State of the Environment Reporting: A framework and indicators for the Columbia Basin

"We humans can no longer assume that the services Nature inherently performs are always going to be there, because the consequences of our frequently unconscious actions affect Nature in many unforseen and unpredictable ways."
– *Chris Maser*

"What gets measured gets managed. What gets reported gets understood."
– *Institute for Research and Innovation in Sustainability, York University*

Final Report

April 2004.

Holt, Rachel .F., Veridian Ecological Consulting Ltd.
Greg Utzig
Deb MacKillop
Cindy Pearce

Table of Contents

List of Appendices

List of Figures

List of Tables

Summary Action Plan

The Columbia Basin extends from Valemount in the north, through British Columbia, Washington, Idaho, Montana, Nevada, Wyoming, and Oregon before reaching the Pacific Ocean at Astoria, Oregon. It covers approximately 671,000 square kilometers and is home to over 700 species of birds, mammals, fish and reptiles as well as many large and small human communities. In British Columbia, the main economic drivers within the basin include forestry, hydroelectric power generation, mining, tourism and agriculture. Ecosystems range from old-growth forests to desert grasslands. But what is the state of the environment and how can we measure, track and monitor environmental trends in the Columbia Basin?

The utility of State of the Environment (SoE) reporting has long been recognised within the Columbia Basin and has been a priority for a number of years. SoE reporting provides a summary and overview of the condition of the environment and is important for providing scientifically credible information to the public and to decision makers. SoE reporting systems can track changes in environmental conditions, highlighting areas where improvements have been made as well as providing an early warning system for potential environmental problems.

Scope of This Report

This is the final report from a contract to provide the Columbia Basin Trust with an initiation point for State of the Environment reporting within the British Columbia portion of the Columbia Basin[1]. In this report, we develop a framework for environmental reporting, with the focus of attention on a suite of indicators and a summary of data sources that can form the mainstay of an environment report. Additionally, we provide linkages to the broader form of sustainability reporting, of which environmental reporting is only one component. Developing an Action Plan to assist CBT in moving forward with SoE reporting and ultimately sustainability reporting is a key focus throughout this report.

Two interim reports were previously provided to the CBT:

Interim report #1 provided detailed background on SoE frameworks and reviewed key points of environmental reporting approaches and systems at international, national, and regional scales. A brief summary is provided in this final report. Interim report #1 also provided a list of options and recommendations to the CBT that required clarification prior to additional work. These have been incorporated into the text and approach of this final report. A copy of Interim report #1 is available at [CBT to insert website link and/or other contact].

Interim report #2 provided an initial overview of the approach taken to identify indicators and data sources for the Basin. That work is finalised and presented in full in this final report.

This report is laid out with a Summary Action Plan, and four additional parts:

Summary Action Plan: summarises key recommendations from each section of the report, and provides an action plan for CBT to initiate a comprehensive, affordable SoE framework that will ultimately fit with a sustainability reporting framework.

Part I: provides an overview and framework for designing a SoE reporting system for the Columbia Basin. Brief background information relevant to the essential elements for a successful SoE reporting system is presented along with a summary of our recommendations to CBT. Elements of interest include the purpose, scope, target audience, framework, format and reporting frequency.

Part II: outlines a framework for successful indicator development. Approaches, criteria for effective measures, types of indicators, benchmarks, and scales of assessment are summarised and examples of other frameworks are provided.

---

[1] This report only refers to the area of the Columbia Basin that is directly addressed by the Columbia Basin Trust. For a map, see http://www.cbt.org/contactus/main.asp?fl=6. The CBT portion of the Columbia Basin does not include the Okanagan and Similkameen Valleys.

Part III: summarises the specific indicators and measures recommended for SoE reporting in the Columbia Basin. A full suite of indicators is identified, along with an assessment of data sources and limitations. The process used for prioritising indicators and measures is also presented along with a recommended subset of priority indicators that should be implemented in the first stages of SoE reporting in the Columbia Basin.

Part IV: provides a short overview of linkages between this project and broader sustainability reporting, including recommendations for implementing sustainability reporting and associated planning in the Columbia Basin.

The key recommendations of our report are provided here in the Summary Action Plan. Recommendations relate to different aspects of building first a State of the Environment report, and second, to implementing broad Sustainability reporting throughout the Columbia Basin.

Delivering a State of the Environment Report

Delivery of a comprehensive State of the Environment report is a large process to undertake at any scale and by any organisation. To develop an effective SoE system, there are several key elements to consider prior to implementation. These elements are itemised in Table 1, with a summary of our recommendations. Additional background information is provided in Part I.

Table 1. Key recommendations for implementing a successful SoE reporting framework in the Columbia Basin.

		RECOMMENDATIONS
Purpose	-	Inform target audiences about the current condition of the environment
	-	Forecast changes in conditions in the environment into the future using an appropriate benchmark to assess actual, rather than relative state of the environment
	-	Describe what will happen if actions are not taken to address issues of concern
	-	Identify which environmental conditions are significant/ of concern, and why
	-	Provide an assessment of changes in the environment since the last report was issued
	-	Explain why particular changes are happening in the environment
	-	Identify information needs
Scope	-	Develop a robust state of the environment reporting system. This can then ultimately be included within a sustainability reporting framework, but will ensure that the "environment' component is meaningful.
	-	For example, the the Australian SoE Reporting and the US State of the Nation's Ecosystems Project both provide good examples of development of indicators, use of benchmarks and reporting approaches. These systems are summarised in Part I.
	-	Simultaneous development of meaningful social and economic indicators can result in a robust and complete picture overall. This requires additional collaboration to develop an integrated framework.
Audience	-	The full range of audiences within the Columbia Basin should be served by this initiative. This includes: public information, educators, planning and operational personnel and policy and decision makers
	-	A 'layered' system is recommended to efficiently serve the range of audiences. This would include a succinct overview in a readily accessible format with links to more detailed technical information. The layered approach provides all audiences with relevant levels of detail, without overwhelming some while seeming scant to others.
Framework	-	The Pressure-State-Response model provides a descriptive approach that identifies linkages between cause and effect, and is recommended as a long-term vision for SoE reporting in the Columbia Basin. The P-S-R model is described in Part I.
	-	In the interim, we recommend that reporting primarily on 'State' will be the most feasible approach. Development of robust State environmental indicators would be a first step in this endeavour.

Report Format	-	Provide a primarily web-based approach, with summary printed versions to publicize the work.
	-	On the web, use a layered approach that provides a range of technical detail to suit the variety of audiences
	-	Use a writing style throughout that non-specialists can understand;
	-	Include a concise executive summary or highlights section upfront;
	-	Make reference to appropriate monitoring programs that are the source of ecological data, support the indicators, and provide information for answering policy questions; and
	-	Document the contributors to, and reviewers of the report.
Frequency of Reporting	-	Detailed reporting should occur every 5 years, with interim reports issued in the intervening period where appropriate.

Identifying Appropriate Indicators and Measures for SoE Reporting in the Columbia Basin

Identifying indicators is a key aspect of SoE reporting. In this work, we undertook a thorough and systematic process to identify a full suite of indicators and measures that would be appropriate for assessing the State of the Columbia Basin Environment (the comprehensive list is presented in Appendix 3). In addition, realising that fiscal and practical realities may limit the ability to deliver comprehensive SoE reporting immediately, we developed a core subset of priority indicators and measures that should be assessed in the first SoE reporting period. Also, to provide the CBT with greater flexibility while beginning a SoE reporting process, we categorized the subset of indicators and measures into those that CBT could likely report on in a shorter period (1-3 years) with minimal investment, and those that will require more time and resources to analyse (4-5 years). The priority indicators and measures are identified in Table 2 below. Non-technical summaries of the prioritised indicators and measures are provided in Appendix 2.

The suggested timeframe for each prioritised measure is presented in the final column of Table 2. “Interim” indicates those for early reporting (2005-2007), and “Full” refers to those that would be included later as part of a full cycle SoE report (by 2008 or 2009). Most of the measures designated in the interim set can be reported with basic compilation of existing data sources or reports, and in some cases with some additional analysis and modelling. Indicators with no suggested measure or timeframe either are lower priority, or require further data collection and/or model development. These should be considered for assessment in subsequent SoE reporting cycles (beyond 2008 or 2009).

Table 2. Core indicators and measures recommended for initial SoE Reporting in the Columbia Basin.

REALM / COMPONENT	CODE	INDICATOR	CODE	MEASURE	REPORT PERIOD
Columbia Basin Terrestrial Systems					
Landscape Level Terrestrial Processes and Functions	T-1	Deviation from “natural” disturbance regimes	T-1.2	Extent of ecosystems (forests and grasslands) with altered seral stage distributions (altered from estimated RONV)	Interim
	T-2	Changes in landscape level habitats		NA due to data availability/ lower priority	
Terrestrial Ecosystems	T-3	Degree of divergence from "natural" community diversity, structure and productivity	T-3.4	Number of red- and blue-listed ecosystems	Interim
			T-3.5	Frequency and distribution of exotic and invasive species (including plants, vertebrates and invertebrates)	Interim

REALM / COMPONENT	CODE	INDICATOR	CODE	MEASURE	REPORT PERIOD
	T-4	Extent and degree of ecosystem integrity	T-4.1	Estimated index of ecosystem integrity based on ecosystem alteration factors such as landuse designations and associated management regimes (e.g., protected areas, forest mgmt. standards, designated non-contributing forest, agriculture, urban/rural, flooded, etc.)	Full
Terrestrial Species and Populations	T-5	Viability of native species and populations	T-5.1	Inventoried changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species – caribou	Interim
			T-5.5	Number of threatened, endangered and recently extinct or extirpated species	Interim
Terrestrial Habitat Elements at the Stand and Site Level	T-6	Changes in abundance and/or distribution of habitat elements	T-6.1	Estimated extent of areas where habitat elements are intact, or changed from their "natural condition (including degree of change – snags	Interim
Soils	T-7	Extent and degree of soil degradation	T-7.1	Estimated area of soils where changes in soil properties are sufficient to negatively affect productivity (including compaction, displacement and contamination)	Full
Columbia Basin Aquatic Systems					
Flow Regimes	Aq-1	Degree of divergence from "natural" flow regimes	Aq-1.2	Number and location of structures that divert, obstruct or alter flow regimes, including area flooded/affected (e.g., large dams, water intakes, micro-hydro)	Interim
			Aq-1.3	Ratio of the length of river/stream reach without flow alteration (dams, locks, canals, etc) in relation to the total river length	Interim
	Aq-2	Extent an degree of watershed integrity	Aq-2.1	Estimated watershed integrity index, based on watershed alterations that affect flow regimes: road density, weighted ECA, reservoir flooding, flow obstructions, water diversions, etc	Full
Water Quality	Aq-3	Degree of divergence from "natural" water quality		NA due to data availability/ lower priority	
	Aq-4	Extent of pollutants and/or pollution sources	Aq-4.1	Total recorded discharges of pollutants to water bodies (permitted, non-permitted, toxic sites, spills)	Interim
	Aq-5	Location and extent sediment/ pollution sources	Aq-5.2	A composite water quality index based on watershed condition factors: presence of potential sediment sources and other sources for chemical and biological pollution	Full
Aquatic Ecosystems (including riparian)	Aq-6	Degree of divergence from "natural" community diversity, structure and productivity	Aq-6.4	Frequency and distribution of exotic and invasive species (including fish, plants, and other taxa)	Interim
	Aq-7	Extent and degree of aquatic ecosystem integrity	Aq-7.1	Index of aquatic ecosystem integrity based on watershed condition, flow disruptions, channel alterations etc. (e.g., dams, diversions, infilling, flood control, riparian development, watershed landuse designations and mgmt. regimes)	Full
Aquatic Species and Populations	Aq-8	Viability of native species and populations	Aq-8.1	Inventoried changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species - sturgeon	Interim

REALM / COMPONENT	CODE	INDICATOR	CODE	MEASURE	REPORT PERIOD
			Aq-8.5	Number of threatened, endangered and recently extinct or extirpated species	Interim
Aquatic Habitat Elements	Aq-9	Changes in abundance and/or distribution of habitat elements	Aq-9.1	Estimated extent of areas where habitat elements are intact, or changed from their 'natural' condition (including degree of change) – adfluvial spawning grounds	Interim
Groundwater	Aq-10	Groundwater availability		NA due to data availability/ lower priority	
	Aq-11	Quality of groundwater		NA due to data availability/ lower priority	
Atmosphere					
Atmospheric Composition/ Air Quality	A-1	Air quality and atmospheric composition	A-1.2	Summary of PM10 concentrations, by season and by estimated source apportionment (home wood burning, slash/agriculture, non-point sources)	Full
			A-1.3	# of days/yr when particulate matter exceeds specified values	Interim
	A-2	Extent of pollutants and/or pollution sources	A-2.1	NA due to data availability/ lower priority	
Ultra-Violet Radiation	A-3	Changes in UV levels	A-3.1	NA due to data availability/ lower priority	
Global Systems					
Climate Systems	G-1	Changes to climate	G-1.2	Predicted changes in temperature and precipitation	Interim
	G-2	Effects of climate change on terrestrial systems	G-2.1	Predicted changes in BEC zonation, disturbance processes (including fire)	Full
	G-3	Effects of climate change on aquatic systems	G-3.1	NA due to data availability/ lower priority	
Geochemical and Nutrient Cycles	G-4	Greenhouse gas emissions	G-4.1	NA due to data availability/ lower priority	

Most of the measures designated in the interim set can be reported on with basic data compilation from existing sources or reports, and in some cases minor analysis. Three measures included in the interim set, measures T-1.1 (deviation from natural disturbance regimes), T-6.1 (changes in abundance and/or distribution of snags) and T-7.1 (estimated extent of soil degradation) will require adaptation of existing habitat assessment models, and preparation of a simplified landuse database for the region. The resources required for these analyses are modest, and will offer an opportunity to pilot the concepts necessary for the recommended second phase of modelling measures. Most of the measures in the "Full" cycle subset require model adaptation or development, and are tied to the preparation of a more complete spatial landuse database model for the Basin. Wildlife habitat relationship research and model development and testing projects are already partially supported by other CBT programs (e.g. the Columbia Basin Habitat Relationship project and website). Other projects in the environmental sector could be coordinated with various aspects of the SoE reporting program to fill data gaps and provide additional relevant information.

Additional Steps

We have taken a comprehensive and systematic approach to identifying a set of indicators that can be used in the short-term to initiate SoE reporting in the Basin. Although we have laid the groundwork for an interim and full cycle SoE reports in the next five year period, we realise that there are many additional questions that require answering prior to preparation of these reports. Necessary details include:

- Methodologies for identifying benchmarks, for each indicator/ measure.
- Confirming that available data is actually in a useable and obtainable form
- Details of analysis methodologies
- Level of detail to provide in reports for various audiences

As these tasks are completed, progress towards assessing the interim and eventually the full reporting priorities should begin. CBT may also wish to undertake a peer review and/or targeted public review of the proposed indicators/ measures, however these reviews would likely be more effective following completion of the interim SoE report, when there would be more detail to actually review.

However, if the CBT feels the need to begin more tentatively, an alternative may be to deliver a mock-up of an SoE report while addressing some of the questions outlined above. An effective approach might be to prepare a mock-up state of the environment report based on the proposed interim reporting subset of indicators/ measures, including a report outline and examples of presentation formats for all of the interim reporting measures. The mock-up could also include in-depth analysis of one or two measures to better understand the range in costs and effort required for data acquisition, compilation and analysis (e.g., T-1.2 Seral stage alterations and A-1.2 Particulate matter levels).

In addition to specifying a core subset of indicators/ measures for the first reporting period, we have also highlighted some indicators/ measures that are important, but generally lacking in sufficient data for environmental reporting at this time. These should be considered as potential targets for further development as CBT sets priorities for funding of other environmental projects over the next few years.

Linking to Sustainability Reporting

The CBT is presently exploring sustainability planning and reporting as a means to maintaining or improving human well-being within the basin. Our report has discussed various aspects of sustainability planning and reporting, including the particular opportunities and challenges for sustainability planning in the Columbia Basin, and the potential relationship between SoE reporting and sustainability reporting. Table 3 provides a series of recommendations on ways the CBT can play an ongoing role in promoting and supporting locally-based sustainability planning and reporting in the Basin.

Table 3. Recommendations on ways the CBT can assist with the development and implementation of locally-based sustainability planning and reporting in the Columbia Basin.

TIME FRAME	RECOMMENDATIONS
Ongoing	- maintain a staff responsibility for development of sustainability reporting, and associated planning, with linkages across CBT activities - monitor opportunities for partnerships with funding sources and administrative jurisdictions to bring expertise and resources to the development of the sustainability reporting framework - monitor sustainability planning and reporting practices nationally and internationally to identify possible feasible approaches (suggested sites include University of Toronto, Sustainable Measures, International Sustainability Indicators Network, and the Canadian Sustainability Indicators Network
Next 2-3 years	- **Background reports**: Fund similar background reports on social and economic 'state of ' reporting and indicators to create short-lists of indicators at the Basin level and contribute to the development of process approaches - **Local initiative sustainability planning support**: Work with representatives of jurisdictions and interests within the Basin, as well as technical specialists, to identify possible geographic units and a preliminary set of characteristics for effective sustainability planning and reporting, including a short-list of core indicators/ measures to support the implementation of sustainability planning through local initiatives. This could lead to the creation of an Advisory Working Group of partners in Basin sustainability reporting including, for example, provincial

		government agencies, community representatives, key organizations and technical specialists
	-	**Interim State of the Basin reports**: When indicators and measures are defined, issue interim environmental, economic and social "state of the basin" reports based on the short-list of core indicators/measures. Basin residents should be informed about this initiative to promote learning and discussion about sustainability topics
	-	**Local sustainability planning pilots**: Through partnership projects with local governments and other entities, provincial government agencies and funding sources, facilitate and support pilot projects to test alternative approaches to sustainability planning and reporting to better understand the strengths and weaknesses of options in the Basin context, and possibly to develop more appropriate approaches. Include reports from these tests in interim "state of the basin" reports. The planning units would be most influenced by the willingness of organizations and individuals to work together
	-	**Capacity building**: Share the learning from these pilots broadly, including providing opportunities for interested individuals to observe the pilot processes and creating web-based and person-to-person forums for information exchange
	-	**Updated support**: Based on what is learned from the pilots, and developments in the practice outside the Basin, refine the preliminary characteristics for effective sustainability planning and reporting, including the core set of indicators to support ongoing planning
Long-term	-	**Continuing to facilitate and support locally based sustainability planning and reporting** throughout the Basin, based on the characteristics defined through the pilots. Where other entities do not take up this function, the Trust should consider taking leadership to create information for Basin-wide sustainability reporting
	-	**Publicly report** on movement toward sustainability within the Basin at regular intervals as updated information is available. Retain sub-Basin and community based information as much as possible to maximize local interest and potential for actions

Part I: Introduction

What is State of the Environment Reporting?

State of the environment (SoE) reporting has been used worldwide to provide information on the current state of the environment, the factors causing environmental change and the actions that jurisdictions are taking in response. SoE reporting has been undertaken at global, national, provincial, regional, municipal and local scales. For example, the UN Environment Program's Global Environment Outlook reporting series outlines major global environmental trends as well as predictions for the future. National SoE reporting systems have been developed for many countries including Norway, China, Australia, and Canada; and provincial or state reports are regularly published for jurisdictions in Canada, the US, Australia, and South Africa. Municipal SoE reports have been produced for smaller cities like Kelowna, BC as well as major urban centres such as Bangkok, Geneva, Moscow, Vancouver, Calgary and Edmonton.

Considerable attention has been given to developing individual state of the environment frameworks, and although there are many commonalities between SoE reports from all scales, most jurisdictions have adapted the general approaches and indicators in order to meet their particular goals, issues, and environments. No common single framework is in use, though efforts are currently underway to provide common frameworks at multiple scales (e.g. Federation of Canadian Municipalities; Anielski and Winfield 2002). Additionally, a number of different organisations have produced frameworks, or guidelines for how to develop an approach; for example the International Institute for Sustainable Development (IISD) developed the Bellagio Principles (in Bellagio Italy) intended to aid groups developing a sustainability system[2]. These and other approaches to environment and sustainability reporting were reviewed in Interim Report #1.

State of the Environment Reporting is one arm of broader Sustainability Reporting. Sustainability Reporting includes social and economic indicators in addition to environmental indicators, and attempts to provide a comprehensive picture of the factors affecting the overall sustainability of a specific geographic area. This report focuses on SoE reporting, but in the context of knowing that a broader Sustainability Report is the ultimate goal for the Columbia Basin Trust.

Designing a State of the Environment Reporting System

Designing a successful SoE system requires a broad range of tasks to be fulfilled. These range from objective setting, to technical assessments of data availability and requirements. In a broad sense, the tasks can be summarised by the following list:

- defining the objectives and scope of the reporting system;
- selecting the primary target audience;
- selecting a structural and organizational framework;
- choosing appropriate indicators and data sources;
- deciding on a format and media for presenting the information; and,
- setting goals for the frequency of publication as well as updating and monitoring protocols.

Each of these tasks is key, and has ramifications in terms of how the system will be developed over time. The decisions are therefore not independent of each other and must be evaluated simultaneously. In an interim report, we focused on ensuring that we canvassed CBT staff and members of the Environment Sector Steering Committee for an understanding of their answers to the first two questions (objectives/ scope and target audience). From this we designed the remainder of the framework. Each of the tasks outlined above is dealt with below.

Figure 1 provides an overview of how we think an effective SoE Framework could be delivered. The SoE reporting cycle provides a series of action items that are required to produce the SoE report. This current work

2 http://www.iisd.org/measure/principles/1.htm

'Designs and Plans the SoE Reporting System', and identifies a set of indicators for the Columbia Basin. Undertaking SoE reporting itself then requires a number of steps, including accessing data sources, determining benchmarks, collating information, analysing data and producing a SoE Report. Various versions of the report, with appropriate levels of detail would then be provided to the variety of audiences, including Basin citizens, decision-makers within a number of agencies, and internal CBT planning and management staff.

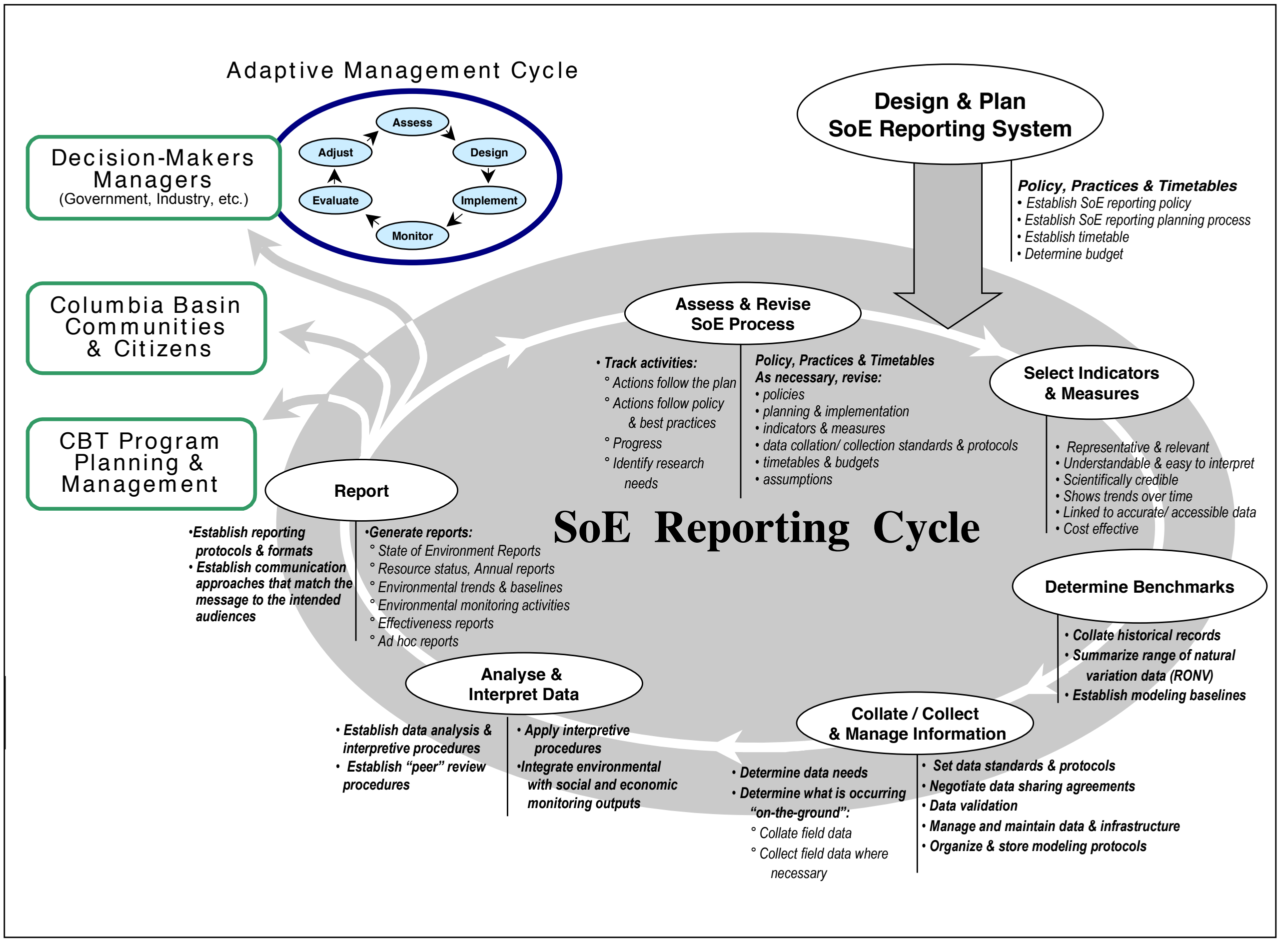

Figure 1. An overview of an SoE reporting system

OBJECTIVES AND SCOPE

State of the Environment reporting can be designed to meet a wide range of goals, objectives or purposes. SoE reports are generally scientific and non-partisan, and provide both technical and non-technical information that compares environmental conditions over time and space. A summary of the types of questions that can be asked within SoE reporting was provided in Interim Report #1. Options were then presented to CBT regarding the potential purposes of SoE reporting in the Basin. The chosen options are shown in Table 4.

The scope of SoE reporting has two general levels of emphasis that can be identified. One approach has been to concentrate on the biophysical environment as an entity in itself, where the primary focus has been to evaluate the degree to which ecological integrity has been compromised by industrial development and other human-caused changes to the environment (e.g., Utzig and Holt 2002; BC Environmental Trends 2003). The alternative view has considered the environment as one of the components necessary for human well-being, with social and economic factors comprising the other components. The second approach often includes issues of sustainability, quality of life and human health (e.g. Quesnel Team 2002; Anielski 2001; US State of the Nations' Ecosystems - John Heinze III Center 2002).

In Interim Report #1 we reviewed a large number of reporting systems worldwide that took both environmental and broader sustainability reporting approaches. We noted that although the intentions were good, current approaches to Sustainability Reporting often fell short on aspects of the environment. This tended to be because within the 'Sustainability Approach', there is a tendency to primarily emphasize those aspects of the environment that are viewed to be directly related to human health and economic development, or to treat other biophysical aspects of the environment in a very cursory manner. We therefore recommended that an initial approach would be to continue to develop the SoE framework independently of a broader sustainability reporting system and ensure that a comprehensive assessment of the biophysical environment, that is essential to a successful SoE report, was in place first. This recommendation was agreed to by CBT (Table 4).

Table 4. Purpose and Scope recommendations chosen by CBT.

ELEMENT	RECOMMENDATIONS
Purpose	- Inform target audiences about the current condition of the environment - Forecast changes in conditions in the environment into the future using an appropriate benchmark to assess actual, rather than relative state of the environment - Describe what will happen if actions are not taken to address issues of concern - Identify which environmental conditions are significant/ of concern, and why - Provide an assessment of changes in the environment since the last report was issued - Explain why particular changes are happening in the environment - Identify information needs
Scope	- Develop a robust state of the environment reporting system. This can then ultimately be included within a sustainability reporting framework, but will ensure that the "environment' component is meaningful. - For example, the Australian SoE Reporting and the US State of the Nation's Ecosystems Project both provide good examples of development of indicators, use of benchmarks and reporting approaches (Tables 8-9). - Simultaneous development of meaningful social and economic indicators can result in a robust and complete picture overall. This requires additional collaboration to develop an integrated framework.

Target Audience

Defining the target audience is key to setting goals, defining the questions asked, developing a framework, selecting indicators, and presenting information in an SoE report. Most producers of SoE reports cite the general public as their primary audience, with policy- and decision-makers as secondary audiences (Gilkeson 2003). In contrast, the background literature and guidelines for SoE reports, such as the International Institute for Sustainable Development's Training Manual (Pinter et al. 1999), the South African guide to producing a State of the Environment Report (Pretorious et al. 2002), and publications by the Organization for Economic Cooperation and Development list policy makers as the primary audience for SoE reporting.

In 2003, the BC State of the Environment Reporting Office surveyed 40 users of its *Environmental Trends 2000* report and found that the publication was most often used as an educational tool and as a reference, with fewer respondents primarily using the report for personal interest and as a policy and planning tool (Gilkeson 2003). An additional audience that receives little attention in the literature is planning and operational staff involved in activities that affect the environment, including commercial operations such as forestry, mining, tourism, and hydroelectric power production, as well as local government activities such as landfills, etc. Raising the awareness of the parties with direct management influence over environmentally degrading activities might be a fertile target for promoting change.

In reviewing SoE systems, we determined that it is possible to address all four audiences through a 'layered' approach that includes overviews and issue summaries linked to technical background information and data. As a result of this complex audience, most SoE reports are geared towards three separate audiences with three separate end uses: policy- and decision-makers, the 'public', and the education sector (students and teachers) – we include these users, and add planning and operational personnel (technical users).

Table 5. Audience recommendations chosen by CBT.

ELEMENT		RECOMMENDATIONS
Audience	-	The full range of audiences within the Columbia Basin should be served by this initiative. This includes: public information, educators, planning and operational personnel and policy and decision makers
	-	A 'layered' system is recommended to efficiently serve the range of audiences. This would include a succinct overview in a readily accessible format with links to more detailed technical information. The layered approach provides all audiences with relevant levels of detail, without overwhelming some while seeming scant to others.

Structural and Organisational Framework

A wide variety of approaches have been used to organise SoE reporting systems worldwide. We summarised and reviewed approaches in Interim Report #1, and present key findings and rationale for the approach we have taken below.

Potential approaches include:

a) Reporting: The simplest approach is to report the status of selected indicators, sometimes relative to explicitly defined benchmarks, without extensive discussion of the reasons or implications of this status. This approach provides basic information about a range of environmental conditions. It may, or may not define whether the status is "acceptable" or "suggests the need for concern", and does not define linkages and what might be done to improve conditions.

b) The Pressure-State-Response Model: The basic premise of the P-S-R model is that human activities exert Pressures on the environment, that in turn create a new State or condition. People Respond in a number of ways to these changes, which then modifies the Pressures on the environment. Evaluating the pressures, the state and the responses results in a State of the Environment report that can facilitate the development of a comprehensive picture of the biophysical, as well as the institutional, socio-economic and policy context for a jurisdiction. The 'Response' element is particularly important in the P-S-R model since it addresses whether policies and actions taken at personal and institutional levels help or hinder the situation. According to Pinter et al. (1999), "although SoE analysis substantiates claims about environmental conditions, policy assessment points out the key leverage points to decision-makers". Although the P-S-R approach provides more information than simply 'reporting', it also necessitates a large set of additional indicators, and therefore requires additional resources. Many SoE systems claim to use the P-S-R approach in an effort to understand the whole picture, however we note that many jurisdictions actually only report out on the state question. We suggest there are a number of reasons for this, in particular, a) the mensuration difficulties in determining causal relationships between environmental change and particular pressures and b) the political difficulties in identifying such relationships.

c) Resource Accounting: The 'resource accounting' approach provides a different framework that draws on traditional accounting tools to measure environmental, social, quality of life, economic, and other factors. The state of the environment is assessed in terms such as assets and liabilities, natural capital accounts, stocks and flows, expenditures, and the 'bottom line'. The resource accounting model has been used by the Pembina Institute in their *Alberta Genuine Progress Indicators Blueprint* (Anielski 2001), by the National Roundtable on Environment and Economy (NRTEE) in their Environment and Sustainability Indicators project, and in terminology by the World Wildlife Fund in their *Canada Nature Audit*. The resource accounting model and the P-S-R approach are not mutually exclusive and can be used together. Where the resource accounting model differs is in its emphasis on accounting rather than characterizing. Although this may be a useful approach, it essentially requires a 'State' reporting system to be put in place, which then has monetary values assigned to it. The descriptive approach, as used in the P-S-R and other conceptual SoE models may be more efficient if indexing and converting scores to monetary values is not desired.

d) Ecological Footprint: The Ecological Footprint tool developed by Wackernagel and Rees (1996) calculates and evaluates the extent to which a jurisdiction's activities are within the earth's ecological carrying capacity. The Ecological Footprint essentially measures the area of land that is required to meet the consumptive demands of a jurisdiction. An assessment of the Ecological Footprint for the Columbia Basin would result in a comparison between the amount of land in the actual Basin and the amount of land required to produce all of the goods and services consumed within. This type of summary overview can be useful to provide individuals or sectors with motivation to change individual practices. It does not, however inform about individual environmental trends, but rather how the composite picture of a set of actions impacts overall.

e) Combination Approaches: Combinations of the Resource Accounting, P-S-R, Ecological Footprint and other systems can also be used. For example, the WWF *Canada Nature Audit* combines both the resource accounting and P-S-R models to describe, assess and evaluate the current state of biodiversity in Canada. The report is divided into three main sections. The first characterizes the State of Canada's biodiversity through an assessment of the country's 'Natural Capital Accounts'. The second evaluates the Pressures or 'Expenditures' against biodiversity using a scoring system that assesses the known or predicted ecological impacts on biodiversity due to key industrial sectors such as forestry, agriculture, oil and gas development, and aquaculture. The third section addresses the natural capital expenditures through issue-based assessments of 'Cumulative Impacts' on biodiversity. The *Nature Audit* uses the resource accounting model as a metaphor, but also provides indexed scores for each indicator. Scores of individual indicators were weighted using relative values assigned to indicators after extensive consultation with technical experts. This approach may be considered in the long-term for the Columbia Basin, but is not practical in the short-term.

The approach we recommended for the Columbia Basin is shown in Table 6.

Table 6. The Approach for environmental reporting recommended for the Columbia Basin.

DECISION	RECOMMENDATIONS
Framework	- The P-S-R model provides a descriptive approach that identifies linkages between cause and effect, and is recommended as a long-term vision for SoE reporting in the Columbia Basin. - In the interim, we recommend that reporting primarily on 'State' will be the most feasible approach. Development of robust State environmental indicators would be a first step in this endeavour.

Report Format

Presentation is key to disseminating the results of SoE reporting systems. Most SoE reports are available in both print and on the internet. With the rise of internet access, the need for print versions has declined. Both Norway and Quebec only provide SoE reports online and the UN Environment Program (UNEP) developed a website providing key information for developing city-based SoE reports – the Cities Environment Reports on the Internet (CEROI). The internet provides relatively easy and instant access to information for decision-makers and the general public, and is easy to update with new information as it becomes available.

Traditionally, SoE reports have been thick, single volume documents. Many print-based reports are now also available as downloadable pdf files. This approach, coupled with additional web-based links and technical information may be the most user-friendly at this stage. In a survey of recipients of *Environmental Trends in British Columbia 2000*, the BC SoE office found that after two years 61% of those surveyed used the hard copy version of the report compared to 33% who used the web-version. However, 58% had visited the website and 6% had used the on-line technical documents. More importantly, 42% said they did not know that technical documents were available online and that they may have used them had they known they existed. This ties in with another finding from the BC survey that found the highest rated suggestion was for 'more background information'. Other suggestions were for a broader variety of indicators, for information on how individual behavior negatively impacts the environment, and suggestions for individuals to help make a difference (Gilkeson 2003).

One major trend in SoE reporting is towards providing information in a variety of media. This includes large, comprehensive reports in print, online and on CD-Rom, as well as fact sheets, 'report cards', detailed issue-based reports, regional or sectoral reports, and web-based information bulletins (Gilkeson 2003).

After surveying numerous websites and print-versions, the most efficient format appears to be web-based with an option to receive a print version. The most effective websites are those that provide the report and supporting details in both html and pdf versions, with links to related sites and additional documents. This 'layered' approach allows users to find quick information or to search for in-depth information on their subjects of interest.

Web-based SoE reports also provide an excellent opportunity for updating of information in the intervals between reports. Many jurisdictions, including Canada are using five-year intervals for their comprehensive reports. BC is in the midst of shifting from a two-year release format to five years, and plans to do regional and sectoral reports such as the upcoming *Coastal Marine Report* and the 2003 *State of Rivers in British Columbia Report* (Gilkeson 2003). Environment Canada has developed a new State of the Environment Infobase website that provides SoE information, and is easily updated (http://www.ec.gc.ca/soer-ree/English/default.cfm).

The recommended format for SoE reporting is shown in Table 7.

Table 7. The Report Format for environmental reporting recommended for the Columbia Basin.

DECISION	RECOMMENDATIONS
Report Format	- Provide a primarily web-based approach, with summary printed versions to publicise the work; - On the web, use a layered approach that provides a variety of technical detail to suit the range of audiences (including web data availability where possible); - Use a writing style throughout that non-specialists can understand; - Include a concise executive summary or highlights section upfront; - Make reference to appropriate monitoring programs that are the source of ecological data (e.g., EMAN projects, Forest Health Network surveys, sentinel fishery projects, soil quality benchmark surveys), support the indicators, and provide information for answering policy questions; and - Document the contributors to, and reviewers of the report.

Frequency of Reporting

SoE reports vary from annual to every 10 years. The frequency of reporting should be appropriate for both budget constraints, and the expected rate of change of the environment or individual indicators. We recommend that the Columbia Basin Trust embark on a series of 5-year SoE reports, with the possibility for interim updates in the intervening period when appropriate.

We have recommended an initial subset of core indicators that we believe are feasible for the first cycle of reporting in four to five years from now (2008-2009). With the idea of providing an opportunity to pilot the reporting process and to facilitate getting a more modest report out in a shorter timeframe, we have also identified a smaller subset of indicators that could be issued as an interim or introductory report in 2 or 3 years (2006-2007).

Although we suggest that an overall five-year reporting cycle is appropriate and likely feasible, we also suggest that updating on more complex indicators on an on-going basis within the five year period may make the budgeting easier, and will benefit the program by maintaining interest in SoE reporting from the public between major reports.

Part II: Selecting Appropriate Indicators and Measures

Indicators are the tools used in SoE reporting to track and monitor conditions and trends. Development of environmental indicators for the Columbia Basin is the primary deliverable for this project, and that process is detailed in Part III, with an Action Plan of specific recommendations in the Summary (page 1). Here, we review the subject of indicators and provide background rationale for our approach.

The state of environment for an area cannot be evaluated without a comprehensive and complete set of indicators. However, there is some variation in the parameters for definitions of indicators. The Australian State of the Environment Reporting Office (http://www.deh.gov.au/soe/) defines indicators as:

"physical, chemical, biological or socio-economic measures that best represent the key elements of a complex ecosystem or environmental issue. An indicator is embedded in a well-developed interpretive framework and has meaning well beyond the measure it represents."

According to Environment Canada (http://www.ec.gc.ca/soer-ree/English/default.cfm):

"Environmental indicators provide an effective means by which complex environmental data can be transformed into easy-to-use communication and decision-making tools — tools that can help us keep track of the state of the environment and measure progress towards sustainable development."

We have used both "indicators" and "measures" in this report. The term "indicators" is used to refer to larger issues of concern such as the viability of native species or the degree of divergence from "natural" water flow regimes. "Measures" are used to identify quantifiable assessments that can be made to evaluate the actual condition of various aspects of an environmental indicator. In many cases, more than one measure is suggested to assess one indicator.

Measures and indicators are often used interchangeably in SoE reporting, although measures usually address issues at a finer level of detail and provide guidance on the specific measurement requirements for an indicator. For example, the Canadian State of the Environment Infobase lists Municipal Water Use as an indicator, although the actual parameters measured include per capita water use, total municipal water use, and the percentage of municipal population with water meters. We have followed a similar model in defining broad indicators in conjunction with specific and quantifiable measures. This approach is consistent with other SoE systems such as BC (MWLAP 2002) and Australia (http://www.deh.gov.au/soe/).

Background: What is a Good Indicator or Measure?

According to Environment Canada, indicators should be selected to 'provide early warning signals' to the public and decision makers. In selecting indicators and measures, there are a number of qualities that are more likely to result in 'powerful' indications of environmental conditions. Many lists of attributes have been developed, and the following is a compilation from a number of sources[3]. An indicator or indicator set should:

- provide a **representative** picture of environmental conditions;
- be simple, and **easy to interpret**
- show **trends** over time;
- be **responsive** to changes in the environment and related to human activities;
- have a **benchmark or threshold** against which to compare it so that users are able to assess the significance of the values associated with it;
- lend itself to **linkages** with economic models, forecasting and information systems.
- **reflect a valued element** of the environment or an important environmental issue;
- have **relevance** to policy or management needs;
- be scientifically **credible**;
- serve as a **robust** indicator of environmental change;

[3] from a combination of S. Africa SoE; Australia SoE ; Maclaren (1996)

- be based on **accurate, available, accessible** data that are comparable over time
- be **understandable** by potential users
- be **cost effective** to collect and use

The more of these attributes an indicator or measure has, the more likely it will be to be a powerful and useful indicator. Single indicators and measures will likely never meet all these conditions, however, some attributes are particularly crucial for using indicators in a clear and defensible manner. One key element is the identification of a benchmark or threshold against which the measure is to be compared (MoE 2000, Beasely and Wright 2001). Without this, an indicator can be largely meaningless to the reader. We provide a section in the methods in Part III on how benchmarks are to be defined within the Columbia Basin SoE framework.

In general, most environment and sustainability systems call for indicators and measures that are scientifically defensible, understandable by the public, and reflective of change. On the practical side, many systems are limited to measures for which there are cost-effective data available. There is often a trade-off between cost and ease of use, and the depth of meaning available from an indicator or measure. These trade-offs need to be considered when designing the suite of indicators and measures, and our approach to trade-offs is discussed in Part III.

Data availability is necessary in order to report out on trends for an indicator, however some systems identify important indicators where data are unavailable, or where the cost to include the indicator is prohibitive (e.g. US State of the Nation's Ecosystems). This approach provides the reader with an overview of elements described well, and elements that should be included, but are currently unavailable. Including indicators that are not currently measured or measurable provides a useful assessment of the current gaps in knowledge and data, and a means of prioritising future data collection needs. We identify those indicators which we believe to be important, but lacking data in Part III. This information can be used by CBT to prioritise future work, and can be included within the SoE report to inform the audience of data gaps.

Developing indicators and measures where data is both available and unavailable results in two indicator sets: a "full set" and a prioritised "core set". Describing an initial "full set" of indicators is important as a first step in order to ensure that the state of the environment is being fully described. Although SoE systems have been in place since 1986, Environment Canada recognizes that gaps in the current environmental indicator set still exist, particularly for emerging issues such as biotechnology, as well as for complex issues like water quality and biodiversity. The connection between risk assessment and indicators is another element of SoE indicators that is in its infancy and "the development of techniques to add the concept of relative risk to indicator development needs further exploration" (Environment Canada 2003).

Indicator Organisation

A review of the literature and SoE reports from different jurisdictions shows that there are a wide range of options for how to organise and structure indicators. This has been summarised by Maclaren (1996; in Anielski and Winfield 2002) and includes:

- the **Domain-Based** structure, where the report and subsequent indicators are based on the three pillars of sustainability: the environment (biophysical), the economy and society.
- the **Goal-Based** structure, which is premised on desired future conditions such as meeting basic human needs.
- the **Sector-Based** structure, which relates to government or institutional responsibilities and reflects industrial activities such as mining, forestry, energy, manufacturing, and tourism. This method relies on established infrastructure and data management systems and provides information on the environmental consequences of economic activities.
- the **Issue-Based** structure, which focuses on popular topics of concern.
- the **'Causal' framework**, which is based on the 'Pressure-State-Response' model discussed above. Maclaren refers to this type of framework as *causal* since it highlights the effects as well as the causes for environmental change.

These organisational structures are not mutually exclusive. For example, a 'domain-based' structure may then have a 'causal' structure nested within it: the environmental domain portion of the report may include evaluation of air quality changes caused by automotive emissions as well as the potential off-setting impacts from increases in public transit. Conversely, within the environmental domain one could examine the role of various sectors (e.g., industrial, governmental and general public) in contributing to a specific environmental change (e.g., loss of snags for woodpeckers).

In the review of SoE reporting systems provided in Interim Report #1, we highlighted a number of examples that appeared to be comprehensive, well thought-out and credible processes for designing indicators. Two examples of comprehensive SoE frameworks are provided below (Tables 8-9), with additional information that shows how and why these examples provided guidance and rationale for the development of our approach for the Columbia Basin. A third example from the US Columbia Basin is also provided (Table 10). The Interior Columbia Basin Ecosystem Management Project was not intended to be a SoE report per se, but is presented here because it incorporates many of the key elements required to successfully characterise the biophysical environment. It also provides relevant guidance for the Canadian portion of the Columbia Basin.

Table 8. Example 1: Australian SoE Reporting.

Agency Reference	State of the Environment reporting is the responsibility of the Ministry of Environment and Heritage in Australia. SoE reporting on 5 year periods is legislated under Australian Law. http://www.deh.gov.au/soe/
Scale	National Level
Reporting Period	5 years
Objective	- Provide accurate, timely and accessible information on the condition and prospects of the Australian environment; - Increase public understanding of these issues; - Continue the development of national environmental indicators, and report on these indicators; - Provide an early warning system for potential problems; and - Report on the effectiveness of policies and programs designed to respond to environmental change, including progress toward achieving environmental standards and targets.
Approach	Pressure – State – Response Model. Focused on environment.
Organisation Framework	The work is organised primarily by biophysical domains (Atmosphere, Biodiversity, Estuaries and the Sea, Inland Waters, Land), with additional sections on Human Settlements and Natural and Cultural Heritage. A report is produced on each of these areas, identifying pressures on the land environment and current states for a range of sub-domains (soil, land cover etc). Responses from government and other organisations are then summarised. The entire package of pressures, states and responses are brought together in a final chapter of the SoE report entitled “Towards ecological sustainability” which summarises what elements need to be sustained, and what can occur to make required changes. Externalities, such as the global economy, are identified and their influences are summarised. Successes and failures in the current system are also identified.
Indicators and Benchmarks	In developing the structure of the report, recommendations for almost 500 indicators that addressed each theme were made. A prioritisation system was used which resulted in a total of 75 ‘core environmental indicators’. These core indicators are the critical pieces and the remaining indicators are used where feasible. Criteria for producing the core set were an assessment against a general list of criteria for producing powerful indicators (see list defined under ‘What is a good Indicator above’.). Where data are available, a range of natural variability (RONV) benchmark is used.
Applicability to CBT Region	For the Columbia Basin, although very different in scale, we used a similar approach in defining biophysical domains for the environment, and within each of these domains, defining a large comprehensive potential indicator list. Our final core set of indicators meet a similar set of criteria as was used to assess the Australian core set of indicators, and were additionally assessed for costs, importance, and predictive power. This report is very comprehensive, achieving a full P-S-R model. We are not recommending that CBT embark on such a detailed task at this time, but CBT should retain the concept as an overall goal for Environment and Sustainability Reporting in the future.

Table 9. Example 2: United States' State of the Nation's Ecosystems.

Agency Reference	***H. John Heinz III Centre for Science, Economics and Environment.*** http://www.heinzctr.org/ecosystems/report.html The H. John Heinz III Center for Science, Economics and the Environment is a nonprofit, nonpartisan institution dedicated to improving the scientific and economic foundation for environmental policy through multi-sectoral collaboration. Focusing on issues that are likely to confront policymakers within two to five years, the Center fosters collaboration among industry, environmental organizations, academia, and government in each of its program areas and projects.
Scale	National
Reporting Period	Annual, for some indicators, and longer time periods (not stated) for others. Initiated in 2002, with an update in 2003, but only a selection of the indicators were updated.
Approach	Focuses on 'state' of ecosystems, rather than identifying pressures.
Indicators and Benchmarks / Thresholds	Indicators at all levels are organized using a framework that uses major groups of characteristics subdivided into ecosystem characteristics that each have between 22 and 33 indicators (see Figure below). The group characteristics are System Dimensions, Chemical and Physical Characteristics, Biological Components, and Human Uses. A key difference between this report and many other SoE documents is its emphasis on identifying indicators that *should* be measured in addition to those that *can* be measured. Indicators with no data sources are included in the report with a description of the issue, as well as an assessment of the data gaps. Descriptions for each indicator include an overview of the issue and a summary of why it is important, a description of what the data show, and either a discussion of the issue or an explanation of why the indicator cannot be reported. Where trends cannot be presented, the report addresses other 'useful reference points'. Benchmarks are usually not explicitly addressed or presented, rather, most results are presented comparing one region to another in terms of changes. The report includes both 'key national indicators', and individual ecosystem indicators. Ten key national indicators are used to describe an overview of all ecosystems, while the individual ecosystem indicators provide details on the condition and trends of the nation's Coasts and Oceans, Farmlands, Forests, Freshwater, Grasslands and Shrublands, and Urban and Suburban Areas.
Applicability to CBT Region	We used the general approach taken by this system. Their approach to dividing the world into components is similar, though not identical to our approach. We did not include a human use element, due to the decision that this report would focus on biophysical aspects of the environment ratter than human derived aspects. We particularly liked their approach to explaining the limitations of available data, by not throwing out key

	indicators that are data poor as this creates a false picture of 'the environment'. As in our approach, the intention is to look comprehensively at pressures, states and responses. However, like our initial recommendations for the Columbia Basin, they deal initially with State indicators.

Table 10. Example 3: Status of the Interior Columbia Basin Ecosystem Management Project

Agency Reference	**Interior Columbia Basin Ecosystem Management Project** A partnership of various US federal agencies. http://www.icbemp.gov/ http://www.fs.fed.us/pnw/int_col.htm **-** provides PNW reports. http://www.fs.fed.us/pnw/pubs/gtr_404.pdf **-** shows highlighted science findings, also pnw-gtr-385: "Status of the Columbia Basin – summary of scientific findings"
Scale	US portion of the interior Columbia Basin
Reporting Period	Initiated in 1994; single initial report (Status of the Interior Columbia Basin) to serve as a basis for developing a long-term approach to management for the area. No specific future reporting periods are planned, however a monitoring plan incorporated in an adaptive management framework will likely result in ongoing reporting in some form.
Objective	Develop a scientifically sound and ecosystem based strategy for forest and rangelands administered by the Forest Service and Bureau of Land Management in the Interior Columbia River Basin and portions of the Klamath and Great Basins.
Presentation Style	Rather than providing a comprehensive SoE report, the ICBEMP consists of multiple reports that are available on the internet. Summary documents such as pnw-gtr-385: "Status of the Columbia Basin – summary of scientific findings" are somewhat analogous to a SoE report focusing on the 'state' or 'condition' of the biophysical environment.
Approach	The initial "status of the basin" approach has an environmental emphasis, but also includes significant analysis of economic and social information. The final management plan that was developed was more of a sustainability planning exercise, as it attempted to balance environmental, social and economic information.
Indicators and Benchmarks Thresholds	A wide variety of different indicators are used (no easily available list due to multiple project structure). Uses 'natural benchmarks' based on range of natural variability to provide comparisons with current state. Overall, the ICBEMP project offers a useful approach with some relevant data.
Applicability to CBT Region	Although this project is not specifically an SoE reporting program, it contains much useful information, and some interesting presentation ideas. It produced a wide variety of scientific reports that summarise the state of the Basin in varying levels of technical detail as well as useful ideas on indicators and approaches. In addition, because it is located in the Columbia Basin it offers opportunities for linkages between the Canadian and US portions of the Basin.
Comments	The approach used for assessing the present state and trends in environmental indicators is very similar to that recommended for some indicators and measures in this report. For example, the Interior Columbia Basin assessment used habit modelling coupled with a landuse database to assess the state and trends for a wide variety of environmental indicators and measures including individual species, ecosystems, habitat elements and processes in both the terrestrial and aquatic realms.

Types of Indicators and Measures

Indicators and measures vary with respect to their directness, or ease of interpretation. Commonly, they can be:

a) **Direct**, which simply state the value of a single direct measure of an environmental state. These are often the easiest to use types of indicators, since they require no additional data manipulation. However, they are often relatively simple as a result, and so tend to be less representative or realistic than more complex indices.

b) **Indirect**, which are ways of inferring information about the environment from indirect sources. For example, where the relationship between a particular indicator and a cause (pressure) is well established, measures of the level of activity related to the cause may serve as a basis for estimating the state of an indicator (e.g., the km of road in a watershed typically is used as an index of the amount of sediment reaching a stream). Alternatively, the degree and extent of responses to potential environmental changes may also provide a general indication of the state of a particular indicator (e.g., the percentage of protect area representation relates to the loss of ecological integrity for specific ecosystems). The construction of such 'models' often results in increased understanding of causal relationships between pressures and environmental components, and demonstrates the potential for choosing the most effective responses.

c) **Complex indices**, which combine individual indicators into indices. They tend to be more complex, and therefore may be more costly than direct measures since they require multiple data sources and often data manipulation. However, they also provide the potential for creating meaningful representations of the complex world, and can be cheaper where direct measurements of environmental conditions are difficult or expensive to obtain. The development of indices requires great care otherwise the results can be hard to interpret, or misleading.

d) **Static or Predictive indicators**: All three of the indicator types outlined above can be presented for the current time (i.e. they are static) and / or predicted out into the future. Predicting into the future adds another dimension to a State of the Environment report, providing the potential for flagging potential upcoming problems and creating opportunities for solving issues before they arise. It is well known that prevention of degradation is cheaper and more efficient than restoration. Some variation of modelling is required to allow for prediction of even direct indicators.

Our approach uses a combination of direct and indirect measures, to provide the most cost-effective but powerful and representative suite of indicators. We have included some indirect and index indicators that are based on the use of spatial habitat models. Although sometimes complex to implement, these indicators are often significantly cheaper than collecting field inventory data and direct monitoring information, and most importantly provide the ability to predict environmental change. This predictive capability allows for an early warning system, and the formulation of preventative management strategies that are virtually always cheaper than restoration or recovery strategies.

Benchmarks

When assessing and interpreting the significance of trends in environmental conditions, it is essential to have a benchmark against which to compare those conditions or trends. Failure to define a benchmark for comparison can result in un-interpretable environmental assessments (Beasely and Wright 2001; Holt and Utzig 2002). Most recent environmental assessments employ some form of "natural" benchmark, as defined by the "range of natural variability" or RONV (Hann et al. 1997, Swanson et al. 1994, MELP 2000, Cissel et al. 1998; Landres et al. 1999, Utzig and Holt 2002, Wilson et al 2003). In developing a framework for SoE reporting in the Columbia Basin, we have provided a conceptual approach to establishing benchmarks based on RONV for each indicator and measure. The following section is adapted from Utzig and Holt 2002 and Utzig 2003.

It is important to understand that using a range of natural variation benchmark provides a context for evaluating present conditions and trends, but is not necessarily a target to achieve. The following section provides background and a rationale for including RONV in state of the environment reporting.

In an environmental assessment for the US portion of the Columbia Basin, Swanson et al. (1994, p89) describe RONV as:

"the composition, structure and dynamics of ecosystems before the influence of European settlers… characterized by: the range of ecosystem conditions such as the extent of particular seral classes of vegetation, and the disturbance regime (defined in terms of frequency, spatial arrangement, and severity of disturbances) that produced such conditions."

Landres et al. (1999) define natural variability as "the ecological conditions, and the spatial and temporal variation in these conditions, that are relatively unaffected by people." Other terms used to refer to similar concepts include natural variability, historical range of variability and reference variability (Landres et al. 1999). This concept is useful in that the influence of recent human interventions is filtered out so that managers can use the resulting description of RONV as an independent reference for comparison when developing or evaluating past or proposed management interventions.

The basic assumption underlying the utilization of the “range of natural variability” concept as a benchmark for environmental assessment is that native species that occur in the Columbia Basin’s ecosystems today have evolved under habitat conditions defined by the range of natural variability. Therefore, where indicators and measures of environmental condition fall within the range of ecosystem conditions, landscape patterns or processes within or similar to RONV, they are more likely to signify habitat conditions necessary for the maintenance of the full diversity of native species (e.g., Bunnell 1995, Cissel et al. 1998, Swanson et al. 1994, Walker 1995).

Natural variability in ecosystem patterns and processes is central to the use of this concept – the environmental benchmark is not a single point, but a range. Defining an appropriate ‘range’ of natural variability for any specific indicator is an important step in the procedure and requires decisions about what timeframe and spatial scale to consider. There is no single ‘correct’ time period for an analysis of range of natural variability. However, the function of a description of natural variation is to define the bounds of system behaviour that remain relatively constant over time (Morgan et al. 1994), and therefore the relevance of the description is decreased if the time period considered is too long (Landres et al. 1999). In the Interior Columbia Basin, vegetation was considered relatively stable over the last 2000 years and this was used as an appropriate timeframe for determining the range of variability (Quigley and Arbelbide 1997 – see Millar and Woolfenden 1999 for cautions). The spatial scale used for an analysis of range of variability is also critical, and should depend on the scale of interaction of the attribute being measured. The scale used should depend on the scale at which the attribute functions, and on the management scale being considered. Using the wrong scale can result in meaningless measures of variation.

Quantification of the environmental benchmark is dependent on data availability. Where appropriate data are available, a quantitative environmental benchmark can be determined (e.g. Cissel et al. 1998 or Rogeau 1996). Where data are sparse and do not adequately represent the range of natural conditions, natural disturbance patterns and processes can be qualitatively described and used as a qualitative environmental benchmark.

Recommending the use of RONV as a benchmark for assessment of environmental change does not imply that we are advocating that communities within the Basin should make a return to ‘RONV’ or ‘natural’ conditions their primary objective. Although society may not choose to emulate natural disturbance regimes, understanding the range of conditions provides important information about the processes that are actively influencing ecosystem structure, function and composition. An alternative approach is to select “future-desired conditions”; however it is important to understand and identify where “future-desired conditions” depart from environmental conditions that would result from natural disturbance regimes. Knowing the extent and characteristics of that departure will provide useful information about the potential consequences and/or costs of attempting to maintain those conditions (Landres et al. 1999). Holling and Meffe (1996, p.334) also commented on the potential importance of retaining

“critical types and ranges of natural variation in ecosystems … [M]anagement should facilitate existing processes and variability rather than changing or controlling them. By so doing, ecosystem resilience and the organizing processes and structures of ecosystems will be maintained, thus better serving not only the natural functions and species diversity of those systems but also the long term (although not necessarily short-term) interests of humanity.”

Where changes from RONV are occurring, an important aspect of SoE reporting would be to alert the public and decision-makers to those occurrences and their potential consequences.

TEMPORAL AND SPATIAL SCALE OF ASSESSMENT

The desired geographic scale and the level of generalization for which data is collected or monitored present several challenges: there is no “best option” and scale reflects a balance between detail and coarser generalizations. Finer-scale data is ideal since it often highlights the sources of problems, and because it can generally be analysed in different ways then “rolled-up” into coarser scales. However, focusing on the details should not lead to losing sight of larger trends at the landscape and system levels.

The frequency and spatial scale of assessment are often a balance between the desire to collect as much detailed information as possible, and the availability of data, time and resources. However, the spatial and temporal scale at which an indicator is assessed is often key to the effectiveness of its evaluation. Some environmental trends may only be detectable at either a large scale or a small scale, but not both. Other environmental components are linked to processes that include significant variability by season or from year to year (e.g. stream flow), while still others are linked to long-term processes and show little variation over decades (e.g., soils).

Although the use of generalized measures and indicators is often significantly cheaper and faster, broad-scale indicators often miss details about environmental change that are essential to crafting effective responses to those changes. For example reporting average road density for each Ecosection will likely result in very low densities due to the inclusion of large areas of alpine, and may mask the fact that road densities in the valley bottoms are very high. In contrast, reporting on seral stage distribution for each small valley is inappropriate because stand-replacing fires often burned across whole valleys under natural conditions.

When assessing a particular indicator or measure, it is essential that careful consideration be given to selecting the “basic analysis unit” for which that measure will be assessed. It may be appropriate to assess some aquatic measures on a watershed basis, while for others it may be more appropriate to look at individual stream reaches, or specific types of aquatic habitats (e.g., small streams or lakes). For terrestrial measures there are various options, but generally the use of ecologically-based units is preferable to using administrative units (e.g., Ecosections, BEC units, individual ecosystem types, homogeneous natural disturbance units). However, in some situations where data is limited to specific data collection sites, it is necessary to report on the basis of the reporting stations (e.g., air or water quality monitoring sites, weather stations), or specific long-term study locations (e.g., experimental watersheds, forest productivity plots)

Overall, the scale and level of generalization of data collection is ideally more detailed than the level at which conclusions are actually presented. The level of scale is particularly relevant to SoE reporting within the Columbia Basin due to the variety of agencies with jurisdiction over the area (e.g. provincial, federal, First Nations, municipalities, and regional districts). Presentations of indicator assessment results sometimes report at the level of the basic analysis units or, if collected with sufficient detail, they can be rolled-up for presentation at more generalized levels. Although it may be necessary to collect information at a detailed level for scientific purposes, its presentation should reflect the needs and abilities of the intended audience. The detailed information can always be provided in an appendix or a linked database for those who need it. Table 12 and Appendix 3 provide some examples of basic units for analysis and presentation for each of the recommended indicators and measures

Limitations of Indicator Sets

In the perfect world, data would be available to describe all the issues of relevance to society, however this is not the case in reality. Where data are not available, surrogate measures may or may not be accessible. Because environmental indicators generally reflect multifaceted issues, it is essential that generalized indicators are not over-simplified or misleading in regards to actual trends.

In this report, we have provided what we think is a comprehensive approach to environmental indicators and measures. Obviously funding and time constraints will not allow for the implementation of all of these indicators and measures in the short-term. However, we think it is important to keep in mind the larger picture of the effort that is really required in terms of effective SoE reporting, and to always portray at best basic information about key indicators where data are unavailable, so that readers/users are also aware of the limitations of the report.

Part III: Developing Specific Indicators for the Columbia Basin

Overview

In selecting indicators and measures for the Columbia Basin, we reviewed systems used in state of the environment reporting in British Columbia, Canada, the US, Australia, and other jurisdictions. Our final approach and selection used relevant facets of other work, and was based on characterizing the condition and trends unique to the environment of the Columbia Basin.

As discussed above, most SoE frameworks divide environmental indicators and measures into three classes: State, Pressure and Response. In this project, we have focused on indicators related to the *State* of the environment because these assess the actual quality of the environment and the functioning of important environmental processes. We have, however, included a small number of Pressure and Response indicators where we felt there was overlap with issues relating to State, or where there were no feasible direct measurable means of addressing the State for a given environmental issue. Over time it may be appropriate to add more Pressure and Response indicators in order to describe the full picture of the Columbia Basin environment, but at this early stage in the development of a SoE system, describing the State of the environment should be the first priority.

Our process to create an initial set of indicators for the Columbia Basin involved the following:

1. Identification of ‘Realms and Components’ that describe the biophysical world of the Columbia Basin primarily in terms of a domain based approach (see below).
2. Using the structure within the ‘Realms and Components’ list we developed of a “full suite” of general indicators and quantifiable measures that would provide a comprehensive description of the Columbia Basin environment. Although extensive, this list includes the minimum required to cover all significant aspects of the biophysical environment. In developing these indicators, we included elements where data are both available and unavailable. The comprehensive list includes 25 indicators that were linked to 75 specific measures. We consider this list to be reasonably comprehensive for describing the condition of the biophysical environment in the Columbia Basin.
3. Prioritisation of the “full suite” of indicators and measures into a feasible short list for the first SoE reporting period. Prioritisation criteria used were i) feasibility (including data availability, data costs, costs of additional manipulation and analysis required), ii) significance of the indicator/ measure in the present context for describing key ecological elements and iii) potential for predicting future conditions for the indicator (see Appendix 3). Through prioritisation, we narrowed the comprehensive list down to a core subset of 22 measures, with at least one measure for most indicators.
4. Development of additional recommendations. This step-wise process allowed us to develop specific recommendations regarding how to implement an efficient but comprehensive SoE system. For example, assessing indicators and measures for data availability and applicability allowed us to identify important gaps in the knowledge of environmental systems within the Columbia Basin and to determine areas where monitoring programs should be implemented.

Step 1: Division of the World into Realms and Components

As a first step it is necessary to define what is meant by “the environment”. Environment can be generally interpreted as

> “*the combination of climatic, physical, chemical and biotic conditions [as well as functions and processes] that affect the growth and welfare of an organism or group of organisms*” (Dunster and Dunster 1996).

For the purposes of SoE reporting, we are also considering the organisms themselves. Given the complexity of the environment, it is necessary to consider various components, such as physical or biotic elements individually, while simultaneously addressing linkages between components. Scale is also important, since some conditions, functions or processes primarily operate at specific scales, and can only be understood when assessed at the relevant scale (e.g., global, regional, landscape, watershed or population).

To ensure that the indicator set proposed for the Columbia Basin is sufficiently comprehensive to address all key aspects of the environment at appropriate scales, we stratified the environment into a series of realms and components. This approach is similar to that used in Australia, the US and for similar work here in BC (e.g., Holt et al. 2003).

We identified three key realms within the Columbia Basin level: Terrestrial, Aquatic and Atmospheric. We also identified an additional realm to address the Columbia Basin's role within environmental systems at regional and global scales: Regional and Global Systems. The realms and components used for indicator development are shown in Figure 2.

The Aquatic Systems Realm has been subdivided into six components for indicator development: flow regimes, water quality, aquatic ecosystems/ communities, aquatic species, aquatic habitat elements and groundwater. The first five components primarily address issues related to surface and near surface waters, including shallow seepage waters and riparian zones, while the last component addresses issues related to deep aquifers. Flow regimes and water quality primarily cover the physical and chemical components of aquatic systems (e.g., amount and time of flows, dissolved substances, sediment loads); however, water quality also includes aspects of biological contamination (e.g., coliform levels and other disease agents). Aquatic ecosystems/ communities, aquatic species and aquatic habitat elements address issues related to most aspects of aquatic biodiversity, including fish, waterfowl, benthic communities and their aquatic habitat needs. Each of these components address biodiversity at different levels of organization – first at the level of ecosystems (i.e. groups of organisms living and interacting together in a specific environment such as riparian cottonwood ecosystems, small tributary streams, etc), secondly at the level of individual species or populations (e.g., the Kootenay Lake Gerrard rainbow population), and finally at the level of individual habitat factors that may be critical to specific ecosystems or species (e.g., spawning gravels, large woody debris for pool formation).

The Terrestrial Systems Realm has been subdivided into five components for indicator development: landscapes, terrestrial ecosystems/ communities, terrestrial species, terrestrial habitat elements and soils. The first component addresses issues related to landscape level processes and functions that affect ecosystem integrity and habitat distribution (e.g., natural disturbance regimes, seral stage distribution, patch size). Terrestrial ecosystems/ communities, terrestrial species and terrestrial habitat elements address issues related to most aspects of terrestrial biodiversity, including vegetation, mammals, birds, insects and their terrestrial habitat needs. Each of these components address biodiversity at different levels of organization – first at the level of ecosystems (i.e. groups of organisms living and interacting together in a specific environment such as grasslands or Interior Cedar-Hemlock falsebox site series), secondly at the level of individual species or populations (e.g., the South Selkirk caribou population), and finally at the level of individual habitat factors that may be critical to specific ecosystems or species (e.g., snags, large trees, browse on winter ranges).

Taking a reductionist approach to the environment always runs the risk of ignoring important components that do not fit neatly into the boxes created (e.g. riparian areas that fall between the aquatic and terrestrial realms, or turtles that have critical habitat in both realms), processes that operate across multiple realms (e.g., erosion/ sedimentation, fire, flooding), and functions that link more than one realm (e.g., large organic debris essential for forming fish habitat in streams, but derived from large trees growing in terrestrial habitats). We have attempted to deal with these cross-cutting features by assigning them to a particular realm or component, but future SoE reporting will have to be diligent to ensure these features are not lost.

We have used two components to address the Atmospheric Realm: air emissions and ultra-violet radiation. The first deals with changes in lower atmospheric composition within the Columbia Basin due to human-caused emissions of particulate matter and other substances released directly into the atmosphere. The second component looks at increases in ultra-violet radiation reaching the earth's surface in the Columbia Basin, mainly due to changes in upper elevation ozone concentrations.

The Regional and Global Systems Realm addresses the impact that environmental changes originating from within the Columbia Basin have on environmental systems at regional and global levels. This includes issues such as the environmental effects of flow regulation from within the CBT portion of the Columbia Basin on downstream reaches of the Columbia River, as well as the Basin's contribution to increased levels of greenhouse gases in the global atmospheric system. The Global Systems Realm also includes an assessment of impacts within the Basin that occur as a result of environmental changes at regional or global levels. This includes the environmental impacts within the CBT portion of the Columbia Basin from global climate change, as well as downstream barriers to salmon movement. At present only two global components have been defined: climate change and nutrient/ geochemical cycling. Specific regional components have not yet been identified.

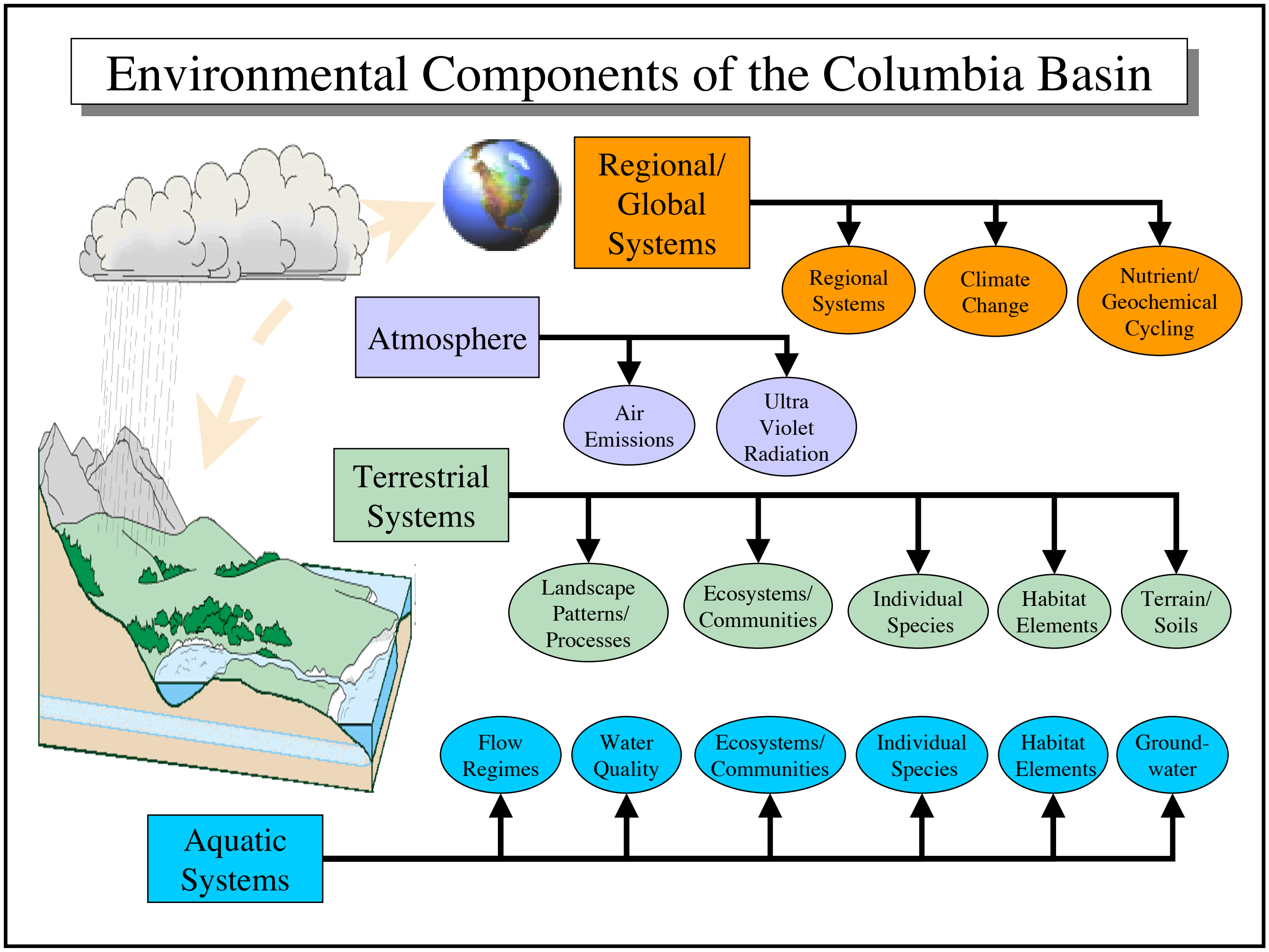

Figure 2. Environmental realms and components established as a basis for selecting environmental indicators for the Columbia Basin.

Step 2: A Full Suite of Indicators

The environmental components derived in Step 1 were used as a basis for developing a comprehensive set of indicators and measures for each environmental realm and component. A summary of the general-level indicators for each realm and component is provided in tabular form in Table 11. This is a brief overview and is expanded upon in Table 12.

Table 12 shows a schematic summary of the general indicators as well as examples of State, Pressure and Response indicators derived for each realm and environmental component. This table also provides examples of potential basic units for indicator assessment and the recommended conceptual approach to establishing benchmarks against which detected indicator changes should be evaluated.

Detailed background information for each indicator and measure is provided in Appendix 3. The expanded table in Appendix 3 includes the following information for each indicator and measure: scale and basic indicator assessment units, potential information sources, estimated environmental significance in the present context, predictive capability, and general estimates of data availability and data compilation/ manipulation requirements.

Appendix 4 provides an additional list of agencies contacted, their current contact personnel and their potential for cooperation.

Table 11. Comprehensive indicators developed to assess the State of the Environment in the Columbia Basin.

REALM / COMPONENT	CODE	GENERAL INDICATOR
Columbia Basin Terrestrial Systems		
Landscape Level Terrestrial Processes and Functions	T-1	Deviation from "natural" disturbance regimes
	T-2	Changes in landscape level habitats
Terrestrial Ecosystems	T-3	Degree of divergence from "natural" community diversity, structure and productivity
	T-4	Extent and degree of ecosystem integrity
Terrestrial Species and Populations	T-5	Viability of native species and populations
Terrestrial Habitat Elements at the Stand and Site Level	T-6	Changes in abundance and/or distribution of habitat elements
Soils	T-7	Extent and degree of soil degradation
Columbia Basin Aquatic Systems		
Flow Regimes	Aq-1	Degree of divergence from "natural" flow regimes
	Aq-2	Extent an degree of watershed integrity
Water Quality	Aq-3	Degree of divergence from "natural" water quality
	Aq-4	Extent of pollutants and/or pollution sources
	Aq-5	Location and extent of sediment/ pollution sources
Aquatic Ecosystems (including riparian)	Aq-6	Degree of divergence from "natural" community diversity, structure and productivity
	Aq-7	Extent and degree of aquatic ecosystem integrity
Aquatic Species and Populations	Aq-8	Viability of native species and populations
Aquatic Habitat Elements	Aq-9	Changes in abundance and/or distribution of habitat elements
Groundwater	Aq-10	Groundwater availability
	Aq-11	Quality of groundwater
Atmosphere		
Atmospheric Composition/ Air Quality	A-1	Air quality and atmospheric composition
	A-2	Extent of pollutants and/or pollution sources
Ultra-Violet Radiation	A-3	Changes in UV levels
Global Systems		
Climate Systems	G-1	Changes to climate
	G-2	Effects of climate change on terrestrial systems
	G-3	Effects of climate change on aquatic systems
Geochemical and Nutrient Cycles	G-4	Greenhouse gas emissions

Table 12. Summary of comprehensive environmental indicators for the Columbia Basin and associated information.

Realm: Columbia Basin Terrestrial Systems

Benchmark: Estimated Range of Natural Variability (RONV); generally conditions prior to 1850

Components: Landscapes

General Indicators	Deviation from "natural" disturbance regimes Changes in landscape level habitats		
Examples of "State" Measures	Area with altered fire regimes or insect outbreak patterns or frequencies	Changes in patch size distribution	Areas with altered seral stage distribution
Examples of Pressure, Response or Other Indirect Measures	Fire suppression activities	Percent of fire-maintained ecosystems that have been restored	
Potential Basic Units for Indicator Assessment	BEC Units, Ecosections, Landscape Units	Units of Similar Natural Disturbance Regimes	Site series or site series groups (ssPEM/ ssTEM)

Components: Terrestrial Ecosystems

General Indicators	Degree of divergence from "natural" community diversity, structure and productivity Extent and degree of ecosystem integrity				
Examples of "State" Measures	Extent of intact or unmodified ecosystems	Number of red-/ blue-listed ecosystems	Changes in native species diversity within ecosystems (spp. loss)	Frequency and distribution of exotic and invasive species	Estimated changes to communities based on habitat and population modelling
Examples of Pressure, Response or Other Indirect Measures	Pressure: estimated index of ecosystem integrity based on ecosystem alteration factors such as landuse designations and associated management regimes (e.g., extent and distribution of protected areas, forest mgmt. standards, designated non-contributing forest, agriculture, urban/rural, flooded, etc.)				
Potential Basic Units for Indicator Assessment	By general ecosystem type - (e.g. grasslands, alpine, forests - mid-low elevation, subalpine)	BEC Units or BEC x Ecosections	Site series or site series groups (ssPEM/ ssTEM)		

Components: Terrestrial Species

General Indicators	Viability of native species and populations (emphasis on vulnerable, keystone, umbrella or representative spp.)			
Examples of "State" Measures	Number of red-/ blue-listed spp.	Actual changes in population size for vulnerable, keystone or other representative spp.	Changes in spp. distribution - degree of range reduction and/or fragmentation	Changes in spp. genetics or health factors (e.g. pesticides, GMOs, introduced pests)
Examples of Pressure, Response or Other Indirect Measures	Habitat supply modelling for individual species or species guilds and/or population modelling for individual species			
Potential Basic Units for Indicator Assessment	Individual species, guilds or species groups (e.g. migratory)	Vulnerable or sensitive species/ spp groups	Keystone or umbrella species	Species where data is available

Components: Terrestrial Habitat Elements

General Indicators	Changes in abundance and/or distribution of habitat elements			
Examples of "State" Measures	Extent of areas where HEs are intact or changed	Type frequency and distribution of snags	Frequency and distribution of deciduous stands	Occurrence of large trees
Examples of Pressure, Response or Other Indirect Measures	Modelling for the occurrence, distribution and temporal variation in supply of specific habitat elements (e.g. old growth, snags, CWD, deciduous trees)			
Potential Basic Units for Indicator Assessment	By individual habitat elements (e.g., snags, deciduous trees, CWD, large trees) assessed throughout the basin, in selected BEC units or by specific ecosystem types (e.g., in grasslands or winter ranges)			

Components: Soils

General Indicators	Extent and degree of soil degradation	
Examples of "State" Measures	Changes in soil properties	Estimated extent of soils where changes in soil properties affect productivity
Examples of Pressure, Response or Other Indirect Measures	% of landbase under various levels of soil conservation standards, level of compliance with the standards and research to back up those standards	
Potential Basic Units for Indicator Assessment	All soils	Individual soil types or groups of soil types

Table 12 continued.

Realm	Columbia Basin Aquatic Systems
Benchmark	Estimated Range of Natural Variability (RONV); generally conditions prior to 1850

Components	Flow Regimes		
General Indicators	Degree of divergence from "natural" flow regimes Extent and degree of watershed integrity		
Examples of "State" Measures	Type and degree of flow regime alterations	Peak flow and low flow levels, frequencies and timing (i.e. height and frequency of flooding)	Proportion of river/ stream lengths without flow alterations
Examples of Pressure, Response or Other Indirect Measures	Estimated watershed integrity index, based on: e.g. road density, ECA, flow obstructions, water diversions, etc		Number and location of structures that divert, obstruct or alter flow regimes
Potential Basic Units for Indicator Assessment	By watershed or selected watersheds and/or other features	Selected hydrologic features (rivers, streams, wetlands, lakes, etc.)	Stream reaches or stream gauge/ sampling locations

Components	Water Quality			
General Indicators	Degree of divergence from "natural" water quality Location and extent of pollutants and/or pollution sources Location and extent of sediment sources			
Examples of "State" Measures	Sediment loads (suspended sediment)	Chemical composition (pollutants, pH and nutrients)	Water physical properties (e.g., temp., dissolved O2)	Biological contaminati on (e.g. coliform, giardia)
Examples of Pressure, Response or Other Indirect Measures	Watershed Disturbance Indices (e.g. road density, livestock use, urban/rural develop-ment)	Discharge permits, toxic sites, estimated sediment yields (sediment budget modelling)	Water quality objectives	Benthic Community Indices
Potential Basic Units for Indicator Assessment	Selected Hydrologic Features (rivers, streams, wetlands, lakes, etc.)	Water Quality Monitoring Sites	Selected indicator watershed s and/or other features	Stream reaches

Components	Aquatic Ecosystems		
General Indicators	Degree of divergence from "natural" community diversity, structure and productivity Extent and degree aquatic integrity		
Examples of "State" Measures	Extent of intact or unmodified aquatic ecosystems	Frequency and distribution of exotic and invasive species	Estimated changes to ecosystems based on habitat and population modelling
Examples of Pressure, Response or Other Indirect Measures	Pressure Indicator Index of aquatic ecosystem integrity based on: watershed condition, flow disruptions, channel alterations etc. (e.g., extent and distribution of dams, diversions, infilling, flood control, riparian development, watershed landuse designations and mgmt. regimes)		
Potential Basic Units for Indicator Assessment	Individual ecosystem type, stream reach, hydrologic feature or watershed		

x

Components	Aquatic Species		
General Indicators	Viability of native species and populations (emphasis on vulnerable, keystone, umbrella or representative spp.)		
Examples of "State" Measures	Changes in spp. genetics or health factors (e.g. pesticides, introduced pests)	Actual changes in population size for vulnerable, keystone or other represent-tive spp.	Number of red-/ blue-listed spp.
Examples of Pressure, Response or Other Indirect Measures	Extent and degree of riparian and watershed developmen t (habitat modelling)	Extent and degree of shoreline alterations	Flow regime and/or channel modifica-tions, obstructions
Potential Basic Units for Indicator Assessment	Individual species or species groups	Species or groups assessed throughout the basin	Selected indicator watersheds and/or other features

Components	Aquatic Habitat Elements		
General Indicators	Changes in abundance and/or distribution of habitat elements		
Examples of "State" Measures	Extent of areas where HEs are intact or changed	Extent and quality of adfluvial fish spawning areas	Occurrence of riparian sources of large woody debris
Examples of Pressure, Response or Other Indirect Measures	Extent and degree of riparian and watershed develop-ment (habitat modelling)	Extent and degree of shoreline alterations	Flow regime, channel and/or bedload modification
Potential Basic Units for Indicator Assessment	By individual habitat elements (e.g., spawning/ rearing areas, LWD, pools, riparian areas) assessed throughout the basin, in selected watersheds or by types of hydrologic features (e.g., small streams, lakes, wetlands)		

Components	Groundwater	
General Indicators	Groundwater availability and quality	
Examples of "State" Measures	Aquifer levels and flow rates	Water quality (chemical composi-tion)
Examples of Pressure, Response or Other Indirect Measures	Karst Manageme nt	??
Potential Basic Units for Indicator Assessment	Individual aquifers	Groundwate r monitoring sites

Table 12 continued.

Realm	Atmosphere				Regional and Global Systems				
Components	Atmospheric Composition/ Air Emissions			Ultra Violet Radiation	Climate Change			Nutrient and Geochemical Cycling	Regional Level Environmental Systems
General Indicators	Air Quality and atmospheric composition Extent of pollutants and/or pollution sources			Changes in UV levels	Changes to climate Effects of climate change on terrestrial systems Effects of climate change on aquatic systems			Changes to global systems affected by activities in the basin e.g., Greenhouse Gas Emissions	Changes to regional systems affected by activities in the Basin, or changes to the Basin's environment caused by regional environmental changes
Examples of "State" Measures	Concentrations of particulate matter	Ground-level ozone	Number of days/yr when air quality standards are exceeded	UV levels	Changes in air temperature (annual and seasonal distribution)	Changes in precipitation (annual and seasonal distribution)	Changes in other climatic factors (e.g. storm frequency, storm force)	Changes in greenhouse gas levels	**Not developed at this stage**
Examples of Pressure, Response or Other Indirect Measures	Particulate matter emissions apportioned by source	Point source emission levels (e.g. SO2, TRS, metals, etc)	Discharge permits by pollutant, non point source estimates	Number of days UV index exceeds 'safe' levels or is in various categories (extreme, high, moderate, low, missing data)	Changes in environmental factors, ecosystem processes, habitat elements or biological phenomena resulting from climate change (e.g. fire frequencies, spp. distributions, phenology, water temperatures)			Total estimates of GHG from human activities in the region including: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride	
Potential Basic Units for Indicator Assessment	Air Sheds	Air Quality monitoring sites	Selected indicator airsheds or communities	Coarse scale: Southern BC; possibly Northern Idaho/ Montana	Climate stations	Specific aspects of the environment with recorded changes due to climate		Basin emissions: by sector, by regional district	
Benchmark	RONV (e.g., natural background levels of ozone: 0.02ppm)			Estimated Range of Natural Variability (RONV); generally conditions prior to 1850					

*Monitored in: Nelson, Castlegar, Trail, Radium, Slocan, Golden, Cranbrook, Creston, Revelstoke, Valemount

Data availability and sources

Environmental indicators and measures must rely on the best scientific information available and are only as good as the data that goes into their assessment. The measures we present in the comprehensive list include those with reliable data sources and those where no data is currently available. For some indicators and measures, minimal data is available and extensive data analysis and compilation may be required. When assessing information availability, we classified each indicator using the following general classes:

- Readily available
- Data available, but multiple sources
- Generally available
- Generally limited availability, but some special cases (specified in entry)
- Limited data availability
- Very limited data availability
- Unknown

In our exploration of data sources, we found that most raw data sources were likely to be provided free of charge, although data analysis and compilation to address the issues specific to SoE reporting would have to be undertaken by the SoE project. For other indicators, data is simply unavailable because it is either difficult or expensive to collect and collate, or because modelling is the only feasible way of assessing the issue at landscape and regional scales. Several models already exist and there is considerable potential for cooperation with the model developers (e.g., Pacific Forestry Centre). We recommend adapting and developing models for complex issues such as assessments of habitat elements, changes in the viability of populations, biodiversity assessments and climate change impacts. Base data for application of the models is generally available, although it often requires compilation from various sources, which can present challenges in meshing data across the whole basin.

Limitations

Although we have made an effort to provide a set of indicators that fully describes the state of the environment in the Columbia Basin, the list should be interpreted as a work continually in progress. Due to scientific uncertainty and lack of comprehensive inventory data, it is not possible to effectively assess State indicators for all components of the environment. For example, it is not possible to develop practical indicators to directly assess changes in biodiversity because it is well known that biodiversity levels are uncertain and that many species remain unnamed[4]. To address these limitations we have proposed indirect indicators based on modelling exercises. These indicators reflect *estimates* of the parameters they are measuring, but in many cases are the only means of assessing complex or poorly understood systems. In a small number of cases we have included Pressure and Response measures where we feel that links between “cause” and “effect” are strong and that these measures can provide useful information in the absence of a fully developed set of State indicators.

The sets of indicators presented here are by no means a final package for assessing the state of the environment in the Columbia Basin. Indicators will have to be continually assessed and evaluated to incorporate new knowledge over time.

[4] The Federal-Provincial-Territorial Biodiversity Working Group and Environment Canada's National Indicators and Reporting Office have undertaken a multi-year process to develop a Canadian Biodiversity Index that will address the uncertainty as well as the measurement challenges associated with biodiversity assessments.

Step 3: Indicator Prioritization into a Core Subset

Comprehensive SoE reporting requires a considerable effort and is most efficient when implemented in stages. After developing a comprehensive set of indicators and measures, we undertook a process to select a subset of those indicators and measures with higher priorities for assessment in the short term. The initial step in developing the subset was based on a subjective assessment of each measure using three criteria:

a) **Estimated significance in the present context** – the degree of importance of an indicator or measure in terms of the current opportunities for slowing, mitigating or reversing harmful impacts on the environment. This includes both emerging environmental issues and issues that have long been recognized.

b) **Estimated effort required for data compilation/ manipulation** – the cost and level of effort required to collect and analyse scientifically credible data; ratings generally based on the continuum from basic data compilation, to the need for varying degrees of analysis to the need from modelling and/or model development. Analysis can include such things as combining databases across regions and sectors, assessing the interactions of multiple variables, or converting tabular data to a spatial representation.

c) **Estimated predictive capability** – the potential for assessing trends in environmental conditions in the past, present and especially the future (i.e. the potential for early warning of impending problems).

The general classes for significance and predictive capability range from Very Low to Very High. The classes for effort required for data compilation included:

- Basic data acquisition/ compilation
- Data compilation/ minor analysis
- Data compilation/ moderate analysis
- Some modelling/ analysis
- Significant analysis/ model development

We used an independent three-way scoring of each of the three factors from three members of the project team, and created an average score for each indicator. A priority list was then created, giving precedence to indicators and measures for environmental issues that on balance were deemed highly significant, had moderate to low effort required for data compilation/ manipulation and showed potential for predicting future trends. Employing some general assumptions[5] regarding a potential budget for SoE reporting in the Basin, we selected a subset of the higher priority environmental measures that we felt would be feasible for one 5 year reporting cycle. Data availability was also factored in at this point. This subset is a rough estimate of what would be feasible within our budget assumptions, and would need to be revisited if our budget assumptions were inaccurate.

In selecting a subset of higher priority measures to utilize in the first round of Columbia Basin SoE reporting, we attempted to ensure representation across realms, including at least one measure for each of the environmental components and realms. Groundwater, Ultra-Violet radiation and Geochemical and Nutrient Cycles were the only components left out of the subset, primarily due to lack of Basin-wide data, and partially due to their lower priorities relative to other components. Four other indicators also do not have specific measures in the prioritised subset for similar reasons.

The Recommended Indicator and Measure Subset

The resulting subset of indicators and measures is presented in Table 13 (use the Codes to find further information on individual measures in Appendix 3). To prepare a complete SoE report utilizing all of the recommended measures will likely require between 4 and 5 years of data acquisition, data compilation and analysis and model development[6]. Analysis and reporting on the complete subset recommended will provide

---

[5] We assumed a budget of approximately $60,000 per year, with a reporting cycle of every 5 years – making available approximately $300,000 per reporting cycle.

[6] This is consistent with our budget assumptions of approximately $60,000 per year

information across every realm and most environmental components included in the description of the Columbia Basin environment.

To any observer, this is a substantial program. Given the ecological complexity of the Basin and the wide range of human activities occurring throughout the Basin, attempting to comprehensively assess the state of the wide range of environmental values in the Basin is no small task.

The core subset of indicators and measures includes a mixture of direct measures for specific environmental conditions, as well as a series of indirect measures based on modelling and other indices. The measures that involve habitat modelling and other types of impact modelling are dependent on the development of a spatial landuse database for the Basin, which is effectively a map of the region that highlights different landuses. Although these types of measures require significant development costs, they have the important advantage of allowing for predictions of future conditions, thereby allowing for early detection of potential environmental problems before they become serious. Modelling efforts also provide the ability to evaluate various remedies, thereby improving the likelihood of choosing a remedy that is most efficient and cost effective. The spatial landuse database will also be invaluable for linking environmental reporting results with other sustainability assessments in the social and economic sectors, as well as further investigations into pressures and responses to specific environmental issues. This approach is very similar to that taken in the analysis of the Interior Columbia Basin in the US (USDA-FS 1996, Quigley and Arbelbide 1997, or on the web http://www.icbemp.gov/).

Most of the spatial data (i.e. GIS layers) necessary for construction of the landuse database presently exist, but there is significant effort required to compile the information into a single continuous coverage for the whole Basin. The information is generally available for individual administrative jurisdictions (e.g., Provincial Regions, Regional Districts, Timber Supply Areas, Tree Farm Licenses), is held by a range of agencies and organizations (e.g., MSRM, MoF, Forest Licensees, Regional Districts), and is often not consistent with regard to data standards or data entry criteria. However there is already a project underway by MSRM and MoF, the Spatial Timber Supply Modelling Project (Price 2004), which has made significant headway on this work for a major portion of the Basin (the Arrow, Kootenay Lake, Cranbrook and Invermere TSAs). This project, in which CBT has already played an indirect role through their support of the “Columbia Basin Database of Wildlife-Habitat Relationships (WHR) in British Columbia” (Steeger et al. 2001, Steeger 2004), has included some innovative modelling projects developing measures for environmental assessment and reporting that employs portions of that database (e.g., see Wilson et al. 2002 and 2003, Utzig and Holt 2002). The Columbia Basin Fish and Wildlife Compensation Program has also begun a web-based biodiversity atlas that will provide additional useful information (Amy Waterhouse, CBFWCP, pers. comm.).

Implementation Options

Although ideally a complete SoE report for the Basin would include all of the measures in the core subset, it may also be advantageous to pilot the SoE reporting process with a smaller subset that could be completed in a shorter timeframe. To provide the CBT with greater flexibility in beginning a SoE reporting process, we have also categorized the subset of measures into those that CBT could likely report on in a shorter period (1-3 years) with minimal investment, and those that will require increased time and resources to analyze. The designations are presented in the final column of Table 13. “Interim” indicates those for early reporting, and “Full” are those that would be included later as part of a full cycle SoE report.

Most of the measures designated in the interim set can be reported on with basic data compilation from existing sources or reports, and in some cases minor analysis. Three measures included in the interim set, measures T-1.1 (deviation from natural disturbance regimes), T-6.1 (changes in abundance and/or distribution of snags) and T-7.1 (estimated extent of soil degradation) will require adaptation of existing habitat assessment models, and preparation of a simplified landuse database for the region. The resources required for these analyses are modest, and will offer an opportunity to pilot the concepts necessary for the recommended second phase of modelling measures. Most of the measures in the “Full” cycle subset require model adaptation or development, and are tied to the preparation of a more complete spatial landuse database model for the Basin. Wildlife habitat relationship research and model development and testing projects are already partially supported by other CBT programs (e.g. the Columbia Basin Habitat Relationship project and website). Other projects in the environmental sector could be coordinated with various aspects of the SoE reporting program, to fill data gaps and provide additional relevant information.

Table 13. Subset of indicators and measures selected for the first CBT SoE reporting cycle.

REALM / COMPONENT	CODE	INDICATOR	CODE	MEASURE	REPORT PERIOD
Columbia Basin Terrestrial Systems					
Landscape Level Terrestrial Processes and Functions	T-1	Deviation from "natural" disturbance regimes	T-1.2	Extent of ecosystems (forests and grasslands) with altered seral stage distributions (altered from estimated RONV)	Interim
	T-2	Changes in landscape level habitats		NA due to data availability/ lower priority	
Terrestrial Ecosystems	T-3	Degree of divergence from "natural" community diversity, structure and productivity	T-3.4	Number of red- and blue-listed ecosystems	Interim
			T-3.5	Frequency and distribution of exotic and invasive species (including plants, vertebrates and invertebrates)	Interim
	T-4	Extent and degree of ecosystem integrity	T-4.1	Estimated index of ecosystem integrity based on ecosystem alteration factors such as landuse designations and associated management regimes (e.g., protected areas, forest mgmt. standards, designated non-contributing forest, agriculture, urban/rural, flooded, etc.)	Full
Terrestrial Species and Populations	T-5	Viability of native species and populations	T-5.1	Inventoried changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species - caribou	Interim
			T-5.5	Number of threatened, endangered and recently extinct or extirpated species	Interim
Terrestrial Habitat Elements at the Stand and Site Level	T-6	Changes in abundance and/or distribution of habitat elements	T-6.1	Estimated extent of areas where habitat elements are intact, or changed from their "natural condition (including degree of change – snags	Interim
Soils	T-7	Extent and degree of soil degradation	T-7.1	Estimated area of soils where changes in soil properties are sufficient to negatively affect productivity (including compaction, displacement and contamination)	Full
Columbia Basin Aquatic Systems					
Flow Regimes	Aq-1	Degree of divergence from "natural" flow regimes	Aq-1.2	Number and location of structures that divert, obstruct or alter flow regimes, including area flooded/affected (e.g., large dams, water intakes, micro-hydro)	Interim
			Aq-1.3	Ratio of the length of river/stream reach without flow alteration (dams, locks, canals, etc) in relation to the total river length	Interim
	Aq-2	Extent an degree of watershed integrity	Aq-2.1	Estimated watershed integrity index, based on watershed alterations that affect flow regimes: road density, weighted ECA, reservoir flooding, flow obstructions, water diversions, etc	Full
Water Quality	Aq-3	Degree of divergence from "natural" water quality		NA due to data availability/ lower priority	
	Aq-4	Extent of pollutants and/or pollution sources	Aq-4.1	Total recorded discharges of pollutants to water bodies (permitted, non-permitted, toxic sites, spills)	Interim

REALM / COMPONENT	CODE	INDICATOR	CODE	MEASURE	REPORT PERIOD
	Aq-5	Location and extent sediment/ pollution sources	Aq-5.2	Composite water quality index based on watershed condition factors: presence of potential sediment sources and other sources for chemical and biological pollution	Full
Aquatic Ecosystems (including riparian)	Aq-6	Degree of divergence from "natural" community diversity, structure and productivity	Aq-6.4	Frequency and distribution of exotic and invasive species (including fish, plants, and other taxa)	Interim
	Aq-7	Extent and degree of aquatic ecosystem integrity	Aq-7.1	Index of aquatic ecosystem integrity based on watershed condition, flow disruptions, channel alterations etc. (e.g., dams, diversions, infilling, flood control, riparian development, watershed landuse designations and mgmt. regimes)	Full
Aquatic Species and Populations	Aq-8	Viability of native species and populations	Aq-8.1	Inventoried changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species - sturgeon	Interim
			Aq-8.5	Number of threatened, endangered and recently extinct or extirpated species	Interim
Aquatic Habitat Elements	Aq-9	Changes in abundance and/or distribution of habitat elements	Aq-9.1	Estimated extent of areas where habitat elements are intact, or changed from their 'natural' condition (including degree of change) – adfluvial spawning grounds	Interim
Groundwater	Aq-10	Groundwater availability		NA due to data availability/ lower priority	
	Aq-11	Quality of groundwater		NA due to data availability/ lower priority	
Atmosphere					
Atmospheric Composition/ Air Quality	A-1	Air quality and atmospheric composition	A-1.2	Summary of particulate matter concentrations, by season and by estimated source apportionment (home wood burning, slash/agriculture, non-point sources)	Full
			A-1.3	# of days/yr when particulate matter exceeds specified values	Interim
	A-2	Extent of pollutants and/or pollution sources	A-2.1	NA due to data availability/ lower priority	
Ultra-Violet Radiation	A-3	Changes in UV levels	A-3.1	NA due to data availability/ lower priority	
Global Systems					
Climate Systems	G-1	Changes to climate	G-1.2	Predicted changes in temperature and precipitation	Interim
	G-2	Effects of climate change on terrestrial systems	G-2.1	Predicted changes in BEC zonation, disturbance processes (including fire)	Full
	G-3	Effects of climate change on aquatic systems	G-3.1	NA due to data availability/ lower priority	
Geochemical and Nutrient Cycles	G-4	Greenhouse gas emissions	G-4.1	NA due to data availability/ lower priority	

Additional Steps

We have taken a comprehensive and systematic approach to identifying a set of indicators that can be used in the short-term to initiate SoE reporting in the Basin. Although we have laid the groundwork for an interim and full cycle SoE reports in the next five year period, we realise that there are many additional questions that require answering prior to preparation of these reports. Necessary details include:

- Methodologies for identifying benchmarks, for each indicator/ measure.
- Confirming that available data is actually in a useable and obtainable form
- Details of analysis methodologies
- Level of detail to provide in reports for various audiences

As these tasks are completed, progress towards assessing the interim and eventually the full reporting priorities should begin. CBT may also wish to undertake a peer review and/or targeted public review of the proposed indicators/ measures, however these reviews would likely be more effective following completion of the interim SoE report, when there would be more detail to actually review.

However, if the CBT feels the need to begin more tentatively, an alternative may be to deliver a mock-up of an SoE report while addressing some of the questions outlined above. An effective approach might be to prepare a mock-up state of the environment report based on the proposed interim reporting subset of indicators/ measures, including a report outline and examples of presentation formats for all of the interim reporting measures. The mock-up could also include in-depth analysis of one or two measures to better understand the range in costs and effort required for data acquisition, compilation and analysis (e.g., T-1.2 Seral stage alterations and A-1.2 Particulate matter levels).

In addition to specifying a core subset of indicators/ measures for the first reporting period, we have also highlighted some indicators/ measures that are important, but generally lacking in sufficient data for environmental reporting at this time. These should be considered as potential targets for further development as CBT sets priorities for funding of other environmental projects over the next few years.

Step 4: Priorities for Data Collection in Subsequent Reporting Cycles

In the prioritisation process described above, we also recognised some environmental measures and indicators that were deemed highly significant, but we were not able to include them in the core subset of measures due to lack of data availability. The primary data gaps identified are actual inventoried species ranges and population levels for a wide range of both aquatic and terrestrial species (measures T-5.1, T-5.4, Aq-8.1 and Aq-8.4). The lack of individual species information also leads to a lack of information regarding changes in ecosystem diversity and function as well (measures T-3.1, T-3.3, Aq-6.1 and Aq-6.3). Understanding changes in species ranges and ecosystem diversity due to present management regimes is likely to be a key element in understanding and adapting to the added impacts of climate change. Understanding that changes to ecosystems are also closely tied to any changes in key habitat elements (measures T-6.1 and Aq 9.1), for which there is also a very limited inventory database (e.g., snags, CWD, stream reach mapping).

The advent of climate change has also brought to the forefront various other subtle environmental changes that we are only beginning to understand. These include changes to fire regimes and other disturbance factors that play important functions in both terrestrial and aquatic systems (measure T-1.1). Although there are extensive data on flow regimes for the main Columbia River and Kootenay River systems due to the extensive dam network, flow information for smaller streams is limited to a few experimental watersheds, and almost non-existent for smaller lakes and wetlands (Aq-3.1).

We recommend that these issues be considered as candidates for future monitoring programs within the Basin, possibly through a partnership between the CBT and other government agencies, industry and/or other organizations.

Part IV: Linking to a Broader Sustainability Planning and Reporting Framework

What is Sustainability Reporting?

State of the environment reporting as outlined in this document, and as practiced by other jurisdictions, provides information on the state of environmental conditions within a geographic area. 'Sustainability' reporting differs from 'state of' reporting in two principle ways:

- economic and social (including cultural) dimensions of sustainability are incorporated, along with the environmental aspects; and
- the purpose is to report on movement towards the achievement of sustainability which is defined by target[7] conditions for each criteria and indicator – these target conditions are usually set through sustainability planning and are based on long-term visions and balancing of environmental, social and economic goals or objectives for a particular geographic area.

Figure 3 illustrates a framework that builds on the SoE reporting approach developed in this project to implement planning and reporting for sustainability.

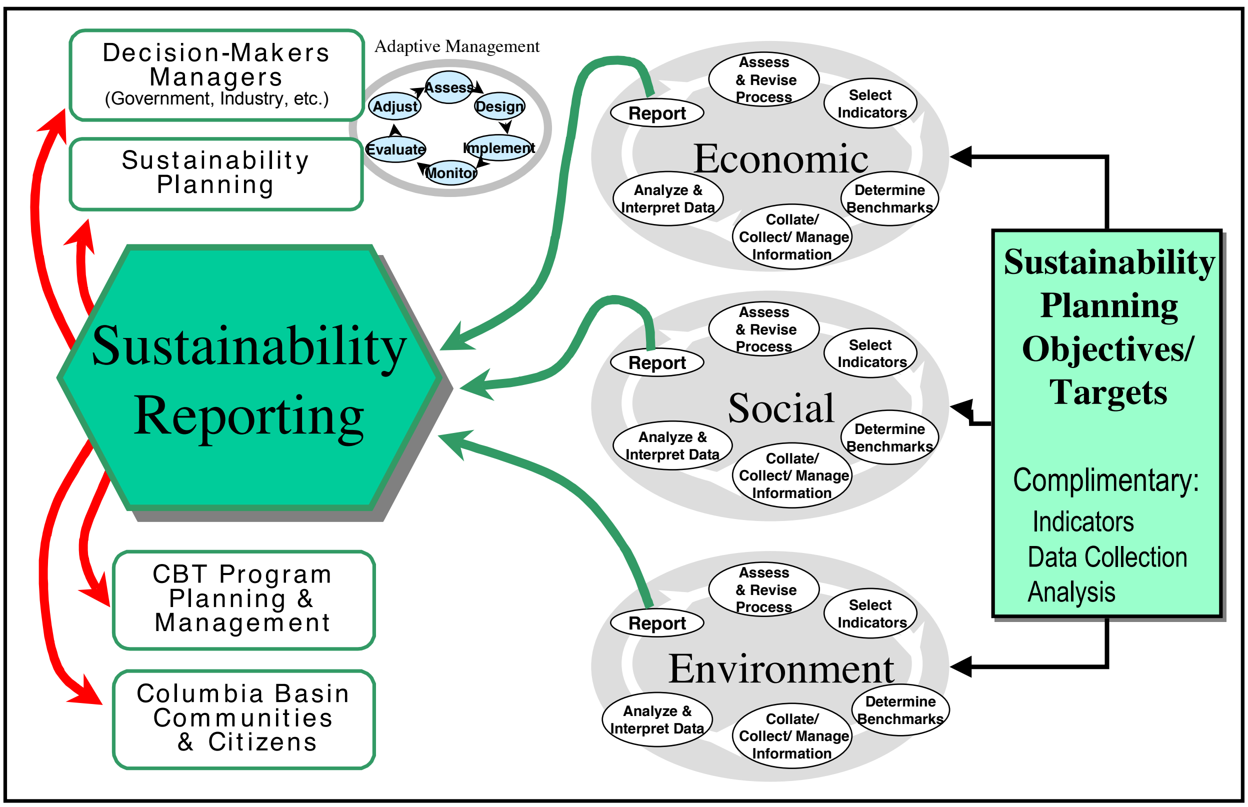

Figure 3. Sustainability Planning and Reporting Framework

[7] In sustainability planning, 'targets', 'benchmarks' and other terms are used to define desired conditions. In this document, 'benchmarks' refer to environmental conditions for state of the environment reporting, and 'targets' refer to sustainable planning/reporting conditions.

The concept of 'sustainability' has developed since the 1985 Bruntland report (World Commission on Environment and Development 1987) focused attention on the need to balance the economic, environmental and social aspects of human activities, now and for the future. Sustainability 'reporting' has been implemented in some jurisdictions through reports on environmental, economic and social conditions. While these are commendable, as defined, sustainability requires 'balancing' environmental, economic and social aspects, and consideration of the now and the future. This implies that sustainability reporting exists within the context of a 'sustainability plan'. Sustainability reporting requires some prior form of planning to examine the interactions amongst these otherwise independent expectations, choosing approaches that promote or create balanced conditions with defined targets, while looking at the present, and projecting into the future. Sustainability planning is a relatively new discipline, with developing approaches.

Ultimately, stimulating action and changes in behavior by citizens, all orders of governments, businesses and other organizations to support achievement of sustainability, is the primary purpose of sustainability planning and reporting. A similar area of reporting and planning focuses on human quality of life (e.g., Federation of Canadian Municipalities) or well-being (e.g., Prescott-Allen, 1997*)*, which overlaps significantly with sustainability planning and reporting.

The purpose of this section of the report is to recommend how this initial SoE project might support the creation of sustainability planning and reporting system for the Columbia Basin. It begins with a review of the challenges to sustainability planning and reporting in the Columbia Basin, followed by a discussion of key characteristics of approaches, including identification of possible prototypes. Recommendations for moving toward sustainability planning and reporting are then provided.

CHALLENGES TO SUSTAINABILITY PLANNING AND REPORTING IN THE COLUMBIA BASIN.

The social, environmental and economic characteristics of the Columbia Basin create several challenges to implementing sustainability planning and reporting by the Columbia Basin Trust, or other organisations. The following is a description of some of the key challenges:

- **Large area with few people** – The Basin covers over 4 million hectares, where approximately 150,000 people live. There are few communities with more than 15,000 people, and many small hamlets of 500 or less residents. In many areas of the Basin one can drive for more than an hour without passing through a municipality or First Nations reserve.
- **Complex ecology** – The Basin spans multiple ecoregions ranging from dry grasslands to interior cedar-hemlock rainforests and alpine tundra.
- **Complex administrative jurisdictions –** Private land exists principally in and around communities located in valley bottoms, with some tracts of private forest lands, principally in the southern Basin. Three orders of government exist within the basin – municipalities, regional districts and First Nations. The provincial government has jurisdiction over much of the broader landscape, where widespread tenured commercial uses exist for timber harvesting, commercial recreation, mining, grazing, water use, etc. The federal government has jurisdictions related to National Parks, fisheries and First Nations' reserves, and a growing involvement in species at risk management. Within this complex administrative mix, the CBT has no administrative jurisdiction.
- **Administrative jurisdictions don't match ecological land units** – Watersheds provide natural geographic units for sustainability planning, however, land ownership and administrative jurisdictions do not reflect watersheds. Municipal government boundaries include settled areas only, usually in valley bottoms, and eliminate the majority of the landscape. Regional district boundaries include the broader landscape, but regional districts have not traditionally taken a planning role on provincial lands, and have no legal mandate to do so. Provincial government planning generally does not include municipality lands.
- **Community sustainability linked to broader landscapes without jurisdiction** – Rural communities in the Basin and in other areas realize their quality of life from social, economic and environmental perspectives are closely linked to the broader landscape. To be authentic, sustainability planning must incorporate the broader landscapes. However, municipal and regional district governments do not have authority over these broad landscapes, or the capacity to conduct sustainability planning in these large, often complex areas.

- **Lack of sustainability planning** – Currently, sustainability planning has not been completed by any order of government or other entity in the Basin. Several initiatives are underway by communities (e.g., Revelstoke, Invermere, Kaslo), by corporations (e.g., Tembec), and through the provincial government's strategic land use planning (Kootenay Boundary Land Use Plan and Revelstoke Minister's Advisory Committee Plan), but none of these initiatives would meet the current expectations of sustainability planning. The provincial government does not intend to complete broad scale sustainability planning – their current focus is to develop Sustainable Resource Management Plans only for specific areas and specific uses as the need arises. In addition, CBT's current management plan does not address sustainability topics.
- **Mixed capacity** – Based on the general absence of sustainability planning in the Basin, there is limited, or at best, mixed capacity in all sectors and communities. However, some communities have extensive planning experience and expertise, most often with economic development planning. With appropriate guidance this experience could be incorporated into sustainability planning.
- **Limited local resources** – At this time in particular, the local and provincial governments have limited resources, in both financial and human terms.

While these challenges are extensive, Basin communities have recognized the need to develop plans for sustainable futures, and some have taken initial steps towards this level of planning. The CBT is in a position to support these communities, and other interests to create a comprehensive set of sustainability plans that span the Basin, and support Basin-wide sustainability reporting.

Seeking a Suitable Approach

The extensive research on State of the Environment and Sustainability Reporting undertaken for this project has provided a foundation for this report, and will be invaluable for others as the CBT moves ahead with SoE and sustainability reporting. The following summary of critical elements, potential approaches and geographic scales for reporting is based on this research, as well as interviews with individuals involved in sustainability planning and reporting.

Critical Elements

It is broadly agreed that there are two equally important elements to effective sustainability planning (Centre for Community Enterprise 2002; United Kingdom*)*:

- the process of efficiently engaging technical specialists, and those who make decisions and implement actions that affect sustainability – citizens, government, business and other organizations; and
- the indicators – how they relate to 'what matters' (i.e. visions, goals/objectives), how they are measured, how they are reported and what they mean in terms of sustainability.

Attention to the process is important to encourage ownership of the outcomes by the broad range of individuals and organizations that make decisions and take actions that influence sustainability. Without appropriate involvement, a sustainability report is likely to be added to a bookshelf, and will not achieve the key purpose of stimulating actions in support of sustainability. The need for involvement must be balanced with available resources. Also, the process must involve technical expertise at appropriate phases – it is not usually appropriate for technical specialists to define community values and objectives, but their expertise is invaluable in defining feasible, practical indicators to measure achievement of objectives.

There has been considerable attention paid to sustainability indicators at many different scales (International Sustainability Network; Maclaren 1996*)*. In fact, there is often extensive focus on the indicators, with less attention to the process, leading to limited ownership and action based on sustainability reporting (Centre for Community Enterprise 2002*)*. In addition, indicators are sometimes selected without having a clear relationship to 'what matters' or the visions, goals and objectives of the planning process. This report, and similar reports for social and economic elements, should be used to develop a core set of indicators for sustainability planning in the Basin. This would not be a restrictive set, but rather a core set that would support Basin wide sustainability reporting. The focus on the biophysical aspects of state of the environment reporting that are incorporated in the indicators recommended in this project should be retained, with the addition of human use indicators as appropriate.

One of the key ways that sustainability planning differs from other planning initiatives is the need to balance social, economic and environmental expectations to send clear signals about movement towards sustainability. This is often expressed through target conditions. These conditions can be expressed as desired trends, which are often easy to identify for most indicators – it is usually obvious when conditions are improving or declining relative to a sustainability objective. More precise targets are more difficult to define, and are often limited by available data and conflicting desired conditions. Many sustainability initiatives thus focus on defining suitable indicators and trends. It is important that these indicators are broadly understood and supported, or the signals they send will be disputed, which may dampen commitment to actions that support sustainability.

Potential Approaches

The simplest option to support sustainability reporting in the Basin would be to identify an existing prototype and encourage its use in the Basin. There have been many sustainability planning approaches developed during the past decade at a range of scales. Many urban communities have embraced sustainability planning (e.g., Calgary, Hamilton, Seattle, Portland), however there are fewer rural-based initiatives, though these have increased in recent years (e.g., Quesnel; Kings County, Nova Scotia, BC Sunshine Coast). A number of approaches have developed, and these continue to evolve. Few have been implemented in any jurisdiction for more than one or two reporting cycles, making it difficult to assess the utility of any one approach in achieving the key goal of prompting action.

The project team examined a number of prototypes to identify the best options. Table 14 lists sustainability planning approaches that appear applicable to the Basin situation. None of these prototypes meets the characteristics and needs of the Basin fully. Testing these options in Basin communities, and perhaps developing an innovative model that meets Basin needs will be needed. Approaches and applications are changing rapidly so regular review of current practices is required to identify promising options.

Table 14. Summary of potential approaches for sustainability planning within the Columbia Basin.

APPROACH	DESCRIPTION	EXAMPLES[8]
Strategic planning	Traditional planning approach with identification of values, vision, objectives, indicators, reporting and action plans	Oregon Progress Board; City of Hamilton, Fraser Basin Council, United Kingdom
Genuine Progress Indicators	Adaptation of GDP accounting to incorporate social and environmental elements.	Alberta (Anielski 2001); GPI Atlantic; Redefining Progress/US locations
Well-Being Assessment	Combines several indicators and data sources into ecological and human well-being indices	World-wide (Prescott-Allen 1997); BC Coast (Coast Information Team 2004)
Genuine Wealth Index	Examines human, social, natural, manufactured and financial wealth to define assets, liabilities and equity, and actions to improve conditions	New approach (Anielski 2004)

Appropriate Geographic Scale for Sustainability Planning

The relatively spread out nature of the Columbia Basin, and its ecological and jurisdictional diversity makes it difficult, if not impossible to implement sustainability planning at the Basin level at this point in time. This scale is also likely too large to effectively prompt action by citizens, governments and organizations. Sustainability planning has been initiated in the Fraser Basin, which has similar challenges regarding geographic scale. In the Fraser Basin, broad-scale sustainability reporting provides some information at the level of the whole Basin, but there are also consistent requests for more detail at the local or regional level. In response, the Council is now

8 Websites provided in references

developing through expansion of its reporting, a project with the Thompson Nicola Regional District and a continuing project with the City of Quesnel (S. Litke, Fraser Basin Council, pers. comm.).

Locally based sustainability planning initiatives offer a more appropriate option than Basin-wide planning. The exact scale would depend on the characteristics of the landscape, communities and administrative jurisdictions in a particular area, and the willingness of organizations and individuals to work together. This scale allows greater involvement by those who will need to take action, and is more appropriate to address ecological and administrative complexities. It is also more consistent with the Trust's commitment to building community capacity.

Boundaries for locally based initiatives will need to incorporate local governments, including First Nations, and the broader provincial landscape, which will be a significant new element for sustainability planning. However, in sustainability planning, rural communities come to recognize that sustainability, and their quality of life and well-being, are greatly affected by the condition and sustainability of the broader landscape, making the need to include the broader landscape obvious. For example, Quesnel's sustainability indicators include measures for protected areas and stream conditions for an endangered species in the local area.

Overlaying local government boundaries with watersheds boundaries to identify feasible geographic units has promise. These units will include a number of local governments in some situations (such as the Trail, Montrose, Rossland area for example), while in others, individual communities and associated regional district areas would be linked with particular groups of watersheds (such as in Revelstoke, Valemont and Golden).

Need for Partnerships

For CBT to independently take leadership in sustainability planning in the Basin would be inconsistent with the organization's mandate, values and available resources. Given the complex jurisdictional situation, partnerships are needed to generate the best planning with limited resources, and to promote ownership and ultimately action by the many jurisdictional entities and interests within the Basin.

Sustainability planning will require resources and expertise beyond the capacity of most organizations within the Basin. In addition, the complex jurisdictional situation will require additional effort to create partnerships to support planning at the recommended scale. Fortunately, there is some interest from funding sources including the federal government and foundations to support rural community-based sustainability planning.

CBT's role in encouraging Basin-wide sustainability planning through locally based initiatives could include:

- fostering and supporting partnerships;
- supporting the development of expertise within the Basin;
- supporting tests and pilots of the possible approaches;
- encouraging local initiatives to incorporate key process elements, and a core list of indicators, such as provided in this report for environmental resources, so measures can be aggregated for Basin-wide reporting, learning, and when appropriate, actions;
- developing information for indicators that is beyond the capacity of local organizations, such as the environmental indicator modelling recommended in this report; and
- disseminating information about local initiatives to prompt learning, and encourage other local areas to begin sustainability planning.

A key challenge to implementing locally based sustainability planning will be to secure provincial government support for the concept, and to provide resources, particularly in terms of data access and analysis. Without this support it may only be possible to implement sustainability planning for settled areas and local government jurisdictions.

Realistic Expectations

Given the challenges to implementing sustainability planning in the Basin, and the need for the Trust to facilitate and support initiatives rather than take leadership, initiatives are likely to proceed at a rather haphazard pace, based on local levels of interest and available resources. It can be expected that it will take at least five years and up to ten years before sustainability planning will be completed for the entire Basin. In the interim, it is feasible and desirable for the Trust to proceed with 'state of' reporting, starting first with environmental conditions based on the recommendations in this report, and building in social and economic conditions over time. This information will be valuable to define priorities for CBT activities and will identify priority geographic areas for localized sustainability planning.

Recommendations

The following recommendations reflect the challenges and possible approaches outlined above, respecting the Trust's mandate and preference to support and facilitate local initiatives. A significant shift in the role the Trust would require a reconsideration of these recommendations.

On an ongoing basis the Trust should continue to:

- maintain a staff responsibility for development of sustainability reporting, and associated planning, with linkages across CBT activities;
- monitor opportunities for partnerships with funding sources and administrative jurisdictions to bring expertise and resources to the development of the sustainability reporting framework; and
- monitor sustainability planning and reporting practices nationally and internationally to identify possible feasible approaches (suggested sites include University of Toronto, Sustainable Measures, International Sustainability Indicators Network, and the Canadian Sustainability Indicators Network).

Figure 4 illustrates the recommended next steps for implementing sustainability reporting in the Columbia Basin.

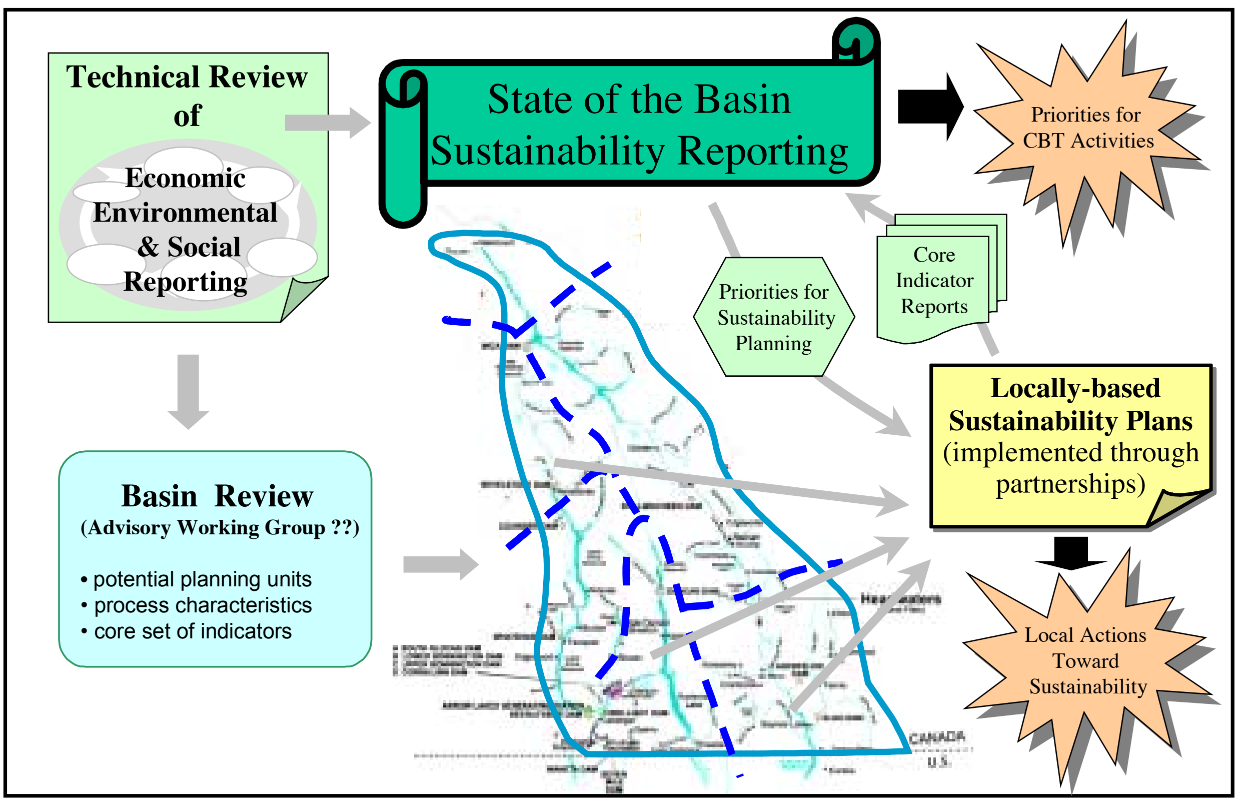

Figure 4. A framework for implementing sustainability reporting and local sustainability planning.

During the next 2-3 years it is recommended that the Trust implement the following key steps:

- **Background reports**: Fund similar background reports on social and economic 'state of ' reporting and indicators to create short-lists of indicators at the Basin level and contribute to the development of process approaches.
- **Local initiative sustainability planning support**: Work with representatives of jurisdictions and interests within the Basin, as well as technical specialists, to identify possible geographic units and a preliminary set of characteristics for effective sustainability planning and reporting, including a short-list of core indicators/ measures to support the implementation of sustainability planning through local initiatives. This could lead to the creation of an Advisory Working Group of partners in Basin sustainability reporting including, for example, provincial government agencies, community representatives, key organizations and technical specialists.
- **Interim State of the Basin reports**: When indicators and measures are defined, issue interim environmental, economic and social "state of the basin" reports based on the short-list of core indicators/ measures. Basin residents should be informed about this initiative to promote learning and discussion about sustainability topics.
- **Local sustainability planning pilots**: Through partnership projects with local governments and other entities, provincial government agencies and funding sources, facilitate and support pilot projects to test alternative approaches to sustainability planning and reporting to better understand the strengths and weaknesses of options in the Basin context, and possibly to develop more appropriate approaches. Include reports from these tests in interim "state of the basin" reports. The planning units would be most influenced by the willingness of organizations and individuals to work together.
- **Capacity building**: Share the learning from these pilots broadly, including providing opportunities for interested individuals to observe the pilot processes and creating web-based and person-to-person forums for information exchange.
- **Updated support**: Based on what is learned from the pilots, and developments in the practice outside the Basin, refine the preliminary characteristics for effective sustainability planning and reporting, including the core set of indicators to support ongoing planning.

Having created a strong foundation based on background research, pilot projects and capacity building, the Trust should maintain a role in sustainability planning and reporting over the longer term by:

- **Continuing to facilitate and support locally based sustainability planning and reporting** throughout the Basin, based on the characteristics defined through the pilots. Where other entities do not take up this function, the Trust should consider taking leadership to create information for Basin-wide sustainability reporting.
- **Publicly report** on movement toward sustainability within the Basin at regular intervals as updated information is available. Retain sub-Basin and community based information as much as possible to maximize local interest and potential for actions.

Conclusions

State of the Environment and Sustainability Reporting are large, but important initiatives to undertake in the Columbia Basin. In this report, we have provided a summary of recommended core indicators and measures that will provide an overview of the condition of the biophysical environment in the Basin. We have also outlined a process for initiating locally and regionally based sustainability planning and reporting initiatives.

The environmental indicators and measures prioritised for initial SoE reporting are provided in the Summary Action Plan and in Part III of this report. These indicators are consistent with effective approaches to characterising environmental conditions in other jurisdictions around the world. They are based on divisions of the environment into biophysical realms such as Terrestrial Systems, Aquatic Systems, and Atmospheric Systems, as well as larger Regional and Global Systems. Non-technical background information on each recommended core indicator and measure is provided in Appendix 2. Potential data sources for the actual measures are presented in Appendix 3.

REFERENCES

Anielski, M. 2001. The Alberta GPI Blueprint: The Genuine Progress Indicator (GPI) sustainable well-being accounting system. The Pembina Institute, Drayton Valley, Alberta. 119p. Available at: http://www.pembina.org/

Anielski, M. and M. Winfield. 2002. A conceptual framework for monitoring municipal and community sustainability in Canada. Prepared for Environment Canada. 130p. Available at www.anielski.com

Anielski, M. 2004. Genuine Wealth Accounting – Measuring Sustainability of Communities. Available at: Anielski.com

Beasely B., and P. Wright. 2001. Criteria and Indicators briefing paper. Unpublished report prepared for the North Coast LRMP, for MSRM.

British Columbia Ministry of Water, Land and Air Protection. 2002. Environmental Trends in British Columbia 2002. State of the Environment Office, Victoria, BC. 64 p. Available at http://wlapwww.gov.bc.ca/soerpt/

Bunnell, F. 1995. Forest-dwelling vertebrate faunas and natural fire regimes in British Columbia: patterns and implications for conservation. Conservation Biology 9: 636-644.

Canada-United States Working Group on Environmental Indicators. 2002. Georgia Basin-Puget Sound Ecosystem Indicator Report. Available at: http://wlapwww.gov.bc.ca/cppl/gbpsei/overview/index.html

Canadian Standards Association Sustainable Forest Management Program. http://www.csa.ca

Canadian Sustainability Indicators Network. http://www.ec.gc.ca/soer-ree/English/csin/default.cfm

Centre for Community Enterprise. 2002. BC Benchmark & Indicator Activities & Lessons. Prepared for Prince George CDI conference.

Cissel, J.H., F.J. Swanson, G.E. Grant, D.H. Olson, S.V. Gregory, S.L. Garman, L.R. Ashkenas, M.G. Hunter, J.A. Kertis, J.H. Mayo, M.D. McSwain, S.G. Swetland, K.A. Swindle and D.O. Wallin. 1998. A landscape plan based on historical fire regimes for a managed forest ecosystem: the Augusta Creek study. USDA FS PNW-GTR-422.

City of Hamilton. Vision 2020. Available at: http://www.vision2020.hamilton.ca/default.asp

City of Revelstoke. 2003. Revelstoke Community Environmental Strategy. Produced by Future Legacy Consulting Group.

Coast Information Team, Well-Being Assessment of North and Central Coast BC. Available at: http://www.citbc.org

Colman, R. 1998. Measuring Sustainable Development: The Nova Scotia Genuine Progress Index: Framework, Indicators and Methodologies. GPI Atlantic, Halifax, Nova Scotia.106 p. Available at www.gpiatlantic.com

Denisov, N., L. Hislop, P. Rekacewicz and O. Simonett. 1998. Cookbook for State of the Environment reporting on the internet. UNEP/GRID-Arendal, Arendal, Norway. 32 pp. Available at: http://www.grida.no/soe/cookbook/

Environment Canada. 2003-2004. State of the Environment Infobase – Introduction and Environmental Signals. Part of Canada's National Environmental Indicator Series. Available at: http://www.ec.gc.ca/soer-ree/English/Indicator_series/default.cfm

Environment Canada. Pacific and Yukon Region Environmental Indicators Project. http://www.ecoinfo.org/env_ind/indicators_e.cfm

Environmental Protection Agency. 2002. Framework for Assessing and Reporting on Ecological Condition, June 2002. Produced by the Science Advisory Board. Available at: http://www.epa.gov/indicators/

Federation of Canadian Municipalities. Quality of life reporting system. http://www.fcm.ca/qol3/

Forest Stewardship Council British Columbia. http://www.fsc-bc.org/

Fraser Basin Council. 2003. State of the Fraser Basin report: A snapshot on sustainability. Fraser Basin Council, Vancouver, BC. 24 pp. Available at: http://www.fraserBasin.bc.ca/publications/documents/2003-SnapshotRpt.pdf

Gilkeson, L. 2003. State of environment reporting: past, present and future. Prepared by the head of State of the Environment Reporting in British Columbia for the Ministry of Water, Land and Air Protection, Victoria, BC. 23p.

GPI Atlantic. Community GPI. http://www.gpiatlantic.org/community.shtml

Hann, W., J. Jones, M. Karl and others. 1997. An assessment of landscape dynamics of the basin. Vol 2, Chapter 3 in: Quigley, T. and S. Arbelbide, tech. eds. 1997. An assessment of ecosystem components in the Interior Columbia Basin and portions of the Klamath and Great Basins. USDA FS PNW GTR-405.

Holling, C. and G. Meffe. 1996. Command and control and the pathology of natural resource management. Conservation Biology 10(2):328-337.

Institute for Research and Innovation in Sustainability, York University. The Sustainability Report. http://www.sustreport.org/
Interior Columbia Basin Ecosystem Management Program. http://www.icbemp.gov/
International Institute for Sustainable Development. Winnipeg, Manitoba. http://www.iisd.org/
International Sustainability Indicators Network. http://www.sustainabilityindicators.org/index.html
John Heinz III Center for Science, Economics and the Environment. 2002. The State of the Nations' Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. Cambridge University Press, NY. 226 pp. http://www.heinzctr.org/ecosystems/report.html
Landres, P.B., P. Morgan and F.J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9(4):1179-1188.
Maclaren, V.W. 1996. Developing Indicators of Urban Sustainability: A Focus on the Canadian Experience. ICURR Press, Toronto. 130pp.
Maser, C. 2003. The real value of healthy forests. Distant Thunder – Journal of the Forest Stewards Guild. 16:1-9.
Millar, C.I. and W.B. Woolfenden. 1999. The role of climate change in interpreting historical variability. Ecological Applications 9(4):1207-1216.
Ministry of Environment Lands and Parks. 2000. Environment Risk Assessment: An Approach for Assessing and Reporting Environmental Conditions. Habitat Branch, MELP. Available at: (website)
Morgan, P., G.H. Alpet, J.B. Haufler, H.C. Humphries, M.M. Moore, W.D. Wilson. 1994. Historical role of variability: a useful tool for evaluating ecosystem change. Journal of Sustainable Forestry 2(1/2):87-111.
National Round Table on Environment and Economy. http://www.nrtee-trnee.ca/
Oregon Progress Board. 2003. Is Oregon making progress? The 2003 benchmark performance report. Salem, Oregon. 70p. Available at http://www.econ.state.or.us/opb/sitemap.htm
Organisation for Economic Cooperation and Development (OECD). http://www.oecd.org
Pinter, L., D.R. Cressman, K. Zahedi. 1999. Capacity building for Integrated Environmental Assessment and Reporting Training Manual. International Institute for Sustainable Development, Winnipeg, Canada, and the United Nations Environment Program, Nairobi, Kenya. 144 pp. Available at: http://www.iisd.org/publications/publication.asp?pno=310
Prescott-Allen, R. 1997. Barometer of Sustainability: Measuring and communicating well-being and sustainable development. Vol. 2 in An Approach to Assessing Progress Toward Sustainability Tools and Training Series, IUCN. 32p.
Prescott-Allen, R. 2001. The Wellbeing of Nations – A Country-by-Country Index of Quality of Life and the Environment. Island Press. Washington, DC.
Pretorious, R., E. Muller, A. Balance. 2002. The South African guide to producing a State of the Environment Report. Department of Environmental Affairs and Tourism, Pretoria, South Africa. Available at: < http://www.environment.gov.za/soer/resource/soeguide/index.htm>
Price, L. 2004. Spatial Analysis in the Nelson Forest Region. Unpubl. powerpoint presentation presented at Spatial Forecasting Workshop, Selkirk College, February 19, 2004. BC MSRM. Kamloops, BC.
Quesnel Community Indicators Project Team. 2002. Quesnel State of our Community. Moving sustainability forward.
Quigley. T.M. and S.J. Arbelbide. 1997. An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins, Vol. 1. USDA FS PNW-GTR-405.
Redefining Progress. 2001. The US Genuine Progress Indicator 2000. Oakland, California. Available at: http://www.rprogress.org/projects/gpi/
Redefining Progress. http://www.rprogress.org/
Rogeau, M. 1996. Understanding Age-class Distributions in the Southern Canadian Rockies. Unpubl., PhD. Thesis. Univ. of Alberta. Edmonton, Alberta.
State of the Environment Australia. http://www.deh.gov.au/soe/
State of the Environment New Zealand. http://www.environment.govt.nz/reports/
State of the Environment Norway. http://www.environment.no/
Steeger, C. 2004. Columbia Basin Database of Wildlife-Habitat Relationships – Version 2003 – Species Mapping and Web Site Development. Unpubl. report for Columbia Basin Trust, Golden, BC.
Steeger, C., J. Dulisse, and M.M. Machmer. 2001. Wildlife-habitat relationships in the Columbia River Basin: a British Columbia database for terrestrial vertebrate species. Unpublished Report, Research and Forest Practices Branch, B.C. Min. of Forests, Victoria, B.C. 50 p.
Sustainable Calgary: State of the City Report 2001. http://www.sustainablecalgary.ca/projects/sooc/

Sustainable Communities Indicator Program. http://www.ec.gc.ca/soer-ree/English/Scip/default.cfm
Sustainable Development UK. http://www.sustainable-development.gov.uk/indicators/index.htm
Sustainable Measures. www.sustainablemeasures.com/
Swanson, F.J., J.A. Jones, D.O. Wallin, and J.H. Cissel. 1994. Natural variability – implications for ecosystem management. Pages 80-94. in M.E. Jensen and P.S. Bourgeron, eds. Eastside forest ecosystem health management. Volume II: Ecosystem management: principles and applications. USDA FS PNW GTR 318.
Tarzia, V. (Ed). 2003. European Common Indicators: Towards a local sustainability profile. Ambiante Italia Research Institute, Milano, Italy. 211p. Available at http://www.ceroi.net/
UN Committee on Sustainable Development. Indicators of Sustainable Development. Available at: http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm
United Kingdom Government. 2000. Local quality of life counts. Available at: http://www.sustainable-development.gov.uk/index.htm
United States Department of Agriculture, Forest Service. 1996. Status of the Interior Columbia Basin: summary of scientific findings. USDA-PNW-GTR-385. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. USA. 144pp. or on the web: http://www.icbemp.gov/
University of Toronto. Local level state of the environment and state of community reporting in Canada. http://www.geog.utoronto.ca/CommunityReporting/index.htm
Utzig, G. 2003. The range of natural variability: a literature compilation applicable to the East Kootenays. Unpl. Rpt. for Tembec Industries Ltd. by Kutenai Nature Investigations Ltd. Nelson, BC. 35 pp. and database.
Utzig, G. and R.F. Holt. 2002. Environmental Trends: Assessing the Environmental Effectiveness of the Kootenay Boundary Land Use Plan Higher Level Plan Order in TFL 14. Prepared for MSRM.
Wackernagel, M. and W.E. Rees. 1996. Our ecological footprint: Reducing human impact on the earth. New Society Publishers, Gabriola Island, BC.
Walker, B. 1995. "Conserving Biological Diversity through Ecosystem Resilience," Conservation Biology 9(4):747-752.
Washington State Department of Ecology. 2000. Washington's Environmental Health 2000. Olympia, Washington. Available at: http://www.ecy.wa.gov/pubs/0001003/index.html#n
Wilson, S, C. Steeger, D. Hamilton. 2002. Habitat Supply Modelling – TFL 14 Pilot Project. Unpubl. Rpt. for BC MWLAP, Victoria, BC and Tembec Industries Ltd., Cranbrook, BC.
Wilson, S, C. Steeger, D. Hamilton. 2003. Habitat Supply Modelling for the Arrow Timber Supply Area. Unpubl. Rpt. for BC MWLAP, Victoria, BC and Arrow Forest Licensee Group, Slocan, BC.
World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press. Oxford, UK. 400pp.
World Wide Fund for Nature. 2003. The Nature Audit: Setting Canada's conservation agenda for the 21st Century. Available at: http://www.wwf.ca/AboutWWF/WhatWeDo/TheNatureAudit/TheNatureAudit.asp

Appendix 1. List of acronyms used in this report.

ACRONYM	FULL NAME
BEC	Biogeoclimatic Ecosystem Classification
CBFWCP	Columbia Basin Fish and Wildlife Compensation Program
CBT	Columbia Basin Trust
CDC	Conservation Data Centre
CEROI	Cities Environment Reports On the Internet (UNEP)
CFS	Canadian Forest Service
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSA	Canadian Standards Association
CWD	Coarse Woody Debris
DPSIR	Driving Force-Pressure-State-Impact-Response
EC	Environment Canada
ECA	Equivalent Clearcut Area
EMAN	Ecological Monitoring and Assessment Network
EPA	US Environmental Protection Agency
FSC	Forest Stewardship Council
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographic Information System
GMOs	Genetically Modified Organisms
GPI	Genuine Progress Indicator
IISD	International Institute for Sustainable Development
IUCN	International Union for the Conservation of Nature
LU	Landscape Unit
MAFF	Ministry of Agriculture, Food and Fisheries

ACRONYM	FULL NAME
MOF	Ministry of Forests
MoH	Ministry of Health
MoTH	Ministry of Transportation and Highways
MSRM	Ministry of Sustainable Resource Management
MWLAP	Ministry of Water, Land and Air Protection
NPRI	National Pollution Release Inventory
NRTEE	National Round Table on Environment and Economy
OECD	Organisation for Economic Cooperation and Development
PEM	Predictive Ecosystem Mapping; ssPEM: small scale PEM
PFC	Pacific Forestry Centre
PM10	Particulate Matter <10 microns in diameter
P-S-R	Pressure-State-Response
RONV	Range of Natural Variability
SoE	State of the Environment
SoER	State of the Environment Report
spp	Species
TEM	Terrestrial Ecosystem Mapping; ssTEM: small scale TEM
TSR	Timber Supply Review
UNCSD	United Nations Committee on Sustainable Development
UNEP	United Nations Environment Program
UV	Ultra Violet radiation
WWF	World Wide Fund for Nature

Appendix 2. Detailed descriptions of the priority subset of indicators and measures recommended for the first CBT State of the Environment reporting cycle.

Columbia Basin Terrestrial Systems

COMPONENT: Landscape level terrestrial processes and functions

INDICATOR: Deviation from "natural" disturbance regimes

MEASURE T-1.2: Extent of ecosystems (forests and grasslands) with seral stage distributions altered from estimated RONV

Seral stage distributions reflect the ages and developmental stages of grassland and forested ecosystems within the Basin. In many forested and grassland ecosystems, seral stage distributions are not consistent with the range of natural variation for that ecosystem. Assessing seral stages in relation to RONV provides an important indication of the deviation from natural disturbance regimes at a landscape level.

This measure includes issues such as the amount of young, mature and old forest, as well as the proportion of unaltered native grasslands. Assessments should be done at the scale of Homogenous Natural Disturbance Units, BEC units, and/or Ecosections and should focus on past, present and projected future conditions.

This measure has far reaching impacts and can be assessed at a moderate cost since considerable data is available through projects such as spatial timber supply analyses (by MoF, MSRM and industry).

COMPONENT: Terrestrial Ecosystems and Communities

INDICATOR: Degree of divergence from "natural" community diversity, structure and productivity

MEASURE T-3.4: Number of red- and blue-listed ecosystems

The BC Conservation Data Centre (MSRM) maintains lists of red- and blue-listed ecosystems by plant community. Listed ecosystems should be monitored by ecosystem type (e.g., forest, grassland, alpine), as well as by Ecosection, BEC unit, BEC x Ecosection and by site series or groups of site series. Parameters to assess within this measure include new listings, the shift between blue and red classifications, reasons for listing, etc. This measure can be assessed with reasonable accuracy at a low cost.

It is important to note that the CDC listings are an indication of endangered ecosystems, but they should be interpreted as an estimate rather than an exact measure.

MEASURE T-3.5: Frequency and distribution of exotic and invasive species (including plants, vertebrates and invertebrates)

Detrimental impacts from invasive species include predation and habitat alteration as well as competition with native species. It is not possible to monitor the spread, impact and location of all invasive species, but the Provincial Weed Coordinators, the MoF, MoTH and other ministries monitor those species with considerable impacts or risks to native species. In addition, the BC Ministry of Agriculture, Food and Fisheries maintains a considerable listing of invasive plants, insects and diseases.
http://www.agf.gov.bc.ca/cropprot/nonnativepests.htm

The impact of invasive species should be assessed on the basis of individual species (where available) and their impact on specific ecosystem types and/or BEC units and Ecosections. As a start, SoE reporting could focus on species where inventories are available to reduce costs. Over time, additional species could be added or assessed.

INDICATOR: Extent and degree ecosystem integrity

MEASURE T-4.1: Estimated index of ecosystem integrity based on ecosystem alteration factors such as landuse designations and associated management regimes (e.g., protected areas, forest mgmt. standards, designated non-contributing forest, agriculture, urban/rural, flooded, etc.)

Measuring land use designations and associated management regimes will provide a surrogate for the level of ecosystem disruption within the Columbia Basin. This measure is intended to assess land use designations using an indexed scale of impacts. For example, protected areas, if managed for 'wilderness' values, will have a low level of disruption, while intensively managed forests and agricultural lands will have a higher level, and urban and flooded areas will have an extreme level of disturbance. The results of this measure could be a series of maps showing actual land use designations as well as the 'index of human-caused ecosystem disruption and disturbance' using levels such as low, moderate, high and very high. Knowing land use designations also has high predictive value for estimating future impacts on ecosystems and communities within the Basin.

This measure will provide high predictability and is related to several other measures. Although it involves a modelling exercise, it can be assessed at a moderate cost.

COMPONENT: Terrestrial Species and Populations

INDICATOR: Viability of native species and populations

MEASURE T-5.1: Inventoried changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species

Focus on Mountain Caribou for initial SoE reporting period.

While it would be ideal to assess the actual levels of populations of all species, it is more feasible to analyse vulnerable, sensitive, keystone, umbrella or otherwise representative native species. A key element of this strategy is selecting species that are either critical or representative of other populations. For example, keystone species are those species that have a disproportionately large impact on ecosystem processes as compared to their size or distribution. Alternatively, focusing conservation efforts on an 'umbrella species' is intended to also protect lesser-known species with similar habitat requirements.

Assessing individual species or groups of species is a very large task. For the first phase of SoE reporting in the Columbia Basin, we recommend a focus on Mountain Caribou. Caribou are a red-listed species that have received considerable research and management attention recently. They are vulnerable, sensitive and in may act as an umbrella species for other old growth obligates. Reliable caribou population data are available and could be analysed at a reasonably low cost.

As application of this measure expands to other species in subsequent SoE reports, it could include inventoried population measures as well as estimated population measures derived from modelling.

MEASURE T-5.5: Number of threatened, endangered and recently extinct or extirpated species

The BC Conservation Data Centre (MSRM) maintains lists of red- and blue-listed species within British Columbia. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the International Union for the Conservation of Nature (IUCN) also list the status of species at national and international levels. The status of endangered species is intended to reflect the loss of species in an ecosystem or area and is likely a very reliable measure for large conspicuous species, but may not reflect smaller, less known groups. This measure should be used to monitor the number of species listed at the scale of BEC units, Ecosections and ecosystem types, as well as by major species group (e.g., reptiles, mammals, snails, arachnids, dicots, etc). Assessments and reporting can be conducted at a low cost.

COMPONENT: Terrestrial Habitat Elements at the Stand and Site Level

INDICATOR: Changes in abundance and/or distribution of habitat elements

MEASURE T-6.1: Estimated extent of areas where habitat elements are intact, or changed from their “natural condition (including degree of change)

Focus on the type, frequency and distribution of snags within the Columbia Basin for the initial SoE report.

This measure is intended to assess specific habitat elements and their status within the Columbia Basin. In the initial stage of SoE reporting, we recommend focusing on the type, distribution and frequency of snags. Snags, or standing dead trees, provide habitat for a wide range of plant, vertebrate and invertebrate species including woodpeckers, beetles, wolverine, bears, and lichens. Snags should be assessed by BEC unit, Landscape Unit, Ecosection, site series or groups of site series. This will include a modelling exercise that can be related to the ecosystem integrity index and landuse mapping outlined above in T-4.1.

We recommend snags as a preliminary habitat element of concern because snags are important to numerous species, have been studied considerably within the Columbia Basin and surrounding environs and could be assessed at a moderate cost. Similar analyses have already been conducted using spatial timber supply models in some parts of the Basin.

COMPONENT: Soils

INDICATOR: Extent and degree of soil degradation

MEASURE T-7.1: Estimated area of soils where changes in soil properties are sufficient to negatively affect productivity (including compaction, displacement and contamination)

Changes in soil productivity fundamentally impact biological, physical and economic realms. This measure will evaluate the extent of soil changes and can be modeled in concert with the ecosystem integrity index measure outlined above (T-4.1). Representative detrimental soil survey data, contaminated site information, and agricultural and forestry data could also be used to assess this measure. Evaluations should be done at the scale of broad soil types, terrain types, BEC units, and landscape units.

We predict assessment will require moderate costs and will have predictive value for this measure as well as a range of others. A similar assessment was completed at the provincial level in the 1990s.

Columbia Basin Aquatic Systems

COMPONENT: Flow Regimes

INDICATOR: Degree of divergence from "natural" flow regimes

MEASURE Aq-1.2: Number and location of structures that divert, obstruct or alter flow regimes, including area flooded/affected (e.g., large dams, water intakes, micro-hydro)

Dams have played a critical role in altering the flow regime along the Columbia River and its tributaries. For example, there are three dams on the mainstem of the Columbia River within BC, 12 dams within the Kootenay River basin (in Canada and the US) and numerous smaller and medium sized dams, micro-hydro systems, water intakes and other structures that divert, obstruct and alter flow regimes.

This measure is also intended to reflect the area of land affected by dams and other structures (e.g., the area flooded behind large dams). Dams and other obstructions have changed the timing and volume of flow within waterways, and have often permanently altered associated terrestrial and riparian habitats.

Data from this measure can be used in the larger modelling exercises encompassing landuse and land management, water quality, and ecosystem/ community measures. Assessing the actual structures associated with flow regime alterations will require low to moderate costs, mainly for data acquisition and compilation.

MEASURE Aq-1.3: Ratio of the length of river/stream reach without flow alteration (dams, locks, canals, etc) in relation to the total river length

With a long history of diversions and obstructions, few 'natural' segments of the Columbia Basin's main waterways still exist. This measure will assess the portions of unaltered rivers in relation to the sections altered and should be assessed at the scale of individual streams, rivers or reaches. This measure can be assessed with moderate costs and can be linked to larger modelling exercises evaluating land use and watershed condition.

INDICATOR: Extent and degree of watershed integrity

MEASURE Aq-2.1: Estimated watershed integrity index, based on watershed alterations that affect flow regimes: road density, weighted ECA, reservoir flooding, flow obstructions, water diversions, etc

This measure assesses the integrity of watersheds on the basis of the potential alterations to flow regimes and is based on an examination of current human-impacts. Impacts include water diversions and obstructions, but also focus on activities such as road density and urban/rural development.

Costs should be moderate for this measure, as it can utilize a modified version of the landuse database assembled for various terrestrial measures (e.g., T-4.1). However, it may be desirable to begin modelling with pilot assessments in key watersheds. Data used and produced in this measure will also apply to the larger aquatic modelling exercise described below.

COMPONENT: Water Quality

INDICATOR: Extent of pollutants and/or pollution sources

MEASURE Aq-4.1: Total recorded discharges of pollutants to water bodies (permitted, non-permitted, toxic sites, spills)

Pollution in watercourses has a significant impact on water quality. Point-source pollutants come from a variety of sources such as sewage outflows, industrial sites and storm drains and include a range of pollution types. Point source pollution is monitored by the BC MWLAP and the National Pollutant Release Inventory (NPRI) program of Environment Canada through a permit system. Non-permitted releases also occur and are harder to measure accurately across the Basin. For some sources such as known spills, toxic sites, abandoned mines, etc, estimates could be developed or modeled although further research is required to determine information sources and data needs for non-permit and non-point source pollution.

Measures of pollutants could be assessed on the basis of source type, pollutant, or an aggregate for all pollutants in a watershed, hydrologic feature or stream reach, and would require moderate costs.

Tracking pollution is important in assessing toxic substances within the Columbia Basin, and could be used in conjunction with the overall landuse mapping and modelling discussed in relation to several other measures.

INDICATOR: Location and extent sediment/ pollution sources

MEASURE Aq-5.2: Composite water quality index based on watershed condition factors: presence of potential sediment sources and other sources for chemical and biological pollution

Changes to water quality include impacts on human health as well as ecosystem integrity. This measure takes an indirect approach and uses an index of potential impacts on water quality based on landuse and land management mapping, actual pollution and toxic site reporting, natural and management-related erosion hazard, and other sediment and pollution sources with point- and non-point origins. Modelling will be required to evaluate this measure, and should be linked to the assessments for assessing watershed integrity, as well as terrestrial and aquatic ecosystem integrity (T-4.1, Aq-2.1 and Aq-7.1).

Data used and produced in this measure will require moderate costs, but will also be linked to the other aquatic and terrestrial modelling exercises.

COMPONENT: Aquatic Ecosystems and Communities (including riparian)

INDICATOR: Degree of divergence from "natural" community diversity, structure and productivity

MEASURE Aq-6.4: Frequency and distribution of exotic and invasive species (including fish, plants, and other taxa)

Detrimental impacts from invasive species include predation, habitat alteration and out-competing native species. It is not possible to monitor the spread, impact and location of all invasive species, but the BC Ministry of Agriculture, Food and Fisheries maintains a considerable listing of invasive plants, insects and diseases (http://www.agf.gov.bc.ca/cropprot/nonnativepests.htm).

Species inventories, control records and estimated distributions could be used to assess the impacts of exotic and invasive species. This could include assessments of the Mysid shrimp, as well as trout species introduced into mountain lakes for sport fishing, purple loosestrife spread, etc. The impact of invasive species should be assessed on the basis of individual species (where available) and their impact on specific ecosystem types and/or hydrologic units or stream reaches.

Exotic species can be evaluated at a reasonably low cost.

INDICATOR: Extent and degree of aquatic ecosystem integrity

MEASURE Aq-7.1: Index of aquatic ecosystem integrity based on watershed condition, flow disruptions, channel alterations etc. (e.g., dams, diversions, infilling, flood control, riparian development, watershed landuse designations and mgmt. regimes)

This indicator should be developed to monitor and assess changes across aquatic systems. It is a composite of many activities including alterations to flow regimes, land use designations and management regimes that will provide a surrogate for the level of aquatic ecosystem disruption within the Columbia Basin. It could be assessed similar to the terrestrial ecosystem integrity measure described above (T-4.1).

Knowing land use designations also has high predictive value for estimating future impacts on ecosystems and communities within the Basin. Data used and produced in this measure will also apply to the other aquatic modelling exercises described above (Aq-2.1, Aq-5.2).

Modelling costs may be moderate to high for this measure, but will address multiple issues and would be available for updating in future SoE reports.

COMPONENT: Aquatic Species

INDICATOR: Viability of native species and populations

MEASURE Aq-8.1: Inventoried changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species

Focus on sturgeon for the first SoE reporting period.

Assessing individual species or groups of species is a very large task and it is generally more feasible to analyse vulnerable, sensitive, keystone, umbrella or otherwise representative native species. The keystone species concept refers to those species that have a disproportionately large impact on ecosystem processes as compared to their size or distribution. The umbrella species concept refers to protection of habitats for wide-ranging species with the intent that lesser-known species and those species with similar but narrower habitat needs will also be protected.

For the first phase of SoE reporting in the Columbia Basin, we recommend focusing on sturgeon. Sturgeon have been widely studied in the Basin by provincial and federal government agencies as well as private industry and their population dynamics could be assessed at a moderate or low cost. Many of the impacts on sturgeon also relate to issues associated with dams on the Columbia and Kootenay rivers.

In subsequent SoE reporting phases, other plant, vertebrate or invertebrate species could be assessed or monitored in addition to sturgeon.

MEASURE Aq-8.5: Number of threatened, endangered and recently extinct or extirpated species

The Conservation Data Centre of the MSRM maintains lists of red- and blue-listed species within British Columbia. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the International Union for the Conservation of Nature (IUCN) also list the status of species at national and international levels.

The status of endangered species is intended to reflect the loss of species in an ecosystem or area and is likely a very reliable measure for large conspicuous species, but may not reflect smaller, lesser-known groups.

This measure should be used to monitor the number of species listed at each level. Assessments should be made at the scale of watershed units, as well as by major species group (e.g., reptiles, mammals, snails, arachnids, dicots, etc). Costs for this measure will be low.

COMPONENT: Aquatic Habitat Elements

INDICATOR: Changes in abundance and/or distribution of habitat elements

MEASURE Aq-9.1: Estimated extent of areas where habitat elements are intact, or changed from their 'natural' condition (including degree of change)

Focus on adfluvial fish spawning grounds for the initial SoE reporting phase.

This measure is intended to assess specific habitats and their status within the Columbia Basin. In the initial stage of SoE reporting, we recommend focusing on the distribution and quality of adfluvial fish spawning grounds. Adfluvial refers to the migration from lakes to streams and applies to many fish species in the Columbia Basin such as kokanee, Gerard trout, etc. An assessment of spawning grounds provides links between terrestrial, riparian and aquatic habitats and could be evaluated at the scale of individual hydrologic features, streams, river systems or stream reaches. This indicator can be reasonable accurately assessed at moderate cost.

In future reports, other habitat elements such as the availability of large woody debris in streams, seasonal habitats, etc could be assessed.

Atmosphere

COMPONENT: Atmospheric Composition and Air Quality

INDICATOR: Air quality and atmospheric composition

MEASURE A-1.2: Summary of particulate matter concentrations, by season and by estimated source apportionment (home wood burning, slash/agriculture, non-point sources)

Fine particulates are released into the environment naturally from dust and smoke as well as from human activities such as industry, vehicles, etc. Particulate matter, PM10, is generally defined to include particles less than or equal to 10 micrometers in diameter. Fine particles, 2.5 micrometers or less, are also monitored and addressed in many studies, and are considered to pose the greatest risk to human health (see BC SoE 2002). Within the Columbia Basin, particulate matter is monitored by the MWLAP, Nelson Regional office for Nelson, Castlegar, Trail, Radium, Slocan, Golden, Cranbrook, Creston, and Revelstoke, and by the Prince George MWLAP office in Valemount. The BC SoE reporting framework summarizes particulate matter and it may be possible to use cooperative data sources.

This measure should assess particulate matter concentrations by season and by source. The source of particulates will have to be determined from known (permitted) discharge sites as well as estimates from sources such as home wood burning, slash and agriculture burning, and non-point sources. Apportioning sources will require additional effort and cost, but provides an indication of where it may be possible to make reductions in output.

MEASURE A-1.3: # of days/yr when particulate matter exceeds specified values

The health standard for particulate matter is 25ug/m^3 and human health impacts begin to occur once concentrations exceed this level. This measure should assess the number of days that each monitored community exceeds the health standard. Reporting could be further refined to summarize timing, by season, for high particulate matter concentrations.

This measure can be assessed at a reasonably low cost for communities where particulate matter is monitored.

Regional and Global Systems

COMPONENT: Climate Systems

INDICATOR: Changes to climate

MEASURE G-1.2: Predicted changes in temperature and precipitation

Climate change is arguably one of the most important challenges facing society in the 21st century. Numerous modelling exercises have been conducted to predict conditions around the globe. For this measure, we recommend SoE reporting in the Columbia Basin focus on predicted changes in the mean, minimum, and maximum temperatures and precipitation levels, discerning between rainfall and snowfall, within the region as well as within individual BEC units.

This evaluation should include a summary of changes to date, based on historic weather and climate station data. Predicted changes should be based on the most widely used climate models, and, because there are differences in model outputs, may require reporting of multiple modelling predictions to show the range of expected conditions within the Basin.

Climate change is a very serious issue with far reaching impacts on all other measures. Although predictions require the use of models, this measure should be assessed at a reasonably low cost, as other agencies are already doing the modelling.

INDICATOR: Impacts of climate change on terrestrial communities

MEASURE: Predicted changes in BEC zonation, disturbance processes (including fire)

The impacts of climate change are expected to be far reaching. For this measure, we recommend an analysis of predicted changes to ecosystems and natural disturbance processes. In particular, an assessment of predicted changes in vegetation zones (BEC units) would provide a context for potential changes in many other realms and measures. A scientifically robust assessment of this measure may involve considerable analysis, modelling and cost, but its utility in predicting future conditions and providing managers, decision makers and citizens with useful information is high. Fortunately, other agencies are already covering a major portion of the costs by completing the climate modelling.

Researchers at the Canadian Forest Service - Pacific Forestry Centre have initiated this type of research and there is potential for collaboration.

Appendix 3. Comprehensive list of indicators and measures with associated information/ analysis requirements, estimated significance and potential data sources.

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
Columbia Basin Terrestrial Systems												
Landscape Level Terrestrial Processes and Functions	T-1	Deviation from 'natural disturbance regimes'	T-1.1	Extent of area with altered fire regimes, based on condition classes (i.e. number of missed fire cycles)	S	Homogenous Natural Disturbance Units; BECs; Ecosections	Natural disturbance regimes; present condition (forest cover)	Available but multiple sources	Some modeling/ analysis	High	High	CFS-PFC, MSRM, MoF, Forest Industry
			T-1.2	Extent of ecosystems (forests and grasslands) with altered seral stage distributions (altered from estimated RONV)	S	Homogenous Natural Disturbance Units; BECs; Ecosections	Seral stage distributions - past, present & projected future	Available but multiple sources	Data compilation/ moderate analysis	High	High	Forest cover and PEM/TEM: MSRM, MoF, Forest Industry
			T-1.3	Percent of fire-maintained ecosystems in need of restoration	S	Fire maintained ecosystems; BECs	Estimates of fire-maintained ecosystem distribution	Unknown	Data compilation/ moderate analysis	Low	Very Low	Potential: MoF, MSRM, Ember Project; Forest Industry
			T-1.4	Percent of fire-maintained ecosystems that have been restored	R	Fire maintained ecosystems; BECs	same as above	Unknown	Data compilation/ moderate analysis	Very Low	Very Low	same as above
			T-1.5	Area with altered insect outbreak distributions, frequencies and risks	S	Homogenous Natural Disturbance Units; BECs; Ecosections	Historic, current and predicted insect data	Unknown	Significant analysis/ model development	Moderate	Very Low	FIDS/ Aerial overviews; CFS-PFC National Forest Health and Biodiversity Dbase; modeling projects

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
			T-1.6	Area with altered distributions, frequencies and risks of other disturbance factors (e.g. disease, windthrow, landslides)	S	Homogenous Natural Disturbance Units; BECs; Ecosections	Unknown	Unknown	Significant analysis/ model development	Low	Low	Unknown
	T-2	Changes in landscape level habitats	T-2.1	Changes in patch-size distribution (including analysis of edge and interior habitat, fragmentation and connectivity)	S	Homogenous Natural Disturbance Units; BECs; Ecosections	Forest cover, land use designations, mgmt. regimes for each designation, roads and linear developments	Available but multiple sources	Some modeling/ analysis	Moderate	Moderate	MSRM, MoF, Forest Industry
Terrestrial Ecosystems	T-3	Degree of divergence from "natural" community diversity, structure and productivity	T-3.1	Inventoried/ monitored changes in the diversity of native species within specific ecosystems - plants, mammals, birds and invertebrates	S	Individual ecosystem types, site series and/or groups	Actual species inventory data	Availability is limited for most ecosystems	Significant analysis/ model development	High	Very Low	MWLAP, CBFWCP, MSRM, COSEWIC, CDC
			T-3.2	Estimated changes in the diversity of native species within specific ecosystems, based on modeled changes in species diversity (see below for individual spp./ populations)	S	BEC x Ecosection; ecosystem type; site series/ groups of site series	Forest cover data, predicted mgmt regimes, species accounts, HSIs, adaptation of habitat/ population models	Base data generally available, but multiple sources	Significant analysis/ model development	High	High	CBT Habitat project, MWLAP, CBFWCP, MSRM, Ecosystem Diagnosis and Treatment tool / Multi-species framework approach for the Columbia River Basin

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
			T-3.3	Extent of intact or unmodified (i.e. fully functioning) ecosystems	S	BEC x Ecosection; ecosystem type; site series/ groups of site series	Ecosystem and species inventory data	Very limited data availability	Data compilation/ moderate analysis	Very High	Moderate	MSRM, MoF, Forest Industry, CBFWCP
			T-3.4	Number of red- and blue-listed ecosystems	S	BEC x Ecosection; ecosystem type; site series/ groups of site series	Listed ecosystems and their historic distributions	Readily available	Basic data acquisition/ compilation	High	Low	CDC and COSEWIC
			T-3.5	Frequency and distribution of exotic and invasive species (including plants, vertebrates and invertebrates)	S	BEC x Ecosection; ecosystem type; site series/ groups of site series	Species inventories, control records, estimated distributions	Limited to major species and mapped information may be limited	Data compilation/ moderate analysis	High	Low	Weed Coordinators; MoF; CFS
			T-3.6	Areas with altered predator-prey systems	S	???	Unknown	Unknown	Data compilation/ moderate analysis	Moderate	Low	Studies as available
	T-4	Extent and degree of ecosystem integrity	T-4.1	Estimated index of ecosystem integrity based on ecosystem alteration factors such as landuse designations and associated management regimes (e.g., protected areas, forest mgmt. standards,	S	BEC x Ecosection; ecosystem type	Land use designations; mgmt regimes for each designation; model adaptation required	Base data generally available, but multiple sources	Significant analysis/ model development	Very High	Very High	MSRM, MoF, Forest Industry, LWBC, FSC-BC, Regional Districts, CBFWCP

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
				designated non-contributing forest, agriculture, urban/rural, flooded, etc.)								
Terrestrial Species and Populations	T-5	Viability of native species and populations	T-5.1	Inventoried/ monitored changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species	S	Individual species or groups	Individual species inventory data	Availability is limited	Data compilation/ moderate analysis	Very High	Low	MWLAP, CBFWCP, MSRM, COSEWIC, CDC
			T-5.2	Estimated changes in population size and distribution for vulnerable, sensitive, keystone, umbrella or otherwise representative native species	S	Individual species or groups	Forest cover data, land use designations and predicted mgmt regimes, species accounts, HSIs; some models available	Base data generally available, but multiple sources	Data compilation/ minor analysis	Very High	Very High	CBT Habitat project, MWLAP, CBFWCP, MSRM, Ecosystem Diagnosis and Treatment tool / Multi-species framework approach for the Columbia River Basin
			T-5.3	Range reductions and degree of population fragmentation for vulnerable, sensitive, keystone, umbrella or otherwise representative native species	S	Individual species or groups and their historic distributions	Individual species inventory data	Limited data availability	Data compilation/ minor analysis	High	Low	same as above
			T-5.4	Number of native species with known increases and decreases in distribution	S	BEC Units, Ecosections	Individual species inventory data	same as above	Data compilation/ minor analysis	Moderate	Low	same as above
			T-5.5	Number of threatened,	S	BEC Units,	Endangered	Readily	Basic data	High	Low	CDC and

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
				endangered and recently extinct or extirpated species		Ecosections	species databases	available	acquisition/ compilation			COSEWIC
			T-5.6	Changes in genetic diversity within populations and sub-populations	S	Individual species	Genetic variability within spp.	Unknown	Some modeling/ analysis	Moderate	Very Low	Research studies
			T-5.7	Changes in health status of populations and sub-populations	S	Individual species	Studies on health of spp. populations	Unknown	Some modeling/ analysis	Moderate	Low	CWS
Terrestrial Habitat Elements at the Stand and Site Level	T-6	Changes in abundance and/or distribution of habitat elements	T-6.1	Estimated extent of areas where habitat elements are intact, or changed from their 'natural' condition (including degree of change)	S	Site series, groups of site series, LUs, BEC units, ecosections	Representative samples of habitat element occurrence, forest cover, land use designations; predicted mgmt. regimes; model adaptation	Base data generally available, but multiple sources	Some modeling/ analysis	Very High	Very High	MSRM, MoF, Forest Industry, LWBC, FSC-BC, Regional Districts, CBFWCP
				Example of above: Type, frequency and distribution of snags	S	BEC by LU	as above	as above	Some modeling/ analysis	Very High	High	as above
				Example of above: Frequency and distribution of deciduous stands	S	BEC by LU	as above	as above	Data compilation/ minor analysis	Very High	Low	as above
Soils	T-7	Extent and degree of soil degradation	T-7.1	Estimated area of soils where changes in soil properties are sufficient to negatively affect productivity (including compaction, displacement and contamination)	S	Broad soil types, terrain types, BEC units; landuse units	Representative detrimental soil disturbance survey data, landuse and mgmt regime information; model	Base data generally available, but multiple sources	Some modeling/ analysis	High	Very High	MoF, TSR data bases, MWLAP Contaminated sites, MAFF

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
							development					
			T-7.2	% of landbase under various levels of soil conservation standards	R	Landuse areas, administrative units	Regulatory requirements and mgmt regimes	Base data generally available, but multiple sources	Basic data acquisition/ compilation	Moderate	Moderate	MoF, MWLAP, Forest and Agriculture Certification Orgs.
			T-7.3	Level of compliance with soil conservation standards	S	Landuse areas, administrative units	Compliance and enforcement data	Unknown	Some modeling/ analysis	Very Low	Very Low	MoF, MWLAP
			T-7.4	Percent of contaminated sites rehabilitated	R	Recorded contaminated sites	Contaminated site treatment data	Readily available	Data compilation/ moderate analysis	Very Low	Very Low	MWLAP, EC
Columbia Basin Aquatic Systems												
Flow Regimes	Aq-1	Degree of divergence from "natural" flow regimes	Aq-1.1	Index of the type and degree of flow regime alterations (including the proportion of hydrologic features with flow regimes altered beyond a critical level)	S	Watershed, hydrologic feature, stream reach	Hydrographic records, locations of diversions/ obstructions	Base data generally available, but multiple sources	Significant analysis/ model development	Very High	Low	Env. Cnda., MWLAP
			Aq-1.2	Number and location of structures that divert, obstruct or alter flow regimes, including area flooded/affected (e.g., large dams, water intakes, micro-hydro)	P	Watershed, hydrologic feature	Locations of obstructions/ diversions	Base data generally available, but multiple sources	Data compilation/ minor analysis	Very High	Low	same as above
			Aq-1.3	Ratio of the length of river/stream reach without	S	Individual river/ stream	same as above	Base data generally	Data compilation/	Moderate	Low	same as above

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
				flow alteration (dams, etc) in relation to the total river length				available, but multiple sources	minor analysis			
			Aq-1.4	Changes in level, timing and duration of peak flows (i.e. flooding)	S	Individual hydrologic features	same as above	Limited data availability	Data compilation/ moderate analysis	High	Very Low	same as above
	Aq-2	Extent and degree of watershed integrity	Aq-2.1	Estimated watershed integrity index, based on watershed alterations that affect flow regimes: road density, weighted ECA, reservoir flooding, flow obstructions, water diversions, etc	P	Watershed	Within stream works, forest cover, land use designations; mgmt regimes for each designation; model development	Base data generally available, but multiple sources	Significant analysis/ model development	Very High	High	TRIM, forest cover, MWLAP, MoF, CBFWCP, MSRM, Ecosystem Diagnosis and Treatment tool
Water Quality	Aq-3	Degree of divergence from "natural" water quality	Aq-3.1	Overall water quality measurements (sediment, coliforms, dissolved solids, etc.)	S	Sample points, individual hydrologic features	Water sample data	Limited availability	Data compilation/ minor analysis	Moderate	Very Low	MWLAP, Env. Cnda., MoF, Forest Industry, Watershed Groups
			Aq-3.2	Concentration of selected chemicals (e.g. nitrogen and phosphorous)	S	Sample points, individual hydrologic features	Water sample data	Limited availability	Data compilation/ minor analysis	Low	Very Low	MWLAP, Env. Cnda.
			Aq-3.3	Dissolved oxygen above and below dams	S	Stream reach	Dissolved oxygen	Generally available	Data compilation/ minor analysis	Moderate	Low	MWLAP, CBFWCP ??
			Aq-3.4	Upstream versus downstream water temperature in dammed	S	Stream reach	Stream temperature	Generally available	Data compilation/ minor analysis	Moderate	Very Low	MWLAP, CBFWCP ??

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
				systems								
			Aq-3.5	Areas with healthy or altered benthic communities	S	Stream reaches, hydrologic features	Benthic survey results	Limited availability	Some modeling/ analysis	Moderate	Low	MWLAP
	Aq-4	Extent of pollutants and/or pollution sources	Aq-4.1	Total recorded discharges of pollutants to water bodies (permitted, non-permitted, toxic sites, spills)	P	Watershed, hydrologic feature, stream reach	Discharge and toxic site data	Generally available	Basic data acquisition/ compilation	Low	Very Low	MWLAP, Env. Cnda. NPRI
			Aq-4.2	Pesticide use in riparian areas and within or adjacent to hydrologic features	P	Watershed, hydrologic feature, stream reach	Pesticide permit and use data	Unknown	Some modeling/ analysis	Low	Very Low	MWLAP, MAFF
			Aq-4.3	Extent of streamside and shoreline exposed to livestock use	P	Watershed, hydrologic feature, stream reach	Livestock use locations; possibly some modeling	Base data generally available, but multiple sources	Data compilation/ moderate analysis	Moderate	Low	MoF, MAFF
	Aq.5	Location and extent of sediment/ pollution sources	Aq-5.1	Estimated sediment yield based on the extent and degree of watershed condition and management (e.g., erosion and stability hazards, climate, road density, vegetation cover, etc.)	S	Watershed	TRIM, erosion hazards, forest cover, land use designations; mgmt regimes for each designation	Base data generally available, but multiple sources	Significant analysis/ model development	Moderate	High	MoF, MSRM, Forest Industry
			Aq-5.2	Composite water quality index based on watershed condition factors: presence of potential sediment sources and other sources	S	Watershed	Pollution permits, spill and toxic site reports, TRIM, erosion hazards,	Base data generally available, but multiple sources	Significant analysis/ model development	Very High	Very High	MWLAP, Env. Cnda., MoF, MSRM, Forest Industry

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
				for chemical and biological pollution			forest cover, land use designations; mgmt regimes for each designation					
			Aq-5.3	Development of and compliance with Water Quality Objectives	R	Watershed, hydrologic feature, stream reach	Areas with Water Quality Objs. and the level of compliance	Unknown	Significant analysis/ model development	Very Low	Very Low	MWLAP, MoH
Aquatic Ecosystems **(including riparian)**	Aq-6	Degree of divergence from "natural" community diversity, structure and productivity	Aq-6.1	Changes in diversity of native species within specific ecosystems - fish, plants, birds, invertebrates, mammals	S	Individual ecosystem types, stream reach or hydrologic feature	Actual species inventory data	Availability is limited	Significant analysis/ model development	Very High	Very Low	MWLAP, CBFWCP, MSRM, COSEWIC, CDC
			Aq-6.2	Estimated change in the diversity of native species within specific ecosystems, based on modeled changes in species diversity (see below for individual spp./ populations)	S	Watershed, hydrologic feature, stream reach	Flow data, water quality data, temperature data, predicted mgmt regimes, species accounts, HSIs	Availability is limited and multiple sources	Some modeling/ analysis	High	High	MWLAP, CBFWCP, Ecosystem Diagnosis and Treatment tool / Multi-species framework approach for the Columbia River Basin
			Aq-6.3	Extent of intact or unmodified (i.e. fully functioning) aquatic ecosystems (e.g., riparian, riverine, lake, wetland)	S	Individual ecosystem type, stream reach or hydrologic	Aquatic ecosystem and species inventory data	Availability is limited	Some modeling/ analysis	Very High	Low	MWLAP, CBFWCP, Env. Cnda.

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
						feature						
			Aq-6.4	Frequency and distribution of exotic and invasive species (including fish, plants, and other taxa)	S	Individual ecosystem type, stream reach or hydrologic feature	Species inventories, control records, estimated distributions	Generally available for fish, more limited for other spp.	Data compilation/ moderate analysis	High	Low	MWLAP, MoF, Env. Cnda.
	Aq-7	Extent and degree of aquatic ecosystem integrity	Aq-7.1	Index of aquatic ecosystem integrity based on watershed conditions, flow disruptions, channel alterations etc. (e.g., dams, diversions, infilling, flood control, riparian development, watershed landuse designations and mgmt. regimes)	P	Individual ecosystem type, stream reach or hydrologic feature	In-stream, shoreline and riparian development, watershed land use designations; mgmt regimes for each designation	Base data generally available, but multiple sources	Significant analysis/ model development	Very High	Very High	MSRM, MoF, Forest Industry, LWBC, FSC-BC, Regional Districts, CBFWCP, Env. Cnda.
Aquatic Species and Populations	Aq-8	Viability of native species and populations	Aq-8.1	Inventoried changes in population size for vulnerable, sensitive, keystone, umbrella or otherwise representative native species	S	Individual species or groups	Individual species inventory data	Availability is limited	Basic data acquisition/ compilation	Very High	Low	MWLAP, CBFWCP, COSEWIC, CDC
			Aq-8.2	Estimated changes in population size and distribution for vulnerable, sensitive, keystone, umbrella or otherwise representative native species	S	Individual species or groups	Flow data, water quality data, temperature data, predicted mgmt regimes, species accounts, HSIs; habitat and population modeling	Base data availability likely limited and multiple sources	Some modeling/ analysis	Very High	Very High	MWLAP, CBFWCP, Ecosystem Diagnosis and Treatment tool / Multi-species framework approach for the Columbia River Basin

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
			Aq-8.3	Range reductions and degree of population fragmentation for vulnerable, sensitive, keystone, umbrella or otherwise representative native species	S	Individual species or groups and their historic distributions	Individual species inventory data	Limited data availability	Data compilation/ moderate analysis	Very High	Moderate	same as above
			Aq-8.4	Number of native species with known increases and decreases in distribution	S	Watershed units	Individual species inventory data	same as above	Data compilation/ minor analysis	Moderate	Moderate	same as above
			Aq-8.5	Number of threatened, endangered and recently extinct or extirpated species	S	Watershed units	Endangered species databases	Readily available	Basic data acquisition/ compilation	Moderate	Moderate	CDC and COSEWIC
			Aq-8.6	Changes in genetic diversity within populations and sub-populations	S	Individual species	Genetic variability within spp.	Unknown	Significant analysis/ model development	Moderate	Low	Research studies
			Aq-8.7	Changes in health status of populations and sub-populations	S	Individual species	Studies on health of spp. populations	Unknown	Significant analysis/ model development	Low	Very Low	CWS
			Aq-8.8	Population size and species diversity of migratory and non-migratory waterfowl	S	Species groups; individual aquatic habitats	Inventory data	Unknown	Data compilation/ moderate analysis	Low	Low	MWLAP, CBFWCP, Ducks Unlimited, Env. Cnda.
Aquatic Habitat Elements	Aq-9	Changes in abundance and/or distribution of habitat elements	Aq-9.1	Estimated extent of areas where habitat elements are intact, or changed from their 'natural' condition (including degree of change)	S	Hydrologic feature, river system	Representative samples of habitat element occurrence and associated hydrologic and	Base data availability likely limited and multiple sources	Some modeling/ analysis	Very High	High	MWLAP, CBFWCP, BC Hydro; Fortis

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
		elements					watershed condition variables; model development					
				Example of above: extent and quality of adfluvial fish spawning areas	S	Hydrologic feature, river system	Reports on	Base data likely available, but multiple sources	Data compilation/ moderate analysis	High	Low	MWLAP, CBFWCP, BC Hydro; Fortis
				Example of above: occurrence of riparian sources of large woody debris	S	River/ stream system, stream reach	as above	Base data available, but multiple sources	Significant analysis/ model development	Moderate	Low	MoF, MSRM, Forest Industry
Groundwater	Aq-10	Groundwater availability	Aq-10.1	Changes in aquifer water levels	S	Aquifer	Aquifer water levels	Very limited data availability	Significant analysis/ model development	Moderate	Low	MWLAP
			Aq-10.2	Aquifer recharge/ flow rates	S	Aquifer	Aquifer pumping recovery rates	Very limited data availability	Significant analysis/ model development	Moderate	Low	MWLAP
	Aq-11	Quality of groundwater	Aq-11.1	Chemical composition of groundwater in aquifers and observed wells	S	Aquifer	Chemical composition of groundwater	Very limited data availability	Some modeling/ analysis	Moderate	Very Low	MWLAP
Atmosphere												
Atmospheric Composition/ Air Quality	A-1	Air quality and atmospheric composition	A-1.1	Number of days when air quality is ranked as 'poor, fair, good' for the communities and airsheds where air quality is monitored	S	Communities/ airsheds	Composite account of PM10, pollution permits, ground level ozone	Readily available	Basic data acquisition/ compilation	Very Low	Low	MWLAP - Air Resources Branch

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
			A-1.2	Summary of particulate matter (PM10) concentrations, by season and by estimated source apportionment (home wood burning, slash/agriculture, non-point sources)	S	Monitored in: Nelson, Castlegar, Trail, Radium, Slocan, Golden, Cranbrook, Creston, Revelstoke, Valemount	PM10 data from monitored sites; analysis and possibly modeling to apportion sources	Base data available, but multiple sources	Basic data acquisition/ compilation	Low	Moderate	BC MWLAP - Air Resources Branch; Nelson Environmental Protection group; MoF slashburning records
			A-1.3	# of days/yr when particulate matter exceeds specified values	S	same as above	same as above	Readily available	Basic data acquisition/ compilation	Very Low	Low	BC MWLAP - Air Resources Branch; Nelson Environmental Protection group
			A-1.4	# days that groundlevel ozone exceeds the Canadian Standard of 65 ppb	S	Where monitored	O3 levels	Readily available	Basic data acquisition/ compilation	Very Low	Low	BC MWLAP - Air Resources Branch; Nelson Environmental Protection group
	A-2	Extent of pollutants and/or pollution sources	A-2.1	Yearly emissions of each pollutant, by airshed. Include TRS, SO2, PM10, metals, etc from permitted discharge sources	P	Pollution permit sites	Pollution permits and spill records	Readily available	Basic data acquisition/ compilation	Low	Low	MWLAP - Ric Baker in Nelson; BC SoE: Env Cnd - Nat'l Pollutant Release Inventory (NPRI)
Ultra-Violet Radiation	A-3	Changes in UV Levels	A-3.1	# of days/yr UV indices exceed specified values	S	Region	UV data from relevant stations: Lower Mainland spectral UV	Readily available	Basic data acquisition/ compilation	Very Low	Very Low	Env Cnd. World Ozone and Ultraviolet Radiation Data Centre 2002.

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
							station; multi-band station in US Rocky Mountains					
Global Systems												
Climate Systems	G-1	Changes to climate	G-1.1	Changes to averages, extremes and timing of air temperatures and precipitation (including snow)	S	Regional; by BEC, Ecosection, Watershed	Climate station data	Readily available	Basic data acquisition/ compilation	Low	Low	Canadian Historical Homogenized Temperature Datasets - Cnd Institute for Climate Studies; Meteorological Services of Canada - Env Cnd
			G-1.2	Predicted changes in temperature and precipitation	S	By BEC	Results of climate modeling studies	Readily available, but variable	Data compilation/ moderate analysis	Low	Low	
	G-2	Effects of climate change on terrestrial systems	G-2.1	Predicted changes in BEC zonation, disturbance processes (including fire) and/or distribution of species	S	By BEC	Results of climate modeling studies; present and past climate data; modeling of BECs, disturbance and spp. occurrence	Readily available, but variable	Significant analysis/ model development	Moderate	Low	Canadian Forest Service - Pacific Forestry Centre
	G-3	Effects of climate change on aquatic	G-3.1	Changes in flow regimes and surface water temperatures	S	By watershed or stream reach; by monitoring	Long-term flow measurements and surface water	Unknown	Basic data acquisition/ compilation	High	High	MWLAP; CBFWCP

Realm/ Component	Code	General Indicator	Code	Measure (State - S, Pressure - P, Response- R)		Scale/ Indicator Assessment Unit	Basic Information/ Analysis Requirements	Base Data Availability	Data Compilation/ Manipulation Effort	Estimated Significance in Present Context	Estimated Predictive Capability	Potential Information Sources
		systems				site	temperatures					
			G-3.2	Predicted changes in flow regimes, water physical properties and/or distribution of species	S	By watershed or stream reach	Modeling results of climate change and models relating climate to flow regimes and physical water properties	Unknown	Significant analysis/ model development	Very High	Moderate	MWLAP, EC
Geochemical and Nutrient Cycles	G-4	Greenhouse gas emissions	G-4.1	Total estimates of GHG from human activities in the region including: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride	P	Regional District; by sector	Estimated GHG emissions	Unknown	Some modeling/ analysis	Moderate	Low	Air Resources Branch - MWLAP; stats can

Appendix 4. Agency contact information

Agency	Contact	Position	Phone Number	Email	Potential data source	Contact
MWLAP – Nelson Region	Kathy Eichenberger	Regional Manager	354-6362	Kathy.Eichenberger@gems6.gov.bc.ca	Pollution, water, biodiversity	Y
MWLAP/ CRIEMP – Columbia River Integrated Environmental Monitoring Program	Julia Beatty	Head, Environmental Quality Section	354-6750	Julia.Beatty@gems4.gov.bc.ca	Aquatic data, air quality, climate change	Y
MWLAP/ CRIEMP	Robyn Roome	Environmental Assessment (EIA) Biologist	:250.354.6356	Robyn.roome@gems1.gov.bc.ca	Aquatic data, air quality, climate change	Y
MWLAP - BC SoE Office	Linda Gilkeson	Head of SoE Reporting	250-387-9410	Linda.Gilkeson@gems3.gov.bc.ca	Atmospheric indicators, Climate Change, other indicators that overlap	Y
MWLAP - Nelson Region	Ric Baker	Environmental Management Section Head	354-6754	Ric.Baker@gems6.gov.bc.ca	Pollution - point source permits	N
CBFWCP	John Krebs Amy Waterhouse	Habitat Biologist GIS Tech	352-6874		Dams, spp information (Leopard Frogs, Blue Herron, Badgers, ungulates, wolverine), Conservation Lands; Biodiversity Atlas	Y
Northwest Habitat Institute	Tom O'Neil			habitat@nwhi.org	Habitat-spp info - Canada and US	Y
Canadian Forest Service - Pacific Forestry Centre	Brad Hawkes	Fire Research Officer	250-363-0665	bhawkes@pfc.cfs.nrcan.gc.ca	Natural disturbance - fire	Y
Canadian Forest Service - Pacific Forestry Centre	Steve Taylor	Forestry Officer	(250) 363-0758	staylor@pfc.cfs.nrcan.gc.ca	forest health and biodiversity database	No response
MoF - Kootenay Lake	Mike Curran	Soils Research	825-1118	Mike.Curran@gems5.gov.bc.ca	Soil indicators	Y
MoF Research Branch	John Parminter	Forest Dynamics Researcher	250-356-6810	john.parminter@gems.gov.bc.ca	Historic fire and seral stage maps	Y

Agency	Contact	Position	Phone Number	Email	Potential data source	Contact
MoF Protection					Record of fires fought/suppressed	N
MoF Forest Practices Branch				http://www.for.gov.bc.ca/hfp/forsite/overview/overview.htm	Aerial overview surveys	N
MoF Kamloops	Russ Horton	Range weed specialist	250 828-4910	Russ.Horton@gems5.gov.bc.ca	Invasive spp	No response
MoF Kamloops	Susan Turner	Biological control specialist	250 828-4580	Susan.Turner@gems1.gov.bc.ca	Invasive spp	No response
Weed Coordinators	Kevin Patterson, Kimberly				Invasive spp	N
Weed Coordinators	Barb Stuart, Rock Creek				Invasive spp	N
WWF - Nature Audit Project	Tony Lacobelli	Landscape Conservation and Planning	1-800-26-PANDA	tiacobelli@wwfcanada.org www.wwf.ca	Nature Audit accounts etc	Y
MSRM - Nelson	Mike Panian	Inventory specialist	354-6759	mike.panian@gems7.gov.bc.ca	Has CFS-PFC fire condition class model data	Y
Northwest Power Planning Council				http://www.edthome.org/framework/	Terrestrial and aquatic habitat modelling; Ecosystem Diagnosis and Treatment tool / Multi-species Framework for US Columbia Basin	N
Environment Canada Indicator and Reporting Office	Risa Smith	SoE Office		Soeadmin@ec.gc.ca	Canadian Biodiversity Index; General Canadian Indicators	Y
Pandion Ecological Research	Chris Steeger	Independent Contractor	250-354-0150	csteeger@netidea.com http://habitat.cbt.org/	Habitat and species information; snags	Y
MoF-Kootenay Lake	Dave Gluns	Hydrology Research	250-825-1125		Watershed monitoring; flow information	Y
Aboulder Institute	Pat Field	Independent Contractor	250 365-0425	aboulder@shaw.ca	Spatial modelling	Y
Carver Consulting	Martin Carver	Independent Contractor	250 352-1187	carver@netidea.com	Hydrology modelling	Y

Appendix 5. SoE systems / programs reviewed in interim report #1.

In Interim Report #1, we provided a systematic summary of a number of SoE systems, or programs that may be relevant to the Columbia Basin. This overview was shown to demonstrate the range of possible SoE frameworks available and to provide CBT with a summary of the potential products possible. Within Interim Report #1, the examples are organised by geographic scale in the following order:

National
- Environment Canada
- National Round Table
- WWF
- US State of Nations Ecosystems
- US EPA
- Australia

Regional
- BC SOE
- Washington's Environmental Health
- Oregon Benchmarks
- Idaho, Montana, Nevada, Wyoming
- Alberta Genuine Progress Indicators
- Environment Canada Pacific/Yukon Region
- Fraser Basin Council
- Georgia Basin/Puget Sound
- Columbia Basin (Washington Environmental Health, Oregon Benchmarks, nothing in other states; Interior Columbia Basin)
- BC Forestry Monitoring Strategy

Industrial Sector
- Forest product certification – Forest Stewardship Council
- Forest product certification – Canadian Standards Association

Community
- Quesnel's State of Our Community: Moving Sustainability Forward

For each example we provided a short description organised according to a common series of topics for a rapid overview of the program. These quick descriptions should also allow for a quick comparison between programs.