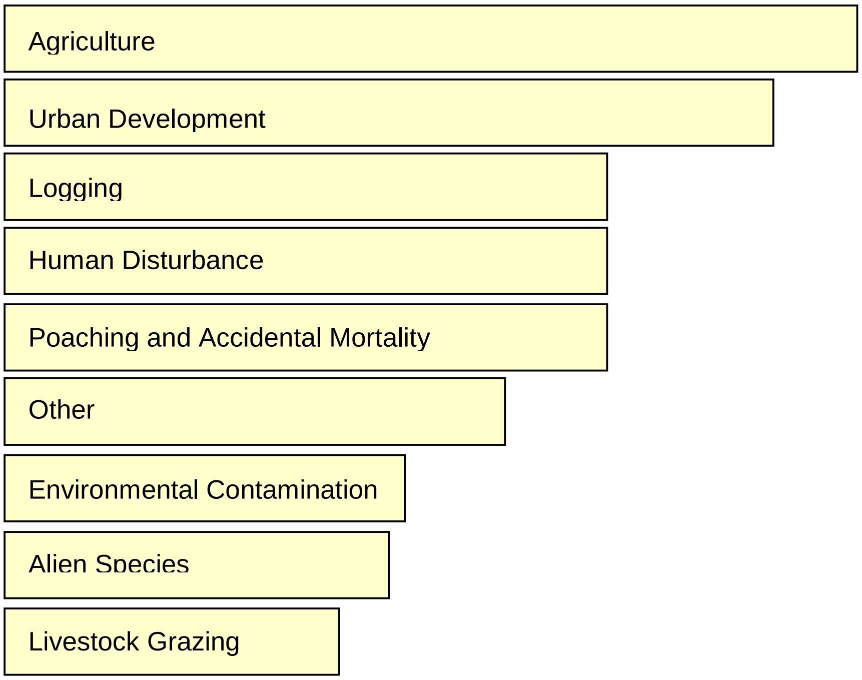
- at a macro-scale (e.g., climate change, change in road density);
- indirect (e.g., habitat alteration, accessibility, dams affecting flow regimes, suppression of fires, introduction of exotic species); and/or,
- direct (e.g., hunting/fishing, predation, point source pollution).

Exhibit 14: Identifying Pressures: Two Examples from British Columbia

Threats to Species at Risk in British Columbia

As part of the State of Environment Indicator Series, MELP has identified species at risk in BC.

The most serious threats (or pressures) to species were ranked by relative importance and reported, as follows:



Source: MELP (2000)

Northwest Anadromous Salmon Populations (see also Exhibit 15 and Exhibit 22)

Often it is not possible to identify single pressures on environmental values. For example, in their recent (1996) study of the status of anadromous salmon and trout in B.C. and the Yukon, Slaney et al. initially identified pressures affecting fish stocks, including habitat degradation, over-utilization, and disease. Several pressures were identified as affecting most stocks examined and the causes of stock declines were thus confounded. To resolve this difficulty, the researchers examined information of a more regional nature to confirm the major pressures affecting stock trends, such as:

- habitat drastically altered by human activities, particularly: changes in land use and forest cover; urbanization; impoundments; dikes, dredging and fills; mining; agriculture; road and rail construction; effluent discharges;
- over-utilization;
- disease;
- other negative interactions such as introgression with non-native hatchery fish; and,
- other natural factors, including major environmental perturbations such as the Babine River slide, overturn of anoxic Nitinat Lake, and reduced ocean survival following El Niño events.

For each of the stocks examined, researchers explored available information sources to determine, to the extent possible, which of these regional pressures or combination of pressures was the principal cause of changes in abundance.

Source: Slaney et al. (1996)

Step 2.2 Review Past or Present Management Regimes which Influence Pressures

The key elements of the policies or management regimes which influence pressures on environmental values should be identified and listed during this step in the ERA. This list, with a short rationale, should include both past and present activities and if possible, identify potential alternatives for further consideration when developing risk reduction strategies. The specific elements listed will be dependent on the needs of the ERA, and could include, for example, forest management regimes (e.g., harvesting rates and silviculture practices) or air quality guidelines (e.g., gasoline additives, vehicle testing, see also Exhibit 15).

Step 2: Summary of Key Questions and Tasks

Key Questions	Tasks
• What pressures lead to changes in ecosystem or watershed processes, functions or attributes? • What are the nature, scale and extent of these pressures? • What key pressures are related to human activities? • What are the linkage mechanisms between human activities and changes in risk to environmental values? • What are the past and predicted patterns of changes in ecosystem or watershed conditions (i.e., what are the trends)? • How have past management regimes influenced changes to environmental values (e.g., what are the cumulative impacts)?	1. Determine pressures causing changes in ecosystem processes, functions or attributes that may directly or indirectly impact the environment: - macro-scale (e.g., climate change, road density increases); and, - direct and indirect (e.g., point source pollution, fire suppression). 2. Review past, present and potential future management regimes that influence these pressures, and characterize the “cause-and-effect” relationships (to the extent possible).

Exhibit 15: The Importance of Specifying Key Values for Assessment: A B.C. Fisheries Example

Selecting the environmental indicators on which to focus the risk assessment can be difficult. For example, in assessing the status of anadromous fish species, it is first necessary to decide on the degree of aggregation to be used; as Lackey (1994) has commented, "for salmonid species, it must be determined whether the focus is on maintaining some or all stocks — or any other ecologically significant unit — from going extinct, or maintain some or all stocks at fishable levels. Defining which species, communities or ecosystems are to be evaluated is a value-based determination, not a scientific one."

Second, the need to standardize data from many sources has to be resolved. For example, in a recent study on the status of anadromous salmon in BC and the Yukon (Slaney et. al. 1996), researchers discovered that different studies collected data at different levels of organization of salmon populations (e.g., biological races, populations, and sub-populations or demes) and moreover key terms defining these levels were often used inconsistently. In an attempt to resolve this problem, researchers accessed data on spawner escapement from local areas — the organizational level that corresponds as closely as possible to the deme level at which biological diversity is maintained. Even so, researchers had to accept that although the reliability of the data was questionable, no alternative data sets were available. However, efforts were made to both review literature sources and contact local experts to verify the accuracy of data, compile corroborating evidence, and identify stock extinctions.

The importance of a clear focus for the assessment cannot be over-emphasized, as it often shapes the information base for the study and can lead to skewed interpretation of results. For example, in the same 1996 study of anadromous salmon and trout, Slaney et al. determined that at the species aggregate level, salmon stocks appear to be either stable or increasing, but this information masks the degree of success in maintaining diversity — which is only discernible at more refined levels of resolution. The same study determined that at the individual stock level, the results of the assessment tell a different story:

9633 stocks were examined, but sufficient information could only be compiled for 5487, or 57% of these — information has not been collected for many smaller stocks that are of lesser commercial value but that are important for maintenance of salmon diversity;

Although most of the stocks assessed were unthreatened, others gave grave cause for concern:

- 624 stocks fell into the high risk or extinction category;
- 78 stocks were considered at moderate risk; and,
- 230 stocks were considered to be of special concern.

Tabulating assessment results by geographic distribution (by production area) also highlights key areas where stocks are at risk and enables further interpretation of major forces leading to declines. See also Exhibit 14 and Exhibit 22.

Step 3: Specify Environmental Values and Indicators

Step 3.1 Select Specific Items from the Preliminary List for Risk Assessment

This task involves reviewing and refining the preliminary list of important environmental values identified in the initial consideration of assessment requirements (Step 1). It will be necessary to limit the risk assessment to values that are likely to be significantly affected and those for which there is a strong link to the decision under consideration. This narrowing of the assessment is critical. The choice of specific values for use in the ERA should be based on:

- their significance, in terms of their ecosystem role (e.g., keystone species);
- their significance, in terms of the potential consequences of their loss (e.g., critical habitats, potential restoration costs);
- their economic or social value;
- the likelihood of an increase in risk;
- strength of the relationship to fundamental pressures identified in Step 2; and,
- their feasibility for use (e.g., in terms of data availability, understanding of habitat requirements or technical assessment methodologies available).

Exhibit 16: Choosing Indicators for Assessment: Advice for Use in Protected Areas

The following list of criteria for choosing "measures" and indicators has been developed by Woodley (Environments, 1996.) in support of monitoring national park ecosystem conditions. Indicators should:

1. be relatively easily and reliably measured, or it will be difficult to maintain a monitoring program over the long term;
2. have the capability to provide a continuous assessment from stressed to non-stressed conditions;
3. utilize multiple criteria when assessing ecosystem condition, not depending solely on single criteria, such as the presence, absence or condition of a single species – any conclusions about ecosystem condition should be based upon a collection of measures, interpreted by experts;
4. focus on critical indicator species;
5. reflect our knowledge of normal succession or expected sequential changes which occur naturally in ecosystems;
6. have a defined reference level with a variance whenever possible – if references and variances do not exist, data collection should be designed to establish them (see base case in Step 4.1);
7. cover the wide range of spatial and temporal scales, from individual to community to landscape; and,
8. be based, as much as possible, on the concept of ecosystems and not institutional boundaries (e.g., the assessment of the state of ecosystems protected by parks and protected areas must be done on the basis of assessing the larger ecosystems of which parks and protected areas are a part).

Step 3.2 Determine Indicators that Link Pressures to Environmental Risks

The preliminary list of indicators for the ERA identified in Step 1 should be reviewed and refined before further assessment is undertaken. Indicators should provide for the early detection of change so that management action, if required, may be taken before the change becomes irreversible. However, not all indicators should be designed to provide for early warning. Some measures should be longer-term and diagnostic in nature. Considerations for choosing indicators include: strength of relationship environmental value of interest; sensitivity to change from human-caused and management related pressures; and availability of data. Examples of potential indicators for use at various scales are provided in Exhibit 17 and in the appendix of this report.

The indicators for monitoring and assessment of environmental conditions must be chosen on a systematic basis. This is best done using a clear set of criteria. For detailed environmental risk assessments, a single species may be selected as the environmental value of interest, accompanied by the selection of appropriate stand level habitat indicators. Exhibit 27 provides an example of such indicators for the Northern Goshawk. In the example, a suite of habitat characteristics are used as indicators to evaluate the extent and quality of four habitat components of a goshawk's home range (nest area, post fledging family area, forested foraging area and home range). The indicators include habitat characteristics such as: the presence of large trees, snags and coarse woody debris, crown closure and patch size.

Broad scale regional environmental assessments often require the use of more general or landscape level indicators. The percentage of area with the application of appropriate habitat management guidelines has been used as an indicator in some regional assessments (e.g. percentage of total study area or percentage of mapped high capability habitat). Exhibit 25 presents a matrix for evaluating various sets of management guidelines for environmental values within such an assessment. Example 1 in Appendix 1 describes a regional assessment where projected changes in seral stage distribution have been employed as a quantitative indicator for the assessment of risk to general biodiversity.

Assessments of risk to aquatic values often use levels of watershed disturbance as indicators of risk to the aquatic environment. Examples 2 and 3 in Appendix 1 describe assessments that have employed road density, extent of riparian logging or the extent of forest harvesting and road construction on unstable terrain as indicators of risk to aquatic resources. More direct indicators may include changes in sediment volumes and stream channel characteristics.

Exhibit 17: Examples of Analysis Methods and Indicators at Various Scales and Levels of Generalization

Scale	km^2 - 1,000,000 ----- 100,000 ------ 10,000 ------ 1,000 ------- 100 -- ('Operational') -- 10 ----- (Stand) – 1----- 0.1 --- (Site) -- <0.01 km^2				
Aquatic "Unit" **Terrestrial "Unit"**	--- Large Basins ----- Medium Watersheds ---- Species/Stocks --- Small Watersheds ------ Stream Reaches ----- Wetlands --------- Springs Ecoregions ------ BEC Zones ----- Species/Guilds ----- BEC Subzone/Variants ------- Ecosections -------- Populations --------- Ecosystems				
Administrative Levels	Province -- Coast/ ---- Regions ----- Forest -------- Management Units ------ Landscape ---- WMA/ ----- Riparian ----- Cutting --- Treatment Interior Districts (TSA, TFL, Wildlife MU) Units WHA Mgmt. Area Permit Unit				
Decision Making Processed	----- Strategic --------- LRMP --------- TSR --------- Watershed ------ Landscape Unit ------ FDP ------- Cutblock ----- Site Mgmt. Planning Management Plans Planning Reviews Prescriptions				
Reporting Levels	----- National/International ----------------- BC Public -------------------- Audits ----------------- Environmental Impact ------------------ On-site Compliance Reports (Internal/Enforcement) Assessments Assessment				
Analysis Methods	---- Gap ------ Rollups of ------- Trend ------- Population -------- WAP ------- Spatial ------ Habitat ------ Habitat Attribute ------ On-site Analysis Mgmt. Regimes Analysis Modeling CAP Analysis Modeling Modeling Assessment				
General Indicators	Protected Area Representation Number of Red/Blue Listed Species	Extent of Development Human Population Density	Habitat Suitability/Capability Road Density Road Use Frequency	Population Trends	Habitat Attributes
Terrestrial & Wildlife Biodiversity Indicators	Habitat Alteration	Seral Stage Distribution Ecosystem Processes	Density of Snags Coarse Woody Debris Winter Range Cover	Reproductive Success Mortality Rates Hunter Success	Forage Production Breeding Sites
Aquatic & Fish Biodiversity Indicators	Pollution Indices Developed Watersheds Pollution Orders	Boil Orders Water Treatment Landslides Flooding Frequency	Riparian Status Peak Flow Index (ECA)	Egg Counts Spawning Returns Angling Success	Channel Characteristics Water Quality Prey Species Large Organic Debris

Step 3.3 Provide a Rationale for the Selected Environmental Values and Indicators

The rationale for choosing the environmental values and indicators used in the assessment should be clearly noted to clarify why choices were made, especially where data sources are limited. This information will be useful in presenting and documenting the results of the ERA, and building confidence in the results among decision-makers, the public and peer reviewers.

Step 3: Summary of Key Questions and Tasks

Key Questions	Tasks
• What environmental values will be examined? • What indicators will be used to assess and report on environmental risk? • Why have these values and indicators been chosen? • Do they provide a good link between the pressures and risk to the environment?	1. Select environmental values from the preliminary list in Step 1 for risk assessment, based on consideration of: - significance of ecosystem role (e.g., keystone species, critical habitats); - economic or social value; - likelihood for increasing risk and strength of relationship to pressures identified in Step 2; - feasibility (e.g., availability of data, understanding of habitat requirements); and, - scale appropriate to the task involved. 2. Determine indicators that best link pressures to changes in risk based on: - strength of relationship with value/resource; - sensitivity to change from human-caused management-related pressures; and, - availability of data. 3. Provide a rationale for the selected assessment items and indicators.

Exhibit 18: Cumulative Effects and ERA

Environmental risk assessment is usually based on single occurrences or sources of environmental effects — but often an ecological system is subject to multiple occurrences or sources of effects. Cumulative effects are increasingly part of environmental assessment and yet they remain difficult to deal with. The National Research Council in reviewing cumulative effects and environmental assessment has found that, in general, the most troublesome cases arose from a mismatch between the scales or jurisdiction of assessment and management, and the scales or jurisdictions of the phenomena involved or their effects. For example, air pollution and fisheries management problems commonly result from a large number of dispersed local sources, with the impacts often spread over wide areas, distant from the sources and covering multiple jurisdictions.

Despite the need to acknowledge cumulative effects, a focus on ecosystems is not always required for ERA — there are cases where risk assessment focused on one or two species has resulted in the development of a successful management strategy. Whatever the scope, it is essential that the scoping process explicitly determines what level of ecological organization is being adopted. If the problem is really an ecosystem one, focusing on an individual species might not reveal the true nature of the problem until it is too late. On the other hand, focusing on an ecosystem when only one or two species (or populations) are at risk can dissipate resources and also lead to a failure of management.

Source: Policansky (nd:47)

ASSESSMENT

Step 4: Characterize Environmental Trends, Indicator Relationships and Establish Risk Classes

Step 4.1 Describe the Range of Conditions for the Selected Environmental Values and Indicators

An analysis of environmental conditions and trends provides important contextual information for an ERA, enabling a comparison between the present status of important environmental values or resources, their historic levels and ranges, and projections of their future status (see Exhibit 5, Conceptual Framework for ERA).

The trend analysis must include at a minimum the following elements:

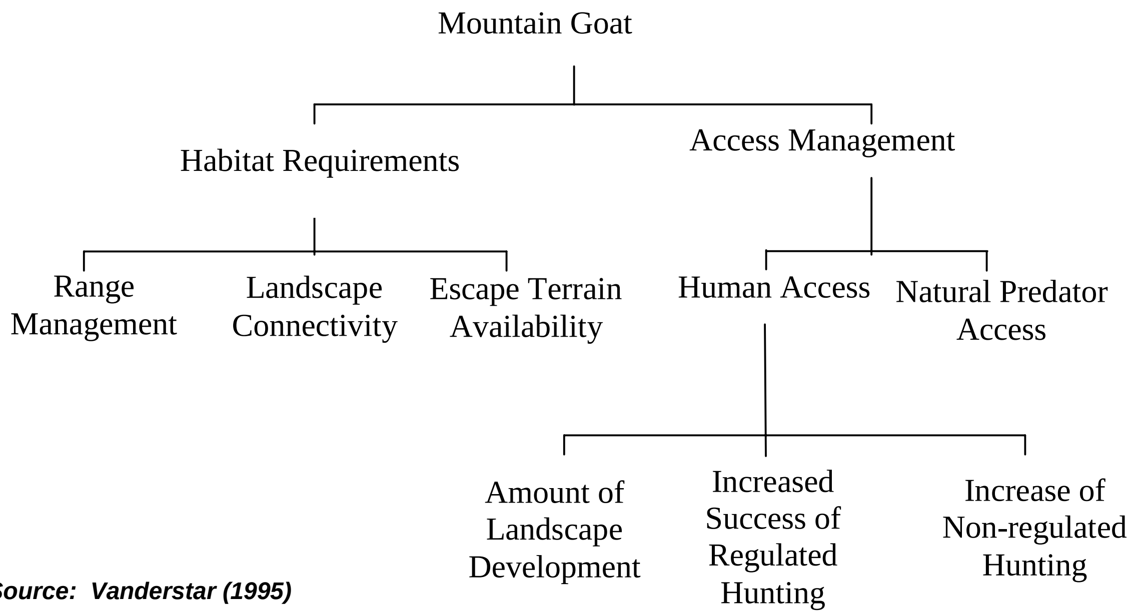
Base Case

For the purposes of ERA, the base case refers to status of environmental values and indicators under "natural" conditions. In the BC context this is defined as pre-European settlement conditions (i.e., pre-1850's). Natural is assumed to include indigenous human activity. Because environmental conditions are usually not constant, but vary on a seasonal, annual or longer term basis, definition of the base case will often require estimation of an average or median condition and a range of variation over a specified time period for a defined area (i.e., the range of historic variation). For example, streamflow is often characterized in terms of average peak flows and specified storm flows with estimated return intervals; or historic percentages of old growth forests are based on estimated average fire return intervals. In the case of Northwest anadromous salmon populations, historical variability has led to high levels of uncertainty regarding past conditions. As one commentator has noted, when assessing risk for salmon, "genetics, habitat relationships, ocean productivity, interactions with other organisms, human harvest, water quality issues, the effects of stocking, and the general problem of uncertainty and random events are all areas of concern" (Lackey 1994:20).

Current Condition

The current condition of environmental values and indicators is a measure of where we are today. Current inventory information should provide the basis for this determination. The difference between the current condition and the base case is an indication of the cumulative impacts of past development and management activities. Although consideration of past activities may be outside the scope of the planning or decision-making process for which the assessment is being performed, the relationship of past activities to pressures and the current condition will often provide the best basis for prediction and modeling of future changes. Past cumulative impacts may include activities such as hydro-electric dams, highways, rail corridors or fire suppression.

Exhibit 19: Key Indicators, Pressures and Linkages for Mountain Goat: An Example from Bulkley Forest District, B.C.



Source: Vanderstar (1995)

Predicted Future Status

For the purposes of ERA, it is important to understand the potential outcome of no changes to present policy and practice (i.e., the null hypothesis). In the preliminary analysis of trends, medium term and long term (e.g., 5-25 and 50-250 year) predictions of future conditions should be made, given the results of cumulative impacts and assumptions of continuing current management practices. This will provide an important comparison for final analysis and decision making.

Low Risk Benchmark

The low risk benchmark is defined as conditions with a high probability of sustaining the environmental value in question over the long-term. The low risk benchmark may not be the same as the base case, but it will likely be within the range of historic variability defined for the base case. Definition of the low risk benchmark should involve definition of management regimes that will create conditions necessary for the maintenance of the environmental value (i.e., best management practices). The process of defining the benchmark will help to understand linkages between pressures and impacts, and provide insights for proposing risk reduction strategies in the decision making process. Definition of benchmarks should avoid direct linkages with any specific option under consideration, such as a particular standard or objective. Selection of benchmarks based on existing conditions often leads to ignoring background risk that may be due to cumulative impacts from past changes. As well, the use of benchmarks linked to regulations or management policies often results in missing potential risks inherent in those regulations or policies. Exhibit 20 illustrates the use of predicted population levels acceptable to BC Environment as a Low Risk Benchmark for assessment of land use planning options.

Thresholds

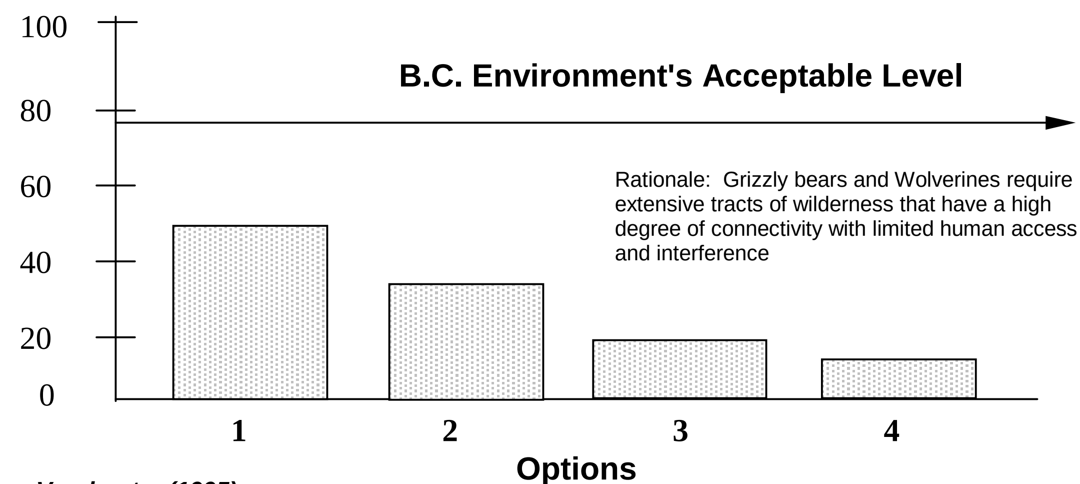
Thresholds describe a critical level at which there is a significant shift in the probability of continued maintenance, utility or viability of the specified environmental value or condition. Thresholds may be inherent or set by regulatory bodies. They tend to be particularly important as higher risk levels are approached. Examples of thresholds could include minimum viable populations (MVP), minimum densities of key habitat features, or levels necessary to satisfy explicit standards (e.g., water quality standards, annual days of flooding events, landslides per km^2). The rationale for the definition of any threshold should be explicit, including a description of or reference to the data or ecological model on which the threshold level is based.

Exhibit 20: Using a Low Risk Benchmark and an Agency-determined Threshold: An Assessment of "Feature Species" and Land Use Planning Options from Northwest B.C.

In this assessment of planning alternatives, analysis of impacts on **Feature Species Environmental Accounts** was based on the level of management required to maintain a minimum population level desired by BC Environment for the species in question (grizzly bear and wolverine, woodland caribou, mountain goat, moose and deer).

The optimum habitat conditions for the given species were defined as a low risk benchmark and set to an arbitrary level of 100 for a comparative analysis of various alternatives. BC Environment's Acceptable Level was then established as a threshold relative to this optimum (ranging from 60 to 95 on the comparative scale) and each alternative land use scenario assessed according to the same scale.

The options range from Option 1, which has the most extensive protected areas and most extensive areas of management zones with habitat management guidelines providing high quality habitat (i.e., access restrictions and large patch size), to Option 4, which has minimal habitat protection, increased fragmentation and extensive ongoing industrial development. Moving from Options 1 to 4 results in a reduction in available habitat and connectivity allowing low risk movement between seasonal habitats.



Source: Vanderstar (1995)

Information sources for this task may include:

- inventory data that describe historic or present status (e.g., vegetation cover, habitat suitability, population surveys);
- historic data (e.g., documented traditional knowledge, archival and museum information); and,
- targeted research (e.g., reconstruction of fire histories).

Given that much of the information for estimating past and future conditions may be based on expert opinion and minimal data, a clear rationale should be provided for trend prediction, particularly in cases where confidence levels are low. The results of the trend analysis should include: assumptions, information sources, methodologies, indicators and their rationale, and limitations to interpretation of the trends.

Experience suggests that several methods of communicating the same information should be attempted including, for example:

- a set of time series maps showing density distributions or other spatial information historically and into the future;
- graphical information including graphs, charts and figures; and,
- tabulated information to support additional interpretation.

Step 4.2 Choose Methods for Risk Analysis

This task involves choosing appropriate methods for analysis of risk. The choice will require weighing the availability of information and resources, against analysis methods and their ability to:

- model “cause-and-effect” relationships between pressures resulting from human-caused development and changes to environmental values;
- track changes to the type, quality and/or extent of environmental conditions, indicators or habitat attributes (e.g., habitat requirements; measures of water quality, quantity and timing; or suitable “proxy” indicators); and,
- describe risks to the environmental values being assessed.

Exhibit 21: Risk Classes for Mature and Old Forest-Dependent Species: An Example from the Environmental Analysis for the Kootenay/Boundary Land Use Plan Implementation Strategy

Risk Class	Description
Very Low	Most populations are likely to remain stable, or possibly increase where habitat restoration is successful. There is likely to be sufficient redundancy in habitats to withstand changes due to all but the most catastrophic natural stand-replacing events. Where local extirpations occur, connectivity is likely to allow for re-establishment of replacement populations.
Low	Some populations are likely to remain stable, or possibly increase where habitat restoration is successful. Some populations dependent on habitats in short supply may decline. There is likely to be sufficient redundancy in habitats to withstand changes due to most natural stand-replacing events. Where local extirpations occur, connectivity may allow for re-establishment of replacement populations.
Moderate	Reductions in some local populations are likely while others remaining stable. Local extirpations are possible where populations are left vulnerable to predators or other increased stress. There may be sufficient redundancy in habitats to withstand changes due to most natural stand-replacing events. Where extensive areas of early and/or mid seral forests are present these will create imbalances in habitat supply through time (e.g., “boom and bust” feeding areas for grizzly bears). Re-establishment of locally extirpated populations may be limited by lack of connectivity.
High	Significant declines in some populations are likely with some local extirpations due to the lack of mature and old forests. The lack of redundancy in habitats will mean that any changes due to natural stand-replacing events will likely result in further local extirpations. Extensive areas of early and/or mid seral forests will create imbalances in habitat supply through time (e.g., “boom and bust” feeding areas for grizzly bears). Risk factor may contribute to semi-permanent and/or regional extirpations if risk level is long-lasting and/or area covers a significant portion of a given population’s range.
Very High	Major reductions in populations dependent on mature and/or old forest cover are likely. There are likely to be many local extirpations. Extensive areas of early and/or mid seral forests will create imbalances in habitat supply through time (e.g., “boom and bust” feeding areas for grizzly bears). There is significant potential for contributing to permanent and/or regional extirpations or extinctions if risk level is long-lasting and/or area covers a significant portion of a given population’s range.

Source: Utzig (1997)

Analysis of the links between the pressures, changing habitat or other relevant factors, and the risk to environmental values may rely heavily on professional judgment, or involve the use of other analytical tools that can represent complex inter-relationships. The vehicle chosen for conducting the analysis will depend primarily on availability of data and resources. Tools can vary from expert opinion risk ratings to multi-variable computer models. Recent assessments by the USDA Forest Service for old growth forest associates and neotropical songbirds, for example, have used expert scientific panels in combination with GIS overlays and computer predictions of future habitat conditions (USDA et al. 1993, Saab and Terrell 1997).

In a recent BC example — impact analyses for implementation options of the Kootenay Boundary Land Use Plan — management options were compared using habitat risk indices calculated from weighted area summaries of GIS overlays of management regimes and defined habitat requirement. Another assessment employed predicted landscape level seral stage distributions generated by the FSSIM timber supply model to predict future stand conditions for habitat analysis (see Appendix for a more detailed description).

Watershed Assessment Procedures specified under the BC Forest Practices Code use GIS overlays and computer algorithms to link a series of key indicators such as road density, equivalent clearcut area and riparian disturbance to hazard indices (roughly equivalent to risk levels). Combinations of hazard scores are then tied to mitigation measures where appropriate (Anon. 1995).

SIMFOR, a habitat computer model under development at the University of British Columbia (Nelson and Hafer 1996; Hafer 1996), uses harvest schedules generated by an external timber flow model to establish the spatial distribution of forest stands over time. Habitat attribute supply (e.g., crown closure or large snags) at a given location, for a specified time, are interpreted from user-defined relationships between those attributes, stand type and stand age. Various projects are underway to test the application of this tool for environmental assessment (see Exhibit 26).

Whatever the methods selected, it is essential to understand their limitations, document key assumptions, and report on the reliability of data and the level of confidence in analysis results. The rationale, definitions and evidence in support of chosen methods should be clearly described in ERA reports and presentations.

Exhibit 22: Risk Classes: An Example for Northwest Anadromous Salmon and Trout Species

Note: These risk classes were based on the estimated minimum viable population necessary for preserving genetic diversity. The classes were acknowledged to be an approximation given the variability of stocks and the questionable reliability of some data, which had to be accepted at "face value" (adapted from Slaney et al. 1996). See also Exhibit 14 and Exhibit 15.

Risk Class	Description
Extinct	Stocks known to have persisted in a given location for several decades but for which no returns have been observed in more than a decade.
At high risk of extinction	Stocks for which the mean population in the current decade was less than 20% of the long term mean and less than 200 fish.
At moderate risk of extinction	Stocks exhibiting serious declines but not immediately threatened: - large populations exhibiting declines to 200-1,000 fish from a long-term mean of more than 5,000 fish; or, - small populations reduced to less than 20% of a long-term mean of 1,000-5,000 fish.
Of special concern	Stocks that: - could be threatened by relatively minor disturbances, especially where a pending threat is known; - have insufficient information on population trends, but available information suggests depletion; - may interbreed with introduced, non-native fish; and, - are not currently at risk but require attention because of unique characteristics.
Unthreatened	Stocks averaging more than 1,000 fish or greater than 20% of their long-term mean abundance.

Step 4.3 Define Risk Classes

Risk classes are used to define the ranges of probability or likelihood of an undesirable outcome. A limited number of classes (e.g., five) should be defined to ease interpretation. However, all effort should be made to include the full range of possible outcomes, from:

- **very low risk** – a high likelihood that environmental values or resources can be sustained at historic, natural or desired levels (given environmental risk assessment methodological assumptions and limitations); to,
- **very high risk** – a high likelihood that an undesirable outcome will result (e.g., greater than 70% probability that a population will be extirpated from the study area within the next 100 years).

Known or predicted thresholds may be useful for setting the class limits for high or very risk classes. Exhibit 27 provides an example of using thresholds for individual habitat attributes (breaks between low habitat quality and unsuitable habitat), while Exhibit 20 demonstrates the use of an agency-determined threshold ("BC Environment's Acceptable Level").

Endangered Wildlife Risk Classes

Risk classes are commonly used in conservation biology, and more specifically, by MELP in its State of Environment Reporting. Terms used to describe the conservation status of species at risk, including endangered, threatened and vulnerable, are essentially risk classes with widely accepted definitions. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) defines these risk classes as follows (Munro 1994):

Vulnerable: any indigenous species of fauna or flora that is particularly at risk because of low or declining numbers, occurrence at the fringe of its range or in restricted areas, or for some other reason, but is not a threatened species.

Exhibit 23: Evaluating "Features" of Alternative Land Use Options for Specified Environmental Values: An Example from Tongass National Forest Plan, Alaska

Note: The table below is a synthesis of results of risk assessment panels composed of appropriate "experts," who examined a series of management alternatives and evaluated the relative risk to specific environmental values associated with implementation of each of the management alternatives (adapted from Everest et al. 1997). See also Exhibit 26.

	Alternative Features of Land Use Options							
Environmental Value	**Beach fringe 0-500 feet**	**Beach fringe 0-1000 feet**	**Estuary fringe**	**Deer winter range**	**Mixed matrix managed lands**	**Matrix and reserve**	**Roads**	**Wild and scenic rivers**
Wolf	+	+	+	+			-	
Bear	+	0	++	0	-	++	-	0
Murrelet	+	+	+	+			0	+
Northern goshawk	+	++	++		++	-	0	
American marten	+	++	++	+	-		-	
Other terrestrial mammals	+	+	+	+	-		-	0
Subsistence deer harvest	+	++	++	++	0	0	-	0
OG abundance and diversity			+	+				0
OG connectivity		+	+			-		
OG process, structure and function	+	+					-	
Fisheries and riparian							-	+

Panel evaluation symbols: 0 neutral or benign; + important positive feature; ++ critical positive feature;
- detrimental

No mark in a column indicates that panels made no comment

Threatened: any indigenous species of fauna or flora that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed.

Endangered: any indigenous species of fauna or flora that is threatened with imminent extinction or extirpation throughout all or a significant portion of its Canadian range, owing to human action.

Extirpated: any indigenous species of fauna or flora no longer existing in the wild in Canada but occurring elsewhere.

Extinct: any species of fauna or flora formerly indigenous to Canada but no longer existing anywhere.

The concept of risk classes extends beyond endangered species and can be used for a variety of environmental values. Two examples are provided in Exhibit 21 and Exhibit 22.

Step 4: Summary of Key Questions and Tasks

Key Questions	Tasks
• What are the relationships between the environmental values, the pressures and indicators and risk? • What defines the base case – the “natural” or historic range of variability, for the selected indicators? • What defines a low risk benchmark for each environmental value (i.e., optimal conditions for sustained maintenance of the value)? • What risk thresholds exist which may affect sustained maintenance of the environmental value? • How does the current condition compare to the base case and low risk benchmarks? • What risk classes will be used in the ERA and what are the criteria used to establish them?	1. Describe a range of conditions for the selected environmental values, including: - the base case (e.g., the historic range of variability or “natural” conditions); - current condition, with a summary of cumulative impacts of past development; - predicted future status (mid/long term trends with current management); - a low risk benchmark (e.g., conditions for sustained maintenance of the value); and, - predicted thresholds (e.g., minimum viable population, drinking water standards). 2. Choose methods for risk analysis based on ability to model relationships, track changes to indicators and describe risks to the environmental values being assessed. 3. Define risk classes (e.g., the types of risks and their specific ranges).

Exhibit 24: Use of "Assessment Trees" for Visualizing Complex Events

There are a number of tools and methodologies available to strengthen the use of expert judgment in supporting decision making and addressing uncertainty. A summary of these is provided in the USFS General Technical Report: *Assessing Uncertainty in Expert Judgment About Natural Resources* (Cleaves, 1994) (website, http://www.srs.fs.fed.us/pubs/viewpub.jsp?index=18).

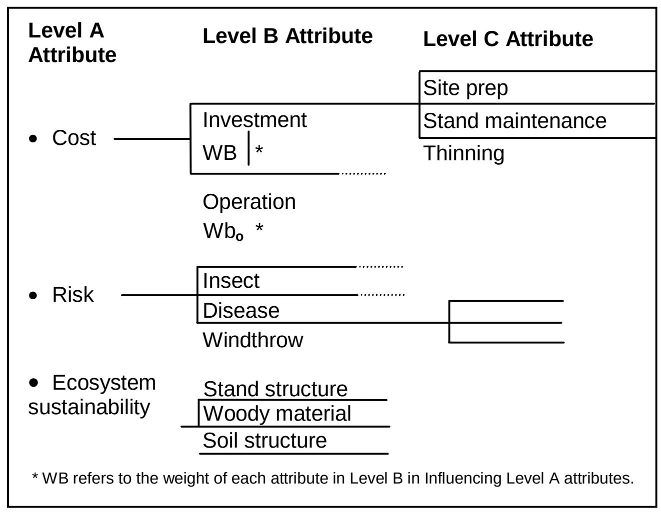
The USFS report, for example, outlines several approaches for dissecting complex decisions into manageable parts, and dealing with uncertainty that may influence a decision. For example, *assessment trees* are devices for visualizing complex events as hierarchical branching patterns of component events or values. An assessment tree suggests possible interventions that might change the overall outcome. Probabilities can be assigned to each intervention and combined mathematically to give an overall rating or probability of occurrence. The premise of assessment trees is that uncertainties of component events or values are easier to comprehend and assess than uncertainties of larger elements. Sensitivity testing of assessment trees can indicate which component assessments are more critical and should get more attention in the assessment process.

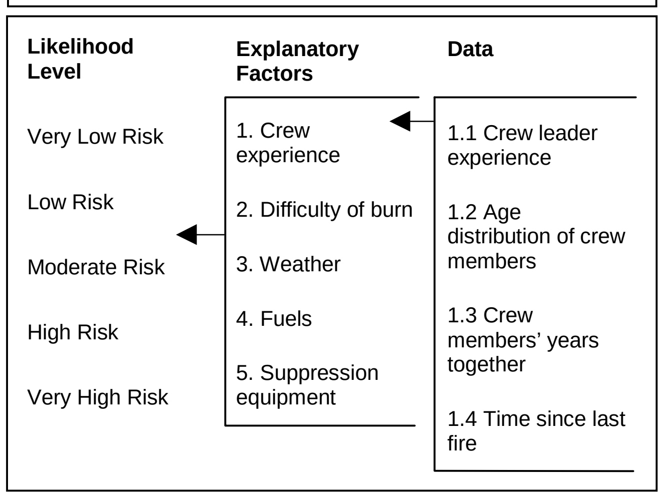
Among the types of assessment trees are value trees and inference trees, as shown below:

Value trees organize attributes into intermediate components and finally into tangible measurements. Each of the branches in a set can be weighted according to its importance in fulfilling the higher level attribute. The attribute of "risk of major disturbance" for example, could be broken into sub-attributes such as insect, disease, and windthrow. Value trees can help identify pivotal factors in decisions and help assessors understand their own preferences and biases.

Inference trees start with hypotheses or scenarios that are as yet unobserved. Preceding these hypotheses are layers of events that explain the hypothesis or the scenario. At the lowest levels of the tree are sources of observable data. Probabilities of the hypotheses are assessed after data and observations are fitted to the structure of the tree. Inference trees can help resolve disagreements between assessors and encourage the use of existing knowledge and data. The example outlines likelihood and factors to be considered that a prescribed burn may escape.

Source: Cleaves (1994)





Step 5: Evaluate Changes to Indicators and Risk

The nature of this step will vary with the specific requirements of the ERA (Step 1). This is related to the application for which the assessment is being undertaken (e.g., planning or decision making process), as well as available inventory data, resources and methodology selected.

Step 5.1 Compile and Evaluate the Relevant Components of Proposed Development Options

Alternative development options, such as those proposed for land use planning, should be reviewed by compiling the components of each option, identifying the differences between them, and comparing the differences. With respect to the environmental value under assessment, identify, for each alternative development option:

- predicted interactions with pressures;
- type, intensity, duration and geographic extent of proposed habitat alteration (e.g., soil disturbance, changes to stream flow regimes, vegetation alteration);
- predicted changes in habitat attributes or indicators specifically linked to the values or resources being assessed;
- type, effectiveness and degree of specificity of proposed environmental protection measures (e.g., general principles, guidelines, regulations and specific rules); and,
- potential for feedback or adaptive management.

As an example, the development of the 1997 Forest Plan for the Tongass National Forest, (Everest et al.) included asking scientists to evaluate the likely effects of various features included in alternative management scenarios on wildlife populations. Exhibit 23 summarizes how this information was presented. Another example is provided in Exhibit 25, outlining management regimes against environmental values for analysis used in the KBLUP Environmental Analysis (1996). Exhibit 13 provides a Nordic example of classifying various management activities according to their intensity and extent of impacts on biodiversity. Environmental accounts analyses and reports undertaken for Land and Resource Management Plans across the province also provide numerous examples for review and consideration.

Exhibit 25: Evaluating "Management Regimes" for Specified Environmental Values: An Example from Kootenay-Boundary Land Use Plan Environmental Analysis

	Environmental Values for Analysis				
Management Regimes	**Representative Ecosystems and Regional Connectivity**	**Woodland Caribou**	**Grizzly Bear and Other Wide-Ranging Carnivores**	**Ungulate Winter Ranges**	**Regionally Significant Fisheries**
Protected	Assumed to be low risk management; assumed that habitat management is the priority; some parts of protected areas may not meet this assumption (e.g., Highway #1 and CPR rail corridor through Glacier National Park)				
MELP Caribou Guidelines	improved distribution of older seral stages in caribou areas	prime retention of old growth in mapped habitat areas; lichen retention	improved seral stage distribution	provides for cover and lichen requirements	reduced ECA due to OG retention; potentially wider and more extensive riparian corridors
MELP Ungulate Winter Range Guidelines	minimal impact	minimal impact	may increase population levels of prey species	cover and lichen requirements; access controls; migration routes; forage species	minimal impact
FPC High Emphasis Biodiversity	improved seral stage distribution; FENs; lack of CWD guidelines	retention of old growth and mature; FENs provide connectivity	improved seral stage distribution and connectivity; lack of CWD guidelines	improved seral stage distribution will provide cover requirements; FENs - connectivity	reduced ECA due to seral stage distribution; potentially more riparian corridors
FPC Low Emphasis Biodiversity	potential for seral stage imbalances with no limits on early seral; some old growth retention; no FENs	insufficient retention of old growth	high density access; lack of early seral controls will likely lead to boom/bust food cycles	high density access; potential for cover limitations	potential for high ECAs; some riparian protection
MoF Visual Management Guidelines	increased retention of mature stands	increased mature stands; insufficient retention of old growth	increased retention of mature stands	increased mature stands to meet cover requirements; possible conflicts with forage areas	increased retention of mature stands to moderate ECAs
TSR pre-FPC Management	no seral stage guidelines; no old growth retention; extensive fragmentation; no FENs	insufficient retention of old growth	high road densities; lack of protection for key habitats; seral stage imbalances	high road densities; potential for cover limitations; vegetation treatments may limit forage species	high road densities and sediment production; limited riparian protection; no ECA guidelines
Dedicated and Private	essentially no management guidelines; habitat can be drastically altered at anytime; potential for conflicts with livestock, domestic pets and food attractants				potential for high ECAs; no riparian management; high potential for sedimentation

Source: Utzig (1997)

Step 5.2 Assess the Degree of Risk Involved with Each Alternative

This task involves assessing the *degree of risk* (by class), at various future times, for the range of alternative development options; based on projected changes in environmental conditions, habitat attributes or indicators identified in Step 4.

Methods commonly used for assessing risk vary from simple rating systems based on individual professional judgment to complex computer models that analyze vast quantities of data. There are also various combinations employed, such as expert panels, GIS map overlays and computer-generated summaries of expert opinion. In general the methodologies fall into four main groups.

1. Professional judgment, where risk classes are subjectively assigned by an individual based on a review of available information. This method may utilize basic statistics on indicators or data summaries to provide the background for assessment.
2. Expert panels, where a group of experts individually assess risk or various aspects contributing to overall risk, and their assessments are averaged or otherwise combined to provide an overall risk assessment.
3. Spatial analysis of management regimes in relation to specified areas or habitats required for maintenance of particular values or resources (i.e., manual or GIS map overlays), combined with a compatibility matrix for the proposed management regimes and environmental values under assessment. This most commonly involves professional judgment and assumptions in the design of the compatibility matrix (e.g., see Exhibit 23 and Exhibit 25).
4. Analysis of predicted future conditions generated by computer modeling of changes in indicators, specific habitat attributes or other environmental conditions — implicitly involves numerous assumptions and professional judgment in the construction of the model (e.g., see Exhibit 25 and Exhibit 27).

Professional judgment has been routinely employed in assessments of LRMP alternatives, often employing a simple scale for rating the potential positive, negative or neutral influences of management practices or predicted environmental changes on a particular environmental value (e.g., see SALASAN et al. 1996). In most cases, professional judgment is augmented by summaries of indicator data, such as: percentages of protected areas and other management regimes, projected road densities, widths of riparian reserves, etc. The U.S.F.S. has also made use of professional judgment for individual species assessments required for National Forest planning (e.g., see Ramotnik (1997) for salamanders and Young (1995) for cutthroat trout).

Exhibit 26: An "Expert Panel" Approach to Assessment of Risk

Scientists on the Tongass Land Management Planning team used panels of subject matter experts, somewhat similar to the "Delphi method", to independently evaluate each of the original nine draft Forest plan alternatives for likely effects on wildlife populations. A second round of risk assessment panels was held to similarly evaluate the emerging final alternative. Members of each panel independently evaluated a selected species (or group) for the likelihood of obtaining specific outcomes regarding its status and distribution following implementation for 100 years of each draft Forest plan alternative. Each wildlife species (or group) was selected according to specific life history characteristics and habitat needs. Collectively their ecologies incorporated the breadth of forest habitat features and other environmental variation represented across the Tongass National Forest (see also Exhibit 23).

Six wildlife panels were conducted in the first set of panels: brown bear, marbled murrelet, Queen Charlotte goshawk, Alexander Archipelago vole, American marten, and "other terrestrial mammals", (which comprised a group of more wide-ranging mammals and a group of endemic small mammals).

Each panel was comprised of subject matter experts who independently evaluated each draft Forest plan alternative. Each evaluator served on only one panel but most served on that panel in both rounds of assessment. With one exception, none of the evaluators had previous involvement with the TLMP process. During the panel, each evaluator independently assigned 100 "likelihood" points across five outcomes for each alternative. Likelihood points assigned to each outcome were not probabilities in the empirical sense of frequencies; rather, they reflected extent of conviction, or uncertainty, according to available information and sound professional judgment in expected outcomes and were expressed through a probability-like scale. Individual ratings remained anonymous. A scribe recorded scores, computed a mean score for each alternative, and provided all results to each panel member for further discussion.

Scientists agreed on several alternatives that would either increase or decrease risk to population viability. Each of the alternatives considered independently affected risk to wildlife viability. As Everest notes (1997:67), "How much each element influences wildlife viability, or more importantly, the cumulative effect of these changes, is difficult to quantify.... Although the TLMP scientists cannot ascribe numerical changes in risk (i.e., specific likelihood scores) to wildlife viability associated with each change, the direction of these changes in the emerging final alternative appeared to present a reduction in risk to wildlife viability."

Source: Everest et al. (1997)

Expert panels are often employed by the U.S.F.S. to evaluate alternative management options. In the case of "Old-Growth Related Species" expert panels were used to assess the sufficiency of habitat to support viable populations, in contrast to performing precise analyses of the likelihood of persistence or extinction. The habitat assessment outcomes were assigned to one of four possible classes: a) sufficient habitat for stable populations; b) sufficient habitat for stable populations with significant reduction in numbers and distribution; c) significant habitat reduction resulting in isolated small populations; or, d) extirpation (USDA 1993). (See Exhibit 26 for a description of the role of expert panels in planning for the Tongass National Forest).

Spatial analysis of proposed management regimes in relation to identified habitats has been increasingly utilized with the availability of GIS technology. Often expert opinion is combined to establish the links between management regimes, future environmental conditions and predicted population trends. This method has been employed by the U.S.F.S. in an assessment for Neotropical Migratory Land Birds in the Interior Columbia Basin. In this case, bird census data were combined with predicted changes in habitat from four management alternatives to assess future population trends for each bird species (Saab and Terrell 1997).

In a Pennsylvania study assessing the risk to biodiversity from future urban development, six alternative scenarios were compared with regard to the likelihood of species extirpation due to habitat loss. GIS maps of land use changes associated with each scenario were used to predict the long-term habitat availability for each of 231 vertebrate species. A literature review and expert opinion was employed to develop 13 habitat classes and establish links between species' requirements, habitat classes and minimum home range size (White et al. 1997).

Detailed computer habitat modeling for individual species has been used in some cases to assess risks of alternative management options, especially for species already recognized to be at high levels of risk. An evaluation by Soulé (1986) of extirpation risk resulting from a proposed dam within the habitat of the Concho water snake in Texas is a frequently cited example of a modeling approach to risk assessment.

Exhibit 27: Detailed Indicators and Assessment Criteria for Modeling Northern Goshawk Habitat-Related Risk

Habitat Component	Indicator and Weighting		Criteria and Suitability Classes*			
			Good	Moderate	Poor	Unsuitable
1. Nest Area 40 ha	V. Large Trees (>60 cm dia.)	(1)	>50/ha	30-50/ha	10-30/ha	<10/ha
	Large Trees (>40cm dia.)	(1)	>60/ha	40-60/ha	20-40/ha	<20/ha
	Crown Closure	(1)	>75%	60-75%	50-60%	<50%
	Canopy Complexity	(1)	>2 layers	2 layers	1 layer	no canopy
	Slope	(0.5)	<30%	30 –45%	45-60%	>60%
	Water Source	(0.5)	< 0.5 km	>0.5-2 km	>2-4 km	>4 km
	Patch Size	(0.8)	>40 ha	20-40 ha	5-20 ha	<5 ha
	Distance to active road or development.	(0.3)	>1000 m	500-1000 m	250-500 m	<250 m
	Aspect	(0.3)	NW,N,NE	W,E	SW,S,SE,nil	--
2. Post Fledging Family Area (PFA) 240 ha	Crown Closure	(1)	60-80%	50-60% & >80%	40-50%	<40%
	Large Trees (>40cm dia.)	(1)	>50/ha	40-50/ha	30-40/ha	<30/ha
	Large Snags (>40cm dia.)	(0.8)	>9/ha	6-9/ha	3-6/ha	<3/ha
	Coarse Woody Debris (large)	(0.8)	>80m3/ha	60-80m3/ha	40-60m3/ha	<40m3/ha
	Density of Small Openings <0.5 ha	(0.5)	10-20/100 ha	5-10/100 ha & 20-30/100 ha	<5/100 ha & >30/100 ha	NA
3. Forested Foraging Area 1920 ha	Crown Closure	(1)	60-80%	50-60% & >80%	40-50%	<40%
	Large Trees (>30cm dia.)	(1)	>120/ha	90-120/ha	60-90/ha	<60
	Large Snags (>30cm dia.)	(0.5)	>9/ha	6-9/ha	3-6/ha	<3/ha
	Coarse Woody Debris (large)	(0.5)	>80m3/ha	60-80m3/ha	40-60m3/ha	<40m3/ha
	Density of Small Openings <0.5 ha	(0.5)	10-20/100 ha	5-10/100 ha & 20-30/100 ha	<5/100 ha & >30/100 ha	NA
4. Home Range 2400 ha	Quantity and Quality of Nesting, PFA and Foraging Habitats		Sufficient quantity of good quality nesting, PFA AND foraging habitat within 2400 ha home range	Moderate quality and/or moderate quantity of nesting, PFA and/or foraging habitat within 2400 ha home range	Barely sufficient area of poor quality nesting, PFA OR foraging habitat within 2400 ha home range	Insufficient quantity of suitable nesting, PFA OR foraging habitat within 2400 ha home range

Source: Utzig and Gaines (1998)

***Note: Class limits will vary regionally among forest types (e.g., #s of large and very large trees – density and size criteria).**

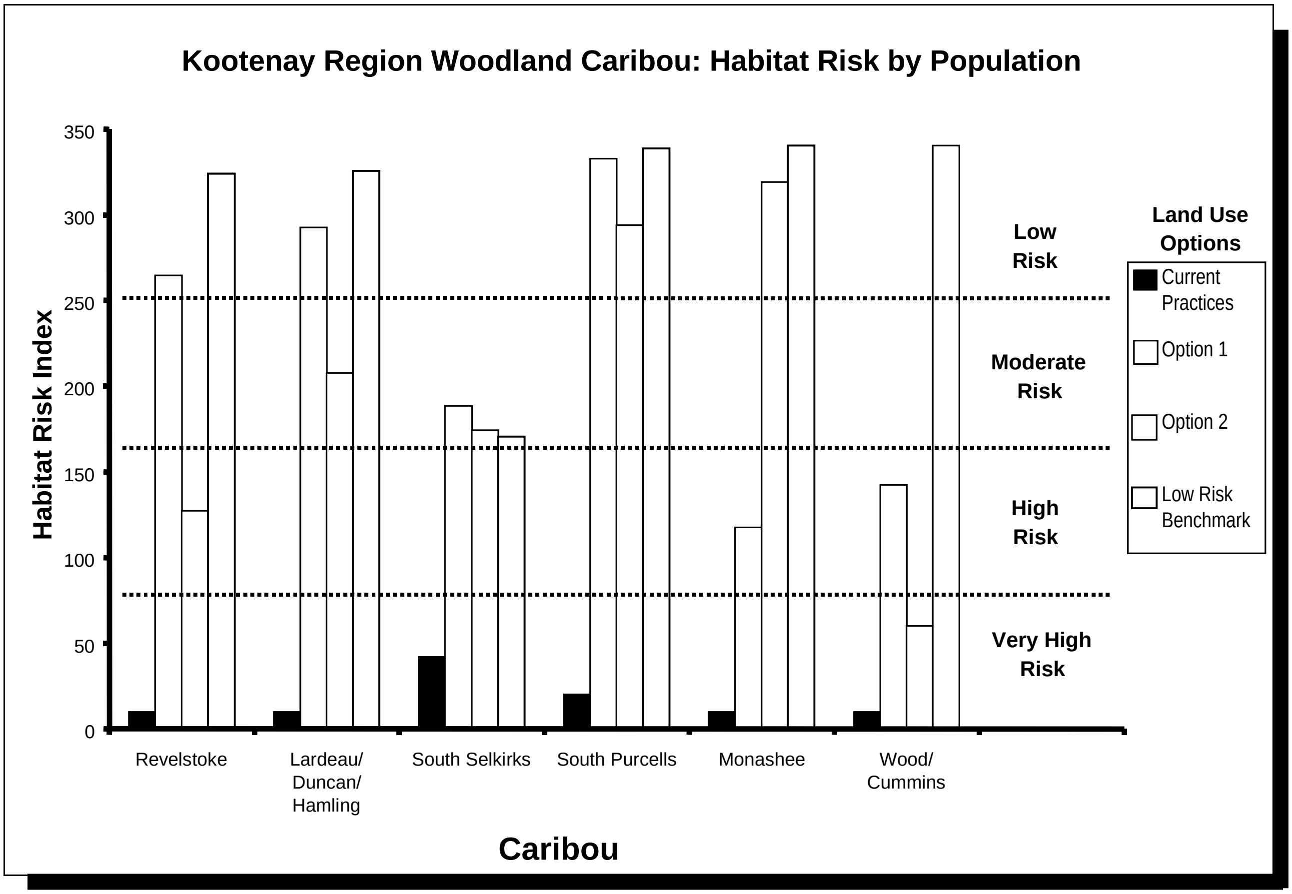
With the increased use of "spatially-based" timber supply modeling in BC, there are increased opportunities for developing detailed habitat supply models for assessing habitat-related risks for individual or groups of species. One example is the use of SIMFOR to model the habitat availability for the Northern Goshawk. Exhibit 27 outlines some of the indicators and criteria analyzed to establish various levels of goshawk habitat suitability within the model.

In addition to assessing the risks, the analysis should also include a series of sensitivity tests to evaluate the assessment methodology, to test assumptions and investigate the degree to which uncertainty in inventory data or other inputs affect the reliability of risk predictions.

Step 5: Summary of Key Questions and Tasks

Key Questions	Tasks
• What are the forecasted changes to indicators for each of the development options? • What risks to the environment are associated with the forecasted changes to indicators? • How do forecasted risks for each proposed development option compare with the base case and low risk benchmarks?	1. Assess the range of proposed development options. For each option identify: - the intensity, scale and duration of the various management activities; - predicted future pressures resulting form those activities; and, - consequent changes in selected indicators linked to the values being assessed. 2. Assess the degree of risk (by class), at various future times, for the range of alternative management options (including cumulative impacts).

Exhibit 28: Presenting ERA Results: An Example from the Kootenay-Boundary Regional Biodiversity Strategy



Source: Utzig (1996)

RESULTS

Step 6: Report Results and Develop Risk Reduction Strategies

Steps 1 to 5 in the ERA process emphasize the technical process involved in identifying, measuring and analyzing risk. At this point, the ERA end-users (e.g., decision makers, involved stakeholders, MELP staff or managers) must understand the extent and nature of risks to environmental values and determine “acceptable” levels of risk. Decisions about acceptable levels of risk are — of course — not based on technical information on risks to environmental values alone and must be considered within the planning, management or decision making process in which they are embedded.

Step 6.1 Interpret the Results of Environmental Risk Assessment

It is important to clarify which options present the lowest and highest risks to the environment, and the evidence supporting these conclusions. The specific differences between the options that contribute to their varying levels of risk to environment should be identified and characterized.

The extent and severity of risk posed by each of the options should be clearly spelled out, such that decision-makers are fully aware of the consequences of their decisions. However, the interpretation of risk levels does not include choosing an acceptable level of risk, that is the role of the decision-maker.

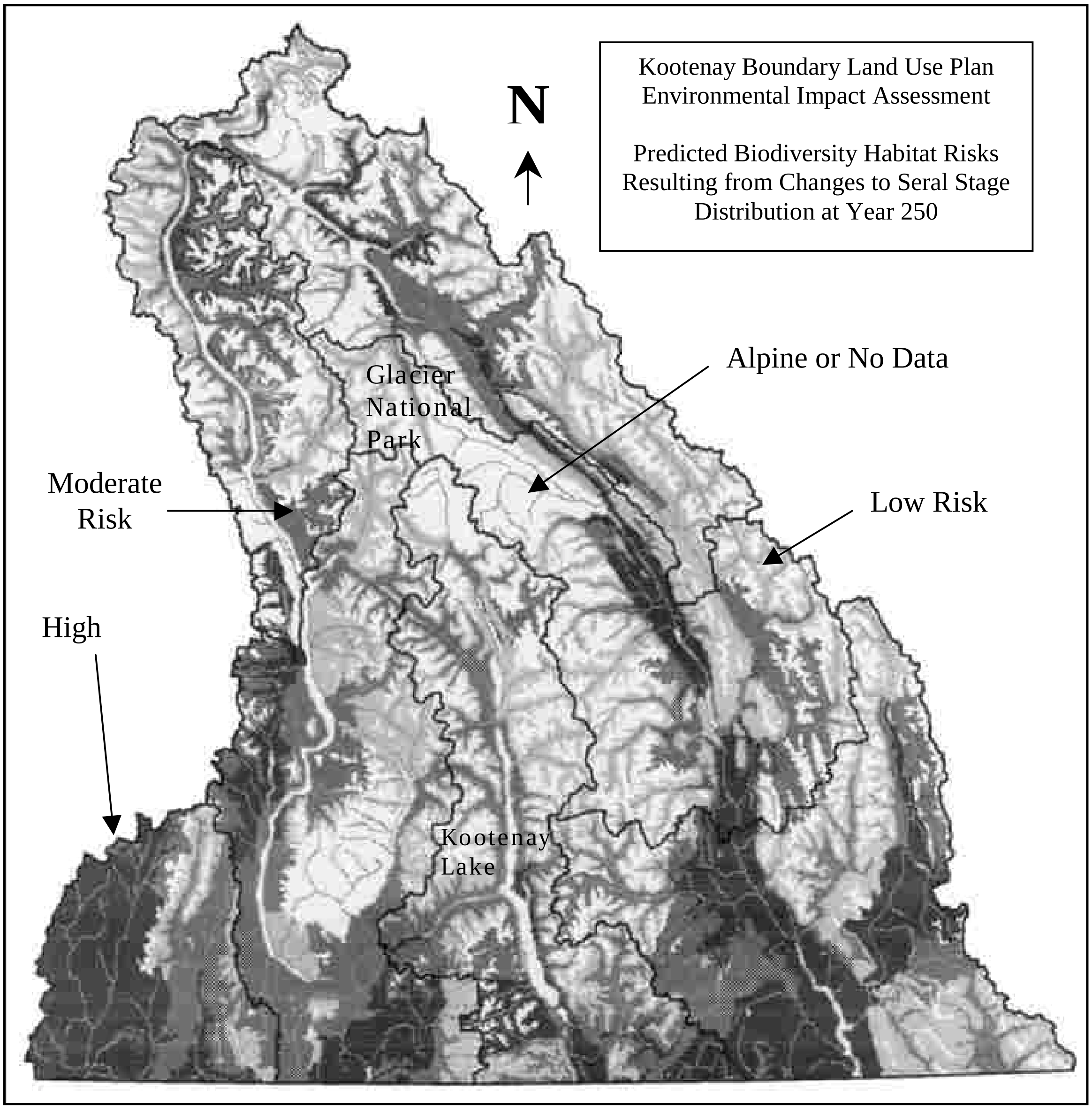
Step 6.2 Identify Risk Reduction Strategies

While completing the ERA, relationships between management activities, pressures and risk will be identified. These elements should be compiled and assessed through the ERA. Risk reduction strategies based in these relationships should then be identified and described, including:

- causal agents related to the *most-limiting* risk factors (e.g., most limiting habitat attribute and cause of its poor quality or minimal supply);
- possible actions to decrease pressures/stress on the value, and support or enhance areas where pressures are less acute; and,
- alternative or modified management scenarios that will reduce or minimize risk.

This step should be clearly separated from other steps in the Environmental Risk Assessment to distinguish the technical elements of the assessment from the management planning or policy role of proposing alternatives or modifications to management actions (see Exhibit 30).

Exhibit 29: A Map-based Presentation of ERA Results: Predicted Biodiversity Habitat Risks of the Kootenay-Boundary Land Use Plan



Source: Utzig (1996)

The persons completing the ERA are not normally decision-makers, nor should they be seen to lobby for a particular decision. They do however, have a responsibility to ensure the actual decision makers are informed of a range of alternatives, especially those which may reduce risk to environmental values. Rigor in identifying and following an explicit methodology through all steps in the environment risk assessment process (including this step) should build understanding of, and potential receptivity to, risk reduction strategies among parties responsible for recommending and/or deciding upon a preferred course of action.

Step 6.3 Report the Results of Environmental Risk Assessment

It is critical to have documentation to support risk assessment conclusions. Documentation should include as a minimum, a clearly written summary of assumptions made in the preparation of the assessment. This summary should clarify:

- information sources, data availability and reliability;
- issues of data accuracy and scale;
- problems in interpretation and extrapolation;
- subjectivity or uncertainty related to information inputs;
- assumptions made, including contingent information included in the analysis (e.g., x will occur if y happens, but only if z occurs);
- the prevailing model of functional relationships or the relationship between factors influencing the values at hand; and,
- overall confidence levels.

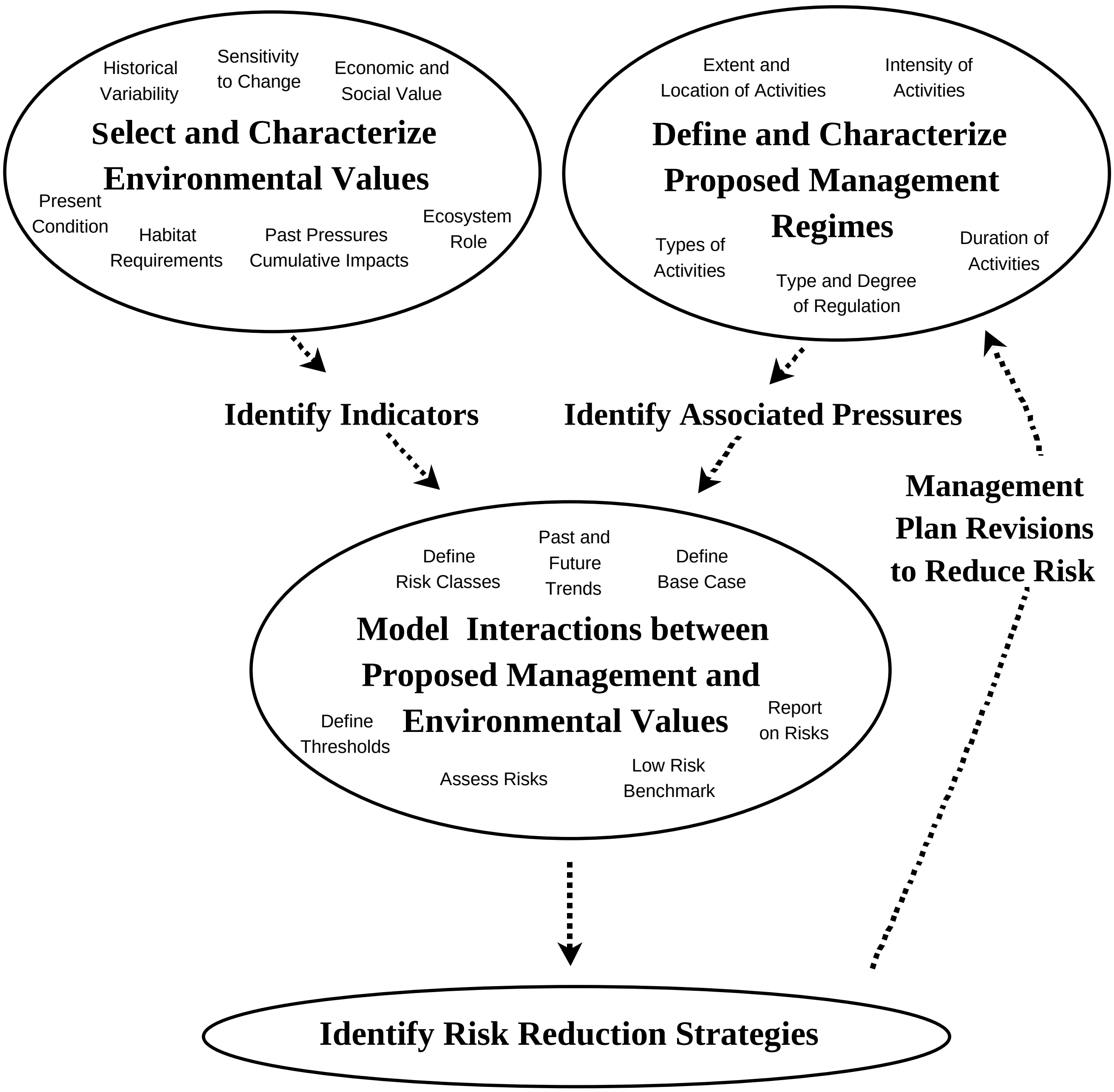
The summary of assumptions is not a "disclaimer" to undermine the credibility of the assessment. Rather, it should provide a foundation for reasoned understanding and interpretation of the results within the limitations of the assessment methodology and available data.

As well as the normal written report, results should be presented graphically where feasible. Tables, charts, graphs and maps may make the information more accessible to a wider audience than written material on its own (e.g., see Exhibit 27 and Exhibit 29).

When presenting ERA results:

- tailor the presentation to the appropriate audience (e.g., planners, policy makers, public);
- clearly articulate assumptions, limitations and uncertainty (level of confidence);
- clearly explain the definitions and consequences of risk levels; and,
- where possible, demonstrate spatial and temporal variation in risk levels, and identify and discuss key causal agents.

Exhibit 30: Role of Environmental Risk Assessment in Comparing Management Regimes and Revising Management Actions



Step 6: Summary of Key Questions and Tasks

Key Questions	Tasks
• What are the comparative levels of risk associated with the various development options? • What actions could be taken to reduce pressures on and/or minimize risk to the environment?	1. Interpret the assessment results; identify low risk options and risk factors. 2. Identify risk reduction strategies: - identify actions to decrease pressures linked to high risks, and actions to support or enhance activities linked to low risks; and, - propose management strategies, policy options or development scenarios that could reduce or minimize risk. 3. Report the assessment results; including assumptions, limitations, uncertainty, and a full explanation of the consequences of risk levels.

4. SUMMARY

Providing review and comment on resource management or development proposals has been part of the responsibilities of Ministry of Environment, Lands and Parks staff for some time. This report is offered as a tool to staff and others to assist in more effectively identifying and communicating potential impacts and outcomes of decisions affecting the environment. It is an underlying assumption of this report that better informed decision makers will lead to more explicit accounting for environmental values in decision making processes, as well as consideration of means and measures to reduce risk to the environment resulting from human actions.

This report provides an assessment framework for use not only by government staff, but also by other stakeholders, interested parties, the general public, and others involved in decision making processes. Only when there is wider understanding and routine reporting on causal factors and changes in risk to the environment can we hope to move towards a more environmentally sustainable future.

In the absence of environmental risk information, decision makers are often compelled to "make decisions in the dark" – with the impacts of human activity unaccounted for due to uncertainties or complexities around environmental values and processes. This report introduces environmental risk assessment as an effective and efficient means within decision making processes to rigorously acknowledge, clarify and account for risk to the environment. Even in situations where time or resources for assessment are scarce, ERA can provide an effective means of presenting available environmental information.

It is hoped that analytical capabilities within and beyond the Ministry of Environment, Lands and Parks will grow – leading to increased confidence in accounting for biodiversity, water, fish and wildlife values. As land use and resource management planning and decision making processes begin to routinely address the probability of sustaining these values, the result will be better informed decisions and improved accountability for the environment.

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APPENDIX 1: ENVIRONMENTAL RISK ASSESSMENT EXAMPLES

The following descriptions are provided as examples of the application of ERA to real situations. They are not intended as a definitive or comprehensive illustrations of the full range of applications for ERA. The examples are described according to the steps outlined in Section 3 of the report.

Example 1: Kootenay-Boundary Land Use Plan Implementation Strategy

This example involves an environmental assessment for a regional land use plan implementation strategy using limited resources.

Step 1: Establish the Context for ERA

The Kootenay-Boundary Regional Land Use Plan Implementation Strategy was recognized to be a key policy document; one that would guide Landscape Unit objective setting, and provide guidance for management of species not covered under the FPC Identified Wildlife Guidebook, such as caribou.

Provincial Cabinet directed government agencies to provide analyses of economic, social and environmental impacts prior to acceptance and approval of the implementation of strategy.

Due to the general acceptance of the “quantitative” timber supply analysis results, it was a priority to develop and undertake a parallel, “quantitative” environmental analysis, to ensure equitable consideration of environmental values. Earlier environmental assessments had been criticized for too much reliance on professional judgment and assumptions about the potential outcomes of management scenarios.

Step 2: Identify and Characterize Key Environmental Pressures

Regional land use planning requires consideration of pressures and fundamental change factors at a broad generalized scale. The most widespread and significant pressure at the regional scale was considered to be timber harvesting and associated road construction. Other changes such as mining, urban development, agricultural clearing or wetland alteration were considered as potentially more severe and long lasting, but more isolated in occurrence. Hydroelectric dams were also identified as an important pressure on environmental values, particularly with regard to cumulative impacts, but were not considered as significant as forest harvest activities for potential to increase pressure in the near and mid-term future.

Step 3: Specify Environmental Values and Indicators

There were various factors considered in choosing values and indicators for the assessment:

- the regional planning process was by definition broad scale, having minimal site-specific detail with regard to plan implementation, indicating that a general environmental indicator was appropriate;
- minimal time and resources were available to mount a full-scale environmental impact assessment;
- forest harvesting was considered the most extensive and significant change factor – therefore, changes in supply of habitat attributes linked to forest harvesting were used as general indicators in determining risk to environmental values; and,
- timber supply modeling provided a data source for predicting future stand types and ages with a moderate degree of spatial resolution.

Based on these considerations, the habitat indicator of seral stage distribution was chosen as the focus for assessment. Seral stage distribution is linked to many important habitat attributes (e.g., coarse woody debris, large trees, large snags, stable substrates for lichen communities). Timber harvesting is likely to be a major, if not the major, determinant of seral stage distribution in the future.

Step 4: Characterize Environmental Trends, Indicator Relationships and Establish Risk Classes

The regional scale and limited time frame of this assessment did not allow for detailed assessment of individual habitat attributes or species. One of the key assumptions of this analysis was that changes in seral stage distribution, particularly reductions in old and mature seral stages, would correlate with increased risk to species dependent on habitat attributes that occur in those types of forest stands. These would include species such as caribou, goshawk, pine marten, and cavity nesters. Developing detailed cause and effect models reflecting increased risk to individual species were beyond the scope of this assessment.

The base case for this study was defined by the “natural” seral stage distribution, as presented by the FPC Biodiversity Guidebook for each natural disturbance type. Although a low risk benchmark was not specifically defined, it was implicitly assumed to be maintenance of seral stage distribution with the range of natural variability. Five classes of risk from “very low” to “very high” were differentiated, based on the degree of change between “natural” levels of old, mature, and early seral, and values predicted to occur with implementation of the KBLUP. The risk classes divided the range from “natural” levels of seral stage distribution to severely altered seral stage distribution into five equal classes (severely altered = 0% old/mature and 100% early seral). Although it was assumed that many species probably have thresholds for habitat suitability or extent, this study did not attempt to define thresholds.

Risk classes were reported for four times: the present, and 20, 70 and 250 years into the future. The risk classes were described in terms of the relative likelihood of population increases or declines, local extirpations or regional extinctions of species dependent on older forest habitats or mosaics of forest seral stages (see Exhibit 21).

Step 5: Evaluate Changes to Indicators and Risks

The ERA was conducted by obtaining forest stand age and distribution data from the simultaneous timber supply modeling project. The FSSIM timber model provided standing crop summaries for calculation of seral stage distributions for the four time periods, for each BEC unit of each Landscape Unit throughout the region.

Step 6: Report Results and Develop Risk Reduction Strategies

Results were presented principally as a series of four maps displaying the geographic distribution of risk at each time period (see Exhibit 29). In addition, the relative levels of risk were summarized in graphical form by management unit, BEC units and by species habitat zones. A written report described the methodology and assumptions, identified limitations, and provided a brief summary of regional trends.

The time frame for decision making did not allow for consideration of alternative development options; however, summaries of the results did demonstrate which landscapes were more likely to have reduced or increased risk. A review of the results also provided some ideas for further refinement of the assessment methodology for future projects.

Example 2: Aquatic Values: Domestic Water Supply, Fish Habitat and Flooding

The following is provided as an example of application of the ERA method to selected aquatic values using a small watershed in the Southern Interior of BC. Silverton Creek flows from a 200-km^2 watershed, with the small town of Silverton situated on an alluvial fan where the creek enters Slocan Lake. The environmental values associated with Silverton Creek include fish habitat in the lower reaches, community water supply and the potential for flooding damage to structures located along the stream channel. Forest harvesting and road building have been ongoing for 20 years in the watershed. Further road building and long term harvesting are proposed for the watershed. A watershed committee composed of stakeholders has been formed to develop recommendations regarding forest development. A series of proposals from the forest licensee were examined to determine the potential risks to the identified environmental values.

Step 1: Establish the Context for ERA

Low-order watersheds throughout BC are increasingly a focus for resource development including forestry, hydroelectric, agricultural, industrial, urban, and recreational uses. They also provide water for domestic consumption, and are often important spawning, rearing and breeding areas for fish and other aquatic organisms. Development in small watersheds may impact water values through modification of the quantity, quality and timing of flow. Multiple use of these watersheds can end in failure if management activities are poorly planned.

Step 2: Identify and Characterize Key Environmental Pressures

Various factors affect the aquatic environment. Pressures that are driving increased risks to water-related values include:

- forest harvesting and road building;
- urbanization and population increase;
- climate change;
- hydro-electric development (loss of migrating salmon, nutrient flow blockages);
- water diversion/consumption for agriculture, domestic, or industrial use; and,
- point source pollution (e.g., industrial).

These pressures can change the quality, quantity, and timing of flows—changes which can alter the value of water for aquatic habitat and its utility for domestic and irrigation uses. The changes can be direct (e.g., enhanced sediment delivery into a spawning channel as a result of road building) or indirect (e.g., changes in micro-climate modifying a watershed's flow regime). The effects of some activities (e.g., urbanization, conversion to agriculture) are felt locally while others (e.g., forest development activities) are extensive over the land base.

In the case of Silverton Creek, the primary pressure was timber harvesting. Timber harvesting has been linked to changes to the aquatic environment, primarily through road construction and forest removal. Secondary pressures included mining exploration and recreation road use, which limited the applicability of road closures and road rehabilitation. Because the total harvested area was well distributed and not a large percentage of the basin (<20%), ECA effects on the flow regime were not considered to be a major pressure at the time of the analysis.

Step 3: Specify Environmental Values and Indicators

Various factors were considered when selecting environmental values and indicators for the assessment:

- forestry activities are extensive on Crown land and private lands in the watershed;
- point source pollution is not presently identified as an issue, and not likely to be one the foreseen future unless mining activity increases;
- the most important impact on water quality due to forestry activities is sedimentation and there is a strong and visible relationship between sedimentation and forestry activities (e.g., a landslide from a road fillslope entering the creek);
- measurement of most attendant effects on the quantity and timing of flow requires measurements (and is also subject to some debate);
- sedimentation is a reasonable indicator of overall water resource degradation (e.g., loss of aquatic habitat, deterioration in water chemistry); and,
- reliance on characterization of the condition of the value (e.g., sediment concentration at a water intake) requires long term detailed measurements and analysis and as such can result in data gaps; it is preferable to base the assessment on quantifiable management activities where possible.

Based on the above considerations, the effect of forest development activities on water quality was selected as the focus for the assessment. Risk to water was assessed based on management-related indicators, rather than relying on direct measures of water quality or flow.

Step 4: Characterize Environmental Trends, Indicator Relationships and Establish Risk Classes

The key indicator relationship used in the assessment was based on the assumption that increased sedimentation leads to increased risk. This included risk to water quality (e.g., for community and individual intakes), risk of flooding (e.g., on alluvial fans), and risk to aquatic organisms due to habitat deterioration (e.g., fish). The factors that determined the extent to which water quality was diminished through sedimentation were:

- sediment sources — their size and persistence;
- the connectivity of the sediment sources to the drainage network;
- the texture of material delivered to the drainage network;
- the condition of the riparian zone (wood recruitment, bank stability); and,
- management regime (e.g., extent and quality of development).

Primary data sources were forest cover and terrain and soil inventories. Proposed development plans identified locations of proposed roads and cutblocks, including an indication of the types of construction and silvicultural practices.

The base case was defined as the watershed in an undisturbed state. However, this did not assume year-round crystal pure water. It was recognized that water quality fluctuates, even under “natural” undisturbed conditions, due to fire and to extreme precipitation/freshet events. Although beyond the scope of this assessment, it was recognized that climatic records could be used to predict the intensity and return intervals for extreme precipitation events (e.g. rain on snow), and natural disturbance regimes could be used to predict the return intervals for major fires. These could then be linked to estimated historic variation in the presence of sediment sources, frequency of flood events, and change in forest cover sufficiently large to impact flow regimes, and the occurrence of channel instability or flooding.

Five risk classes were defined from very low to very high. The low risk benchmark was defined in relation to the historic range of pre-development “natural” conditions. With these assumptions, the low risk benchmark included brief periods in the spring freshet when water quality was diminished (slightly above drinking-water standards) with infrequent occurrence of major channel avulsions on the fan leading to both flooding and lengthy periods of reduced water quality (far above drinking-water standards). In contrast, the very high risk condition was defined as diminished water quality (not meeting drinking-water standards) throughout major periods of the year. Under very high risk, flooding due to channel avulsion was an ongoing threat, largely in conjunction with the annual freshet peak, or with rain on snow events during the spring freshet. The definition of low, moderate, and high risks involved gradations between these extremes.

Thresholds were defined at the point where drinking water standards are not met for more that 20% of the year, where fish habitat is incapable of maintaining sufficient spawners for a viable population, and where channel instability was likely to result in damage to existing structures on the fan.

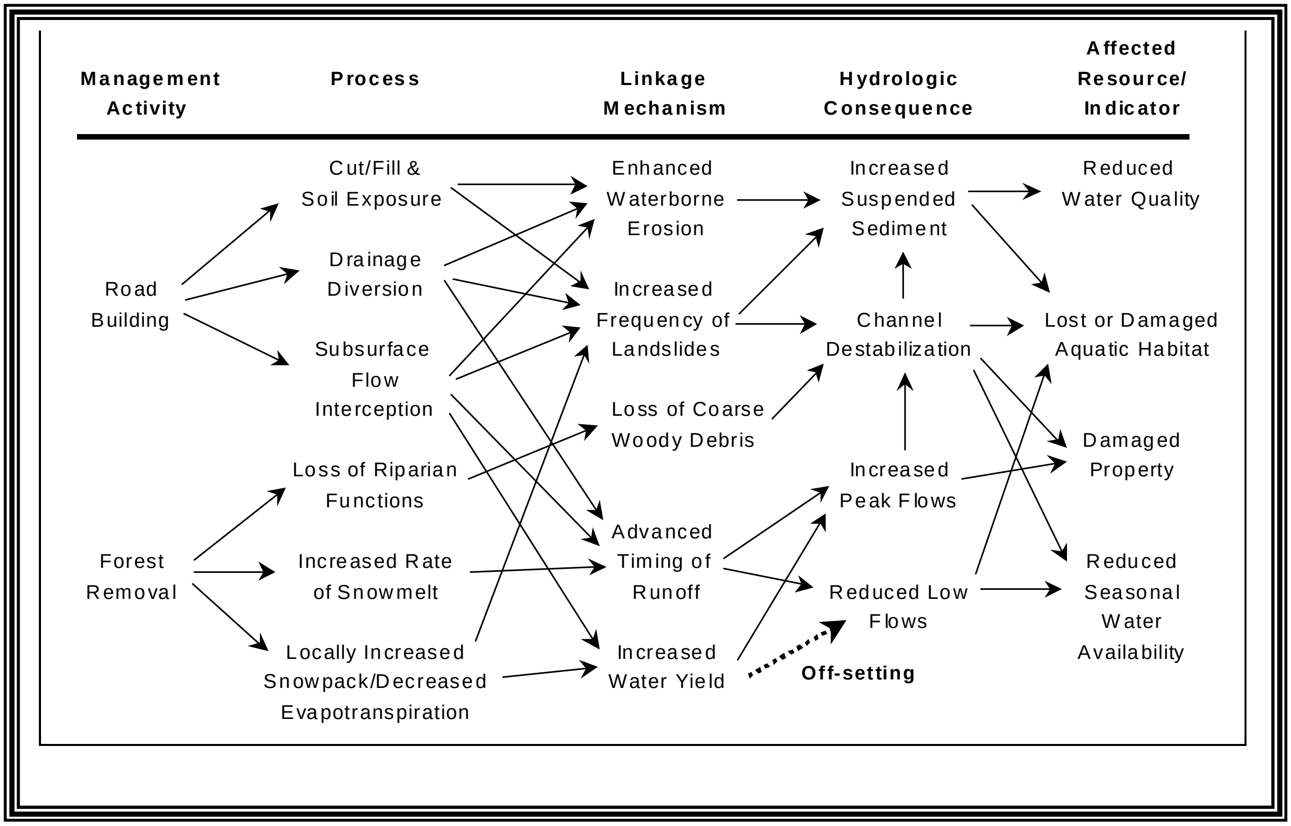
The basic assumption regarding risk was the link between road construction and harvesting, and increasing risk to aquatic values. For an overview approach, the following matrix was proposed:

Figure 1: Risk Classes for Watersheds Based on Road Density and Equivalent Clearcut Area (ECA)

ECA (%)	**Road Density (km/km^2)**			
	0-1	**1-2**	**2-3**	**>3**
0-10	VL	L	M	M
10-20	L	M	M	H
20-30	M	M	H	VH
>30	M	H	VH	VH

For a more detailed approach, it was proposed to utilize a spatially-referenced computer model. GIS data would be used to portray the extent and locations of roads and cutblocks through time. A more complex algorithm approach would be utilized to determine the relative risks (see Figure 2 below).

Figure 2: Links Between Management Activity and Indicators (from Carver and Utzig 1999)



Step 5: Evaluate Changes to Indicators and Risks

Due to a lack of funding and the time-frame for decision-making, an overview approach was selected. The approach involved the calculation of standard Interior Watershed Assessment Procedure (IWAP) indicator values and the use of expert opinion to determine the relative levels of risk to environmental values.

The IWAP indicator values included factors such as:

- peak flow index (based on equivalent clearcut area - ECA and road density);
- road density (total, above and below the H60 line, within 100 m of a stream);
- roads on erodible and unstable soils;
- portion of stream banks logged; and,
- number of landslides.

Step 6: Report Results and Develop Risk Reduction Strategies

Results consisted of a series of ratings for various hazard indices: peak flow, surface erosion, riparian buffers and mass wasting. The interactions between the various hazard indices were then discussed and expert opinion was employed to provide a summary of the level of risks resulting from the proposed development. Further recommendations were also presented on how to minimize or mitigate some of the risks through modification of the proposal and rehabilitation of cumulative impacts of past development.

Example 3: Cariboo-Chilcotin Land Use Plan Integration Process: Fisheries Target Risk Assessment

In 1996, during implementation of the Cariboo-Chilcotin Land Use Plan, it was recognized that further assessment was required to determine whether the proposed level of forest harvesting was compatible with an acceptable level of risk to fisheries resources in the region. The Fisheries Target Committee initiated the analysis described below to evaluate the risk associated with proposed harvesting rates (Fisheries Target Committee 1996).

Step 1: Establish the Context for ERA

The context for the analysis included a short time-frame and a large landbase at a regional scale. The regional land use planning process had set targets for a variety of resources including fisheries and timber products. The primary issue was whether the timber targets were compatible with the fisheries target, which had been defined as no net loss of fish habitat.

Step 2: Identify and Characterize Key Environmental Pressures

The major pressure was identified as timber harvesting targets established by the planning process. The impacts of this pressure was expressed through road construction and associated sediment sources, and removal of forest cover and the potential for changes to flow regimes.

Step 3: Specify Environmental Values and Indicators

Due to the regional scale of the analysis the environmental values were defined in broad terms of “fish habitat”. The first indicator selected was “seral stage distribution” (changes to forest cover) which was linked to potential changes in streamflow and channel stability. A second indicator was defined in terms of the “relative extent and severity of terrain stability hazards” within the watersheds under consideration. This indicator provided a rough index of the likelihood of development of new sediment sources.

Step 4: Characterize Environmental Trends, Indicator Relationships and Establish Risk Classes

It was assumed that the cumulative impacts to fish habitat would be directly related to the amount of harvesting or other disturbances at any given time. Disturbance was indicated by seral stage distributions on Crown land, as this information was already available within landscape units as part of the data used for biodiversity assessment. Where biodiversity units were not individual watersheds, the biodiversity units were aggregated into larger watersheds, or examined as groups of smaller watersheds.

Potential cumulative impacts for watersheds or groups of watersheds were based on the following assumptions:

- Negative impacts to fish habitat tend to increase in proportion with the percent of watershed area that is in a disturbed condition at any given time.
- The major disturbances that are of concern can be estimated from landscape level timber harvesting on Crown land and deforestation of private land.
- Impacts on fish habitat are mainly caused by sediment deposition in channels, channel instability, the destabilization of streambanks, and changes in water flow, temperature and quality. These can result from road building, logging unstable slopes, disturbance of riparian areas and increased peak flows resulting from timber removal.
- Cumulative impacts due to the above factors can be approximated from equivalent clearcut area and terrain characteristics.

In this assessment, the concept of Equivalent Cleacut Area (ECA) was used as a general indicator of a variety of potential impacts of forest harvesting. The ECA was calculated from estimated tree height as a function of seral stage using professional judgement and personal experience. Additional assumptions were needed to associate seral stages and private land with ECA. These were:

- 85% ECA on private lands (i.e., 15% hydrologic recovery);
- 85% ECA for early seral stands (i.e., < 40 years old);
- 40% ECA in mid seral stands (i.e., 40-100 or 40-120 years old depending on species); and,
- 0% ECA in mature and old stands (i.e., 100% hydrologic recovery for stands > 100 or 120 years old depending on species).

It was acknowledged that where private land ownership was substantial (> 10%), the 85% ECA assumption may over-estimate the removal of timber from private land over the next 20 years. It was also acknowledged that actual risk to fisheries in any given watershed can be better estimated by using more detailed inventory and analysis such as the Interior Watershed Assessment Procedures (IWAP). The seral stage method allowed the estimate of cumulative impacts in 1996 and in the year 2016 due to the 20 year spatial forecast of the timber harvest which was available from other timber supply modeling.

Step 5: Evaluate Changes to Indicators and Risks

Fisheries risk was estimated from ECA and the terrain hazard of each watershed or groups of watersheds for which information was available. The terrain hazards for each watershed grouping was categorized as high, moderate or low, based on steepness, precipitation, distribution of forest land and previous terrain stability studies. Risk was assumed to increase with increasing steepness and precipitation and decrease where large lakes were capable of capturing sediment.

Figure 3: Fisheries Risk Classes Based on ECA and Terrain Hazard

Terrain Hazard	ECA Estimated from Seral Stage Data					
	0-15%	**15 - 20%**	**20-25%**	**25-30%**	**30 -35%**	**35% +**
Low	low	low	moderate	moderate	high	high
Moderate	low	low	moderate	high	high	very high
High	low	moderate	high	high	very high	very high

Step 6: Report Results and Develop Risk Reduction Strategies

The assessment over the plan areas concluded that in 1996 there was a high or very high risk that long term fisheries target will not be met in eighteen biodiversity units. The forecast for the year 2016 was that this would increase to twenty-seven biodiversity units. To check the reliability of this approach, the results were compared with the results of more detailed Level 1 IWAPs for eight watersheds for which they were available. The results were found to be comparable, although the broad scale determinations masked differences between individual smaller watersheds within an assessment unit. It was concluded that the results of the regional assessments were acceptable indicators of habitat risk, especially where more detailed information was lacking.

Potential improvements to the assessment method were identified:

- focusing the assessment on watersheds of high value fish streams within the analysis units;
- establishment of an empirical relation between tree height and seral stage;
- more complete and detailed terrain mapping;
- completion of the assessment for watersheds which extended beyond the planning area boundaries; and,
- more detailed impact analysis for high value watersheds (e.g., application of IWAP and Channel Assessment Procedures).

The Fisheries Target Committee report recommended that analysis units with high and very risk to fish habitat in 1996 undergo more detailed assessment to provide more information regarding risks and causes (e.g., Level 1 IWAP). Where rate of cut issues are identified, it was recommended that a multi-agency round table be established to initiate, coordinate and interpret watershed assessments and to recommend restoration and monitoring activities in order to help district managers meet the requirements of the land use plan.