Environmental Monitoring:

Business and Information Needs Study

prepared for

Land Information and Inventory Coordinating Committee
Province of British Columbia

by

Daryl Brown, Daryl Brown Associates Inc.
&
John Dick, Sustainable Visions

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Study Background and Purpose

BC's Land Information and Inventory Coordinating Committee (LIICC) commissioned this study to obtain a current picture of provincial environmental monitoring business and information needs, as a basis for developing a "corporate environmental baseline", which is essentially a system for advising about and distributing environmental information that is needed for environmental management purposes.

Study findings are based primarily on a series of interviews that the consultants held with provincial agency personnel who are involved in delivering environmental monitoring and inventory programs (i.e., data providers); and those who are involved in activities to interpret environmental monitoring information in support of program requirements and for environmental trends / effectiveness assessment purposes (i.e., data users). Various agencies' documentation was also reviewed to identify specific environmental indicators that agencies want to track over time, and the particular environmental information that is needed to support these efforts.

Terminology

Various terminology is applied in the area of environmental monitoring. For the purposes of this study it is important to be clear that environmental *monitoring* involves the collection of *time-series* data on specified environmental *indicators* (parameters) using defined sampling methodologies. This is distinct from environmental or resource *inventories* that are an enumeration of a particular resource or ecosystem and typically provide a snap-shot of resource conditions at a single point in time.

Key Issues

The key issues that need to be addressed in relation to environmental monitoring in BC are:

Supply – Demand Imbalance: There is rapidly increasing interest from various agencies / initiatives to access reliable environmental monitoring (time-series) information. However, most of the environmental information that is available in BC is "point-in-time" inventory information. There is a growing divergence between the demand for high quality, time-series environmental monitoring information and the availability of it.

Lack of Formalized Business Drivers: Although there are some positive signs that certain categories of monitoring data will become more available (e.g., vegetation change monitoring), pressures to reduce monitoring activity for other resource categories continue to increase (e.g., water quality / quantity). Environmental monitoring is currently a discretionary activity that must compete with other environmental management initiatives for scarce budget dollars. To lessen the supply – demand imbalance for environmental monitoring information, formalized business drivers for environmental

monitoring are required (e.g., more explicit requirements for agencies to engage in monitoring, potentially based in legislation).

Technical Capacity: The providers of environmental monitoring information are increasingly being called on, *ad hoc*, by external users of that data to explain and interpret the data. While it is important for this technical service to be provided to data users to prevent the mis-interpretation of data and the potential for inaccurate reporting of environmental outcomes, there is only so much that data providers can do, given their own program priorities and limited resources. A further capacity issue relates to the reduced technical expertise within programs to develop monitoring systems / networks that are capable of producing statistically valid and credible data.

Indicator Proliferation: It is questionable whether or not it is necessary for BC to track the large number of environmental indicators that provincial agencies, in combination, are interested in measuring (over 200). In addition, there are overlaps among agencies / initiatives in the indicators they are / are proposing to measure. Both of these issues need to be addressed to achieve efficiencies.

Lack of Coordination: Along with the expanding agency interest in environmental monitoring comes a critical need for increased coordination and cooperation. A corporate approach to decision-making is required on key questions such as: funding and designing monitoring systems; developing monitoring standards; managing monitoring data collection, storage and distribution; roles and responsibilities for interpreting and reporting monitoring results; etc.

Links to Decision-making: The fundamental purpose behind monitoring environmental conditions is to improve the quality of environmental management decision-making. Closer bridges are needed between the results / findings of environmental monitoring and the policy responses of decision-makers.

Partnerships: Provincial agencies are not the only organizations in BC with an interest in collecting environmental monitoring data. The federal government, First Nations, local governments, universities and institutes and the private sector should all be involved in initiatives for bringing a BC-wide, corporate perspective to environmental monitoring.

Conclusions and Recommendations

Responding to Increasing Demand for Environmental Monitoring Information

BC has plenty of environmental data, but it is generally not the kind that is needed for interpreting trends in environmental condition and assessing program / policy / plan effectiveness. A main reason for the limited supply of environmental monitoring data is that environmental monitoring is currently a discretionary activity that is based in policy or informal / implicit business drivers.

Recommendation 1: Government should institutionalize some more formal business drivers for environmental monitoring — i.e., mechanisms that establish an explicit, non-discretionary requirement for the collection of environmental monitoring information.

Coordinated Design and Delivery of Environmental Monitoring Systems

There is a critical need for improved coordination in determining corporate environmental monitoring priorities and planning the design and delivery of monitoring programs. To-date, agencies' demands for environmental monitoring information have not been rationalized in relation to government's broader corporate priorities. The result is multiple agencies proceeding independently with their own initiatives, all of which have major ongoing, and sometimes overlapping data acquisition implications. As has already been recognized for inventory programs, a corporate perspective on environmental monitoring programs is necessary.

Recommendation 2: Environmental monitoring programs should be explicitly brought under the umbrella of LIICC or a similarly corporate-minded coordinating structure. Coordination should not be limited to provincial government agencies — the coordinating body should include representatives from all parties with a monitoring interest (federal, First Nations, local governments; Crown corporations, universities and institutes; private sector).

Partnering Opportunities

Government needs to identify ways for enhancing the availability of monitoring data by involving outside organizations / interests in designing monitoring systems and collecting and interpreting monitoring results.

Recommendation 3: Partnership opportunities should be explored with other levels of government, universities and institutes and the private sector, as a way of leveraging a cost-effective increase in the availability of reliable environmental information.

Using Monitoring Information to Enhance Environmental Outcomes

There is little evidence of good mechanisms for integrating environmental monitoring results into improved environmental decision-making at the policy level. Unless this occurs, the public investment into environmental monitoring is questionable.

Recommendation 4: As one component of its efforts to oversee the development of a "corporate environmental baseline", LIICC should investigate institutional options for ensuring that the findings from environmental monitoring programs are actually integrated into environmental decision-making.

ABBREVIATIONS

The following abbreviations appear in the report:

AAC	Allowable Annual Cut
BEC	Biogeoclimatic Ecosystem Classification
BCAL	BC Assets and Lands Corporation
BCTFA	BC Transportation Financing Authority
BTM	Baseline Thematic Mapping
CCFM	Canadian Council of Forest Ministers
CCFM C&I	Canadian Council of Forest Ministers Criteria and Indicators
C&I	Criteria and Indicators
CDC	Conservation Data Centre
CSA	Canadian Standards Association
DFO	Department of Fisheries and Oceans
EC	Environment Canada
FiRBC	Fisheries Renewal BC
FISS	Fish Information Summary System
FoRBC	Forest Renewal BC
FSC	Forest Stewardship Council
GIS	Geographic Information System
GVRD	Greater Vancouver Regional District
IAMC	Inter-agency Management Committee
LIICC	Land Information and Inventory Coordinating Committee
LUCO	Land Use Coordination Office
LRMP	Land and Resource Management Plan
MAF	Ministry of Agriculture and Food
MMA	Ministry of Municipal Affairs
MOAA	Ministry of Aboriginal Affairs
MOEM	Ministry of Energy and Mines
MOF	Ministry of Forests
MoFi	Ministry of Fisheries
MOH	Ministry of Health
MOTH	Ministry of Transportation and Highways
MELP	Ministry of Environment, Lands and Parks
MSBTC	Ministry of Small Business, Tourism and Culture
PAS	Protected Area Strategy
PSIR	Pressure-State-Impact-Response framework
SFM	Sustainable Forest Management
SLUP	Strategic Land Use Plan
TRIM	Terrain Resource Inventory Mapping
TSA	Timber Supply Area

1. INTRODUCTION

1.1. Background

The British Columbia government, like many other jurisdictions, faces the challenge of managing increasing pressures on the natural resource base with steadily eroding institutional capabilities. Environmental and natural resource management activities over the next few decades will likely focus on:

1) improving the management of terrestrial and aquatic systems to maintain the diversity and integrity of those systems while providing a sustainable supply of social benefits; and

2) mitigating the environmental and public health effects of terrestrial, aquatic and atmospheric degradation resulting from human activity.

Success in these areas will depend on a broad understanding of environmental issues and on a consensus on priorities for action. These will in turn depend on the regular collection of reliable, time-series information on selected indicators of environmental condition so that:

1) the state of the environment can be determined at any point in time;

2) significant trends in environmental quality (including emerging problems) can be identified; and

3) timely, effective and prioritized management action can be initiated.

It is against this general background that the provincial Land Information and Inventory Coordinating Committee (LIICC) initiated this project to undertake an environmental monitoring needs analysis.

1.2. Study Purpose and Scope

LIICC is mandated to coordinate the development and implementation of land and natural resource inventory programs. The committee is aware of the recent interest in and proliferation of “strategic-level” environmental monitoring and reporting initiatives, including: strategic land use plan and landscape unit plan effectiveness monitoring, environmental trends monitoring, state of forests monitoring, monitoring nationally-defined criteria and indicators for sustainable forest management, and state of parks monitoring. In addition, there is increasing interest in implementing a “results-based” forest practices code, and supporting the delivery of forest certification schemes. Most recently, government has indicated an intent to create a Commissioner of the Environment and Sustainability who will be responsible for monitoring and bi-annual reporting on environmental performance in British Columbia. These activities are in addition to environmental monitoring that is done by agencies in support of their program delivery responsibilities (e.g., air quality, water quality / quantity monitoring).

All of these monitoring initiatives, which are aimed ultimately at improving the ability to make decisions that promote sustainable environmental management, involve the need for diverse types of environmental sampling programs to enable the time-series measurement of various environmental parameters (indicators).

Concerns from LIICC's point of view that are inherent in an uncoordinated approach in the development and delivery of strategic-level monitoring systems are:

potential inefficiencies associated with developing diverse and potentially overlapping sets of indicators. At present, each monitoring initiative is developing its own set of monitoring indicators, with its own data needs. Inevitably, there will be similarities among indicator sets and the methodologies and data needed to monitor and report on the indicators. Can we develop a focused / core set of indicators that can serve the priority needs of multiple monitoring programs, and agree on the data that will be collected to measure the indicators? If we could, this may reduce public expenditure into data collection.

potential ineffectiveness of the monitoring results. Investments into monitoring environmental conditions and trends are only justified if the findings / results of monitoring programs are relevant to, and integrated into, decision-making. Are we measuring the right elements (indicators) of environmental condition — ones that will actually enable us to make decisions that progress us towards goals of sustainable environmental management. If we are not, then some investments into data collection and trends analysis may be wasted.

conflicting reporting among different monitoring initiatives, which may be measuring indicators for the same land base, could possibly arrive at different conclusions about environmental condition. It will be important to ensure that monitoring programs apply the right kinds of data to criteria and indicator measures, and base their interpretations on an accurate understanding of what the data and measurements mean.

To respond to these issues, we must start by clarifying the current information needs of decision-makers. To that end, this study has attempted to answer the following basic question:

> *"What environmental condition information do the province's natural resource management agencies need to support monitoring initiatives that are undertaken to enhance their strategic policy and program decision-making capability?"*

Thus the primary objective of the project was to undertake a "needs analysis" for a government-wide, corporate environmental condition monitoring system to facilitate strategic-level policy and program decision-making. The study focused on information needs for environmental condition monitoring, with minor consideration of operational / compliance monitoring only where information can be aggregated upwards to support "corporate" decision-making (see definitions in section 2.1). This corporate baseline would serve the decision-making needs of both individual Ministries and inter-agency planning entities and processes. The needs-analysis encompassed the information requirements of all environmental "sectors" including atmospheric quality, water quality, water quantity, aquatic ecology and terrestrial ecology.

1.3. Methods

The needs analysis was carried out through interviews and the use of a generic questionnaire directed at agencies that are monitoring, or are preparing to monitor and interpret environmental information as a basis for reporting on the condition of environmental quality in BC, and / or to measure the effectiveness of their program activities in achieving corporate environmental goals and objectives. One element of the analysis was to determine the business drivers (i.e., the mandate) for these monitoring initiatives, which may include: legislation; international and national protocols, commitments contained in individual program plans or integrated resource management plans; agencies' internal efforts to implement adaptive management principles; and requirements for meeting government-wide accountability standards.

The questionnaire and interviews were generally targeted at agency program directors / managers involved in strategic and corporate planning and program / policy analysis, and associated staff that are involved directly in developing, interpreting, and reporting on outcome-based measures (i.e., criteria and indicators).

The questionnaire and interviews were aimed at identifying:

1) the business drivers for their effectiveness monitoring initiatives

2) the general nature, scope, frequency and audience of their monitoring initiatives

3) the individuals that are involved in monitoring

4) the basic questions that they are trying to answer through their monitoring initiatives

5) the environmental parameters (criteria and indicators) they are measuring in efforts to answer their questions

6) the current sources of data / information for measuring their selected environmental parameters

7) issues and comments related to the availability and adequacy of information / data that they require for their monitoring purposes.

Where agencies are not presently involved in monitoring but foresee a need to become involved, contacts were asked to speculate on their future monitoring information / data needs.

1.4. Report Organization

In addition to this introductory chapter, the report contains the following material:

Chapter 2 provides an overview of environmental monitoring, including definitions of key monitoring terminology and a description of the relationships between "research", "inventory" and "monitoring".

Chapter 3 describes BC's current legal, policy and institutional context for environmental monitoring in BC. Monitoring "business drivers" and agency involvement in environmental monitoring are described.

Chapter 4 describes BC initiatives that generate environmental monitoring (i.e., time series) information that is potentially available for various trends interpretation and reporting, and program / plan / policy effectiveness assessment uses. Initiatives are described according to atmospheric, aquatic, terrestrial and land tenure / use categories.

Chapter 5 describes the existing and proposed *users and uses* of environmental monitoring information for agency strategic planning purposes; interpretation and reporting on environmental / sustainability trends; assessments of agencies' plans, programs and policies. This chapter identifies the type of environmental indicators that agencies are currently tracking, or are intending to track, over time, and associated environmental monitoring information needs.

Chapter 6 provides a summary of environmental monitoring issues, leading to study conclusions and recommendations.

Supporting information is provided in report appendices.

2. ENVIRONMENTAL MONITORING: AN OVERVIEW

2.1. Definitions

The general term "monitoring" embraces a number of quite different activities in a natural and environment resource management context:

Environmental Condition (also known as ambient or effectiveness) Monitoring — measures environmental condition, usually against long-term resource management goals or objectives, and when measured in "time-series" determines trends in condition.

Validation Monitoring — is a semi-research activity undertaken to evaluate: a) the degree to which monitoring indicators and techniques measure real environmental conditions and trends, and b) the cause / effect relationship between environmental condition and management interventions.

Compliance (also known as operational) Monitoring — measures performance against legal environmental standards or permit / plan conditions in order to establish a compliance record.

Program (also known as implementation) Monitoring — determines progress in program implementation against established "benchmarks" (number of activities completed, area treated, number of clients served, cost of delivery, etc).

As noted in chapter 1, this project and the following discussion will focus primarily on environmental condition monitoring, with some consideration of operational and program monitoring initiatives where information is comprehensive enough to be aggregated upwards to support strategic decision-making.

2.2. Monitoring and Strategic Decision-Making

Perhaps the most tenuous aspect of the environmental management cycle is the link between monitoring and management action. Even at the operational level, where the relationship would seem to be most straight forward, many industrial operations have not yet fully integrated environmental monitoring with day-to-day decision-making. The result is that non-compliance does not always elicit an immediate and positive operational response. It is, however, at the level of strategic policy and program development in government institutions that the link between monitoring and management action is least developed. There are a number of reasons for this:

- senior decision-makers may not have thought about, or articulated, their needs for data at this level of decision-making;

- the bewildering array of "environmental" information does not lend itself easily to consolidation and aggregation;
- much of the "information" is of poor quality and not collected with either the regularity or the scientific rigour that allows interpretation of the trends and comparisons that are most important in identifying management programs and setting priorities;
- "environmental indicators" being monitored may not adequately represent environmental condition;
- most senior decision-makers lack the technical expertise to properly interpret environmental monitoring data;
- information providers are not always able to present data in a form that is easily understood by "non-technical" persons; and
- environmental issues, and the information relating to them, seldom conform to the jurisdictional and institutional boundaries devised by government planners, with the result that monitoring is often poorly coordinated and fragmented.

Environmental monitoring is of most use to senior decision-makers when it is collected in "time-series" so that trends in condition can be determined and those trends compared with a desired state. Several recent initiatives - Environmental Indicators, State-of-Environment Reporting, State-of-the Forest Reporting, State-of-Parks Reporting - either are doing, or intend to do, comprehensive trend analysis. It is not known, however, how these reporting initiatives influence, or are used by, senior staff for program / policy decision-making purposes. These initiatives also have a significant public education potential, which may require specialized information interpretation and presentation.

A "corporate approach" to monitoring offer a number of advantages for strategic decision-making, including:

1) common standards of information collection and organization;
2) efficiencies and synergies in data collection, interpretation and reporting;
3) ensuring that information sets are readily available to all potential users; and
4) avoiding the appearance of bias.

This does not mean that all information should be collected by a central agency, merely that the corporate system should be able to influence and harmonize standards of data collection and interpretation, accommodate all general information sets, and have the capability to access all specific environmental data sets.

2.3. Indicators and Indices

Given the problems and needs described above, there has been increasing interest over the past decade in the development of scientifically-credible environmental indicators and indices.

Studies in this field do not always distinguish between indicators and indices, and so for purposes of this discussion, the following definitions will be used:

Indicator — a number or other descriptor, measured in real units, which is assumed to be representative of a larger set of conditions or values (e.g., an indicator of biodiversity condition could be the amount or distribution of old forest cover).

Index — values, expressed on a simple numerical (e.g.,1-10, 1-100, 1-200 etc) or descriptive (i.e. low, moderate, high, extreme) scale, which represents a summation of various conditions and measurements across a broad field (e.g., water quality in a particular water body or watershed might be reported on as being excellent, good, fair, borderline or poor, based on a synthesis of various water quality / chemistry parameters such as temperature, dissolved oxygen, nutrients, turbidity, metals, etc.)

Indicators and indices are developed for similar purposes:

- simplification of complex relationships,
- selection of the most relevant information for a given management purpose,
- quantification of information on environmental conditions and trends,
- communication of information to decision-makers and the public,
- allocation of financial resources between issues and regions,
- enforcement of environmental standards, and
- to enhance the efficiency and quality of data collection,

And, they likewise suffer from the same problems and limitations:

- oversimplification,
- subjectiveness, both in the assumed representativeness of chosen indicators and in the numerical valuation and weightings associated with indices,
- a loss of information,
- the potential for misuse,
- inadequate understanding of the underlying cause-effect relationships, and
- the obscuring of important conditions and trends in the individual, aggregate data-sets.

Indices, because they attempt to convert data in different form to simple scales, intensify the problems of loss of information, oversimplification, subjectivity and the masking of important relationships in underlying data. Very simple environmental indices have been developed within discrete sectors (i.e. air and water quality indices) and substantial research has been carried out on “composite environmental indices” that might allow aggregated, multi-sectoral environmental ratings. Most researchers have concluded that the development of composite indices that might be applied to real, practical decision-making are more than a decade away, however, new data bases should, at least, anticipate their eventual development and application.

2.4. The Pressure-State-Impact-Response Framework for the Selection of Environmental Indicators

Nearly all environmental inventory and monitoring initiatives involve the use of indicators of one form or another. Ideally, indicators should be selected that directly reflect the health or condition of the environment, however, this may not always be possible or practical. Proxy parameters that are often easier to measure can sometimes be found through application of the "Pressure-State-Impact-Response" (PSIR) Model (Harvard University 1995). This model assumes that the state of the environment can be linked to socio-economic influences: i.e. that human activities impose pressures on the environment but because humans are also dependent on the environment, the resulting environmental change can cause impacts on humans and their valued ecosystems that in turn require a management response. The major implication of this model to the selection of indicators is that it may be easier to measure pressure, impact or response parameters than actual environmental condition, providing that the pressure-state-impact-response relationship is well understood. Simple examples of the PSIR relationship are shown in Table 1.

Table 1: Examples of "Pressure-State-Impact-Response" Relationship

Environmental Issue	Pressure	State	Impact	Management Response
Ground water use and quality	• Water withdrawal exceeds recharge	• Aquifer depletion	• Drying wells and water shortages	• Increased water use efficiency • Licensing and fees • Provision of alternate sources
Salmonid habitat	• Surface water withdrawals • Disturbance to streams and riparian areas	• Destruction or degradation of spawning and rearing habitat	• Decreased aquatic productivity • Decreased returns of mature fish • Decreased survival and out-migration of juvenile fish	• Fish habitat restoration • Stock rehabilitation • Stream and riparian protection regulations • In-stream flow requirements
Critical lands (steep slopes, fragile soils, etc)	• Increased logging, land disturbance and road building on steep slopes	• Increased soil erosion, land instability and stream sedimentation	• Water quality degradation. • Hydrologic disruption. • Aquatic habitat degradation	• Greater regulation of human activity on critical lands • Watershed and fish habitat rehabilitation

The major problem in the application of the PSIR model to the selection of indicators is that the relationship may not be as straight-forward or direct as it appears (in the table above under salmonid habitat, for example, decreased returns of mature fish and survival of juveniles may be due to influences in the open ocean or to climate change as well as habitat degradation). If a particular indicator is to be really useful as a monitoring tool it must be truly representative of the system being monitored and there must be adequate understanding of the PSIR relationship. It

must always be kept in mind in drawing judgements and interpretations that, however well chosen, indicators are merely an assumed model of reality, not reality itself.

2.5. The Relationship between Research, Inventory and Monitoring

It is important not to confuse monitoring with two closely related activities: *research* and *inventory*.

Research is the most intensive and expensive level of data collection, carried out on relatively small areas to achieve a better understanding of complex relationships with the hope that such understanding can be extrapolated to much larger areas.

Inventory is an enumeration of an ecological system; generally carried out either to provide a basis for estimating potential yield or to establish a baseline. "Time-series" information may be derived from both research and inventory, but only if the research is sufficiently long-term and the inventory is repeated. In both cases this is a very expensive way to derive such information. Additionally, the site-specific level at which research is carried out makes it difficult to aggregate and generalize information, and inventory methods often change, making it difficult or impossible to compare the results of successive inventories. Well-conceived monitoring is always the most practical, pragmatic and least-costly method of deriving time-series information, and has the most direct link to management. The relationship between the three activities is illustrated in the following figure:

RESEARCH ←----------→ INVENTORY ←----------→ MONITORING

←---------- *increasing cost per unit area* ----------
---------- *increasing use of selected indicators* ---------- →
---------- *increasing direct influence on management activities* ---------- →
←----------*increasing spatial intensity of data collection* ----------
←---------- *increasing complexity of data collection* ----------

In summary, *research* can provide a better understanding of cause and effect and the PSIR relationship; *inventory* provides a baseline or "snapshot in time" and a basis for selecting indicators for long-term monitoring; and *monitoring* relies on research and inventory results to provide relatively cheap and simple means of measuring trends and change in environmental condition over time.

2.6. Principles of Environmental Monitoring

However monitoring information is interpreted and presented for strategic policy and program development, the basic information must be collected through monitoring programs that conform to a number of principles:

- monitoring must have a focus or context, i.e. priority issues, predicted impacts;
- management objectives, management plans, environmental standards etc;
- monitoring must be formalized and statistically replicatable, with standards for sampling and reporting, defined responsibilities, and firm schedules;
- monitoring should focus on trends and change in environmental quality rather than on comprehensive description, linking (at least in an inferred way) present condition both to past quality and a desired future state;
- monitoring programs must be both feasible and affordable; and
- wherever possible, monitoring indicators should provide linkages between the environment and socio-economic development.

2.7. Linking Environmental Monitoring to Social and Economic Monitoring

Sustainable development may be described as a development strategy, characterized by prudence and vision, in which social, environmental and economic objectives are *balanced* to produce a community of lasting quality, harmony and prosperity. If that balance is to be achieved, it is vital that monitoring programs of social, environmental and economic condition be linked, and integrated at the points of linkage. As noted above, the PSIR model offers a means of developing these linkages, particularly in the important relationships between environmental health and public health and between environmental quality and economic activity. Table 2 provides simple hypothetical examples of these linkages (see Table 1 for additional examples).

Table 2: Linking Environmental, Social and Economic Monitoring Using the PSIR Framework

Environmental Issue	Pressure	State	Impact	Management Response
Eco-tourism and back-country recreation	• Increasing intensity of recreational use	• Site damage to soil and vegetation • Wildlife populations under stress	• Decreased recreational quality • Decreased economic opportunity • Increased wildlife/human interactions • Loss of biodiversity	• Determination of carrying capacity. • Limitations on visitor use • Introduction of recreational tenures with conditions • Provision of facilities and infrastructure to distribute use and reduce damage • Zoning and timing restrictions

Environmental Issue	Pressure	State	Impact	Management Response
Wood production	• Wood harvesting and processing capacity exceeds sustainable yields	• Deforestation and forest degradation	• Declining wood production and employment. • Loss of forest function and biodiversity	• Rationalize wood processing industry • Economic transition strategies for forest-dependent communities • Intensive plantation forestry on degraded forest lands
Air Quality	• Increasing air emissions from regulated and non-regulated sources	• Degrading air quality (i.e. ozone and respirable particulates)	• Increasing incidence of respiratory disease (P.M. 2.5 and ozone) • Vegetation (natural and agricultural) damage (ozone)	• Airshed planning. • More stringent emission standards • Burning bans. • Improved public transport • Fuel and vehicle taxes • Air quality alerts

3. THE LEGISLATIVE, POLICY AND INSTITUTIONAL CONTEXT FOR ENVIRONMENTAL MONITORING IN BRITISH COLUMBIA

3.1. "Business Drivers" for Environmental Monitoring

A new legislative initiative, that may have a more comprehensive impact on effectiveness monitoring programs than any existing legal instrument, is the "*Budget Transparency and Accountability Act"* (July 6, 2000). The Act requires every "ministry and government organization" to:

1) prepare an annual performance plan, which shall be made public, for the fiscal year and the following two fiscal years, such plans to include a statement of goals, specific objectives and *performance measures*; and

2) prepare annual performance reports, which shall be made public, comparing actual results for the preceding fiscal year with the expected results identified in that year's performance plan.

All Ministries are in the process of developing the performance measures required under the Act. For environmental and natural resource agencies, performance measures will essentially consist of environmental effectiveness monitoring indicators.

Beyond the requirements arising out of the *Budget Transparency and Accountability Act*, "business drivers" for environmental monitoring include such diverse instruments as:

- specific acts and regulations (including licences and permits that are issued under an act or regulation and that require environmental monitoring at a site level);
- international and national conventions and protocols;
- policy and program plans;
- strategic inter-agency planning programs;
- regional and sub-regional inter-agency planning processes; and
- local and operational plans.

These can be categorized as monitoring initiatives that are either:

1) explicitly required by legislation;

2) implicitly required by legislation;

3) required for policy or program development; or

4) required for planning processes.

Currently in BC, aside from *Budget Transparency and Accountability Act* requirements, no land / resource statutes "explicitly require" environmental monitoring, although there are a few potential exceptions presently under consideration. For example, it is expected that changes to protected area legislation will result in a legislated obligation for regular reporting by MELP on the state of BC's parks. This will require MELP to obtain access to various environmental information on ecosystem conditions in protected areas. It can be assumed that this mandated requirement will lead to some form of time-series monitoring of ecological integrity in BC's protected areas. Similarly, it is expected that the proposed new BC Commissioner of Environment and Sustainability will be empowered by law to report periodically on BC's environmental performance and condition. This will require the Commissioner, (as a user of monitoring information, not a generator of it) to obtain access to environmental monitoring information, most likely from line agencies. This may or may not result in an increased level of environmental monitoring in those line agencies.

Environmental monitoring is "implicitly required" by a few statutes that identify particular goals or objectives in the statutes themselves. For example, the *Forest Practices Code of British Columbia Act*, the *Growth Strategies Act*, and the *Environmental Assessment Act* contain various goals or objectives respecting future environmental conditions that the legislation aims to achieve. There is an implied expectation that time-series monitoring would occur to assess the extent to which these stated goals and objectives are being achieved; however, there is no specific requirement imposed on the responsible agencies to actually perform any monitoring, interpretation or reporting on goals achievement.

By far the greatest amount of environmental monitoring that presently occurs in BC is driven by agencies' individual needs for information to support their policy, programming, or planning functions and responsibilities. The consequence of having very few formalized (i.e., legislated) drivers for the ongoing collection of monitoring information is that environmental monitoring proposals have a hard time to compete with other spending priorities. If no requirements for long-term monitoring programs are imposed on budgeting decision-makers, it is very easy for environmental monitoring programs to succumb to other spending obligations and priorities. The lack of formalized business drivers for environmental monitoring is likely a main reason behind the past and current limited availability of good, time-series environmental monitoring information in BC. Although there is recently increased interest in and commitment to greater investment into monitoring programs that can generate good time-series environmental monitoring (e.g., vegetation change inventory and monitoring initiative), it remains to be seen if these programs can be sustained over the long-run without a more formalized foundation.

3.2. Agency Involvement in Environmental Monitoring

Agencies interviewed for this study, either as environmental data users or providers, can be categorized as follows in terms of their involvement in environmental monitoring, as shown in Table 3.

Table 3: Agency Involvement in Environmental Monitoring in BC

CATEGORY	AGENCIES
Data provider that is independent of a resource management function	• Geographic Data B.C. (MELP)
Data provider that is part of a management agency	• Resource Inventory Branch (MELP) • Resource Inventory Branch (MOFor) • Information Services Branch (MOFi) • Information Provision Branch (MOAA) (also an information user / analyst)
Management agency with its own data collection capacity	• Air Resources Branch (MELP) • Pollution Prevention and Remediation Branch (MELP) • Wildlife Branch (MELP) • Parks and Ecological Reserves Management Branch (MELP) • Crown Lands Branch (MELP) • Water Management Branch (MELP) • Public Health Protection Branch (MOH)
Management agency with an associated data provider.	• Habitat Branch (MELP) • Fisheries Management Branch (MOFi) • Forest Practices Branch (MOFor) • Strategic Planning and Policy Branch (MOFor) • Timber Supply Branch (MOFor) • Implementation Branch (MOAA)
Agency with trend analysis / reporting responsibilities	• Corporate Policy Branch (MELP) • Forest Practices Branch (MOFor) • Inter-agency Management Committees (Land Use Coordination Office) • Commissioner of Environment and Sustainability (Auditor General)
Management agencies with no associated data provider (rely on secondary data)	• Tourism Policy and Land Use Branch (MSBTC) • Green Economy Secretariat • Growth Strategies Office (MMA) • Environmental Assessment Office • Fisheries Renewal B.C. • Risk Assessment and Toxicology Branch (MOH) • Implementation Branch (MOAA)
Agencies that fund inventory and monitoring initiatives	• Forest Renewal BC • LUCO • MAA

MELP = Ministry of Environment, Lands and Parks
MOFi = Ministry of Fisheries
MSBTC = Ministry of Small Business, Tourism and Culture
MMA = Ministry of Municipal Affairs
MOFor = Ministry of Forests
MOH = Ministry of Health
MAA = Ministry of Aboriginal Affairs

All of the agencies interviewed for this study have their own unique needs, however, a number of generalizations can be made on the basis of the different types of organizations reflected in the table above:

1) a diverse array of agencies want to access environmental monitoring data in one form or another;

2) many organizations have no forum in which to express their monitoring information needs, or access to funds that would allow them to “influence” data collectors;

3) several agencies are requesting information that may not have been collected to suit their particular needs;

4) some agencies lack a technical information group to assist in data management and interpretation and, conversely, others (i.e., data providers) lack the business case expertise to develop monitoring products;

5) there is no corporate or inter-agency body (as there currently is for inventory — LIICC / RIC) to champion, integrate and coordinate environmental monitoring initiatives for the province.

4. THE GENERATION OF ENVIRONMENTAL INFORMATION IN BRITISH COLUMBIA

This chapter describes existing or proposed environmental *monitoring* initiatives that produce time-series environmental information that may be used for various purposes, including: strategic / program planning; environmental and sustainability trends interpretation and reporting; and assessing the effectiveness of programs, policies, plans, etc. in achieving their underlying objectives. Also described here are selected *inventory* initiatives where it was apparent from study interviews that inventory information will be used as a monitoring baseline.

Monitoring initiatives are organized in four categories: atmospheric resources, aquatic resources, terrestrial resources, and cross-sectoral land use / land condition monitoring initiatives. Within each of these categories, information is provided on business drivers, indicators within the PSIR framework for which monitoring information is / will be available, sources of monitoring information, primary users of the monitoring information, and primary data deficiencies and needs. At the end of the chapter, a summary is provided of the status of provincial monitoring initiatives. (See chapter 5 for a detailed look at agencies' information requirements as derived from the specific environmental indicators that agencies wish to track over time.)

4.1. Atmospheric Environmental Monitoring

Business Drivers

Current atmospheric monitoring initiatives focus primarily on two environmental issues: air quality and public health; and *global climate change*.

Air quality monitoring is not specifically required by legislation but is necessary to provide a context for air emission standards in permits issued under the authority of the Waste Management Act. Air quality monitoring is further driven by the National Air Pollution Surveillance (NAPS) program for urban air quality, the need to demonstrate compliance with the Canada Wide Standards (CWS) for ozone and suspended particulates, and the need to provide information to the public on serious air quality episodes and in the event of environmental emergencies.

Climate change monitoring is driven by Canada's commitment to greenhouse gas reductions under the Kyoto Protocol. Monitoring responsibilities are shared with the Government of Canada, with the province's responsibilities now detailed in a three-year "Climate Change Business Plan". Meteorological monitoring, carried out in conjunction with air quality monitoring, supports activities to address both issues: providing information for pollutant dispersion modelling and regional / local airshed management; and long-term climatic records to monitor changes.

Indicators

Provincial agencies have expressed a need / desire to monitor the following types of atmospheric resource indicators. See Appendix 4 for a more detailed description of indicators and associated environmental information requirements.

Issue	Pressure Indicators	Condition Indicators	Impact Indicators	Response Indicators
Air Quality	• Emission source inventory • Compliance records • Dispersion models	• Ambient air quality monitoring network • (P.M. 10, P.M. 2.5, ozone, CO, NO_x, SO_2, TRS). • Meteorological monitoring network	• Public health statistics on morbidity and mortality from respiratory diseases	• Frequency and distribution of air quality alerts • Number and extent of airshed plans
Climate Change	• Inventory of greenhouse gas emission sources and amounts • Dynamics of carbon sinks and sequestration in natural and agricultural systems	• Long-term climatology and meteorology monitoring and modeling	• Ecological monitoring *(i.e. extent of snow and ice fields, frequency of natural wildfires, frequency of stress-related forest insect and disease attack, changes in fish species composition and abundance)* • Economic monitoring *(i.e. frequency and extent of economic losses due to extreme climatic events)*	• Implementation of the B.C. Climate Change Business Plan *(i.e. energy and industry, transportation, communities and buildings and forests and agriculture, and supporting action strategies)*

Sources of Information

Air quality and meteorological monitoring information is collected and managed by MELP and by the Greater Vancouver Regional District (GVRD). GVRD currently has the highest density of air quality monitoring stations in the province. Outside GVRD, air quality stations are either operated directly by MELP (34 sites), by industrial operations operating under waste management permits (44 sites) or in partnership (6 sites). Of these, 42 sites also provide a standard range of meteorological data. Information from all sources is stored in a separate data management system maintained by the Air Management Branch of MELP. Additional meteorological information for B.C. is available from the federal network maintained by Environment Canada.

Greenhouse gas inventories are currently estimated by Environment Canada with information provided by MELP, Statistics Canada and industrial partners.

Primary Information Users

Air Quality: MELP (Headquarters and regions), GVRD, Risk Assessment and Toxicology Branch (MOH), Regional Medical Health Officers, Environment Canada.

Climate Change: MELP, MEM, MEI, MOA, MOFor, MOFi, MOH, MOMA, MOTH, MCDCV, MFCR, Green Economy Secretariat, BC Hydro, BCBC, Crown Corporations Secretariat, Purchasing Commission, GVRD, BCTFA. (All contributing agencies to the B.C. Climate Change Business Plan).

Data Deficiencies and Needs

Air Quality: Data deficiencies identified by MELP and MOH relate to both the amount and type of information collected. Current geographic distribution of monitoring stations is inadequate, particularly in the interior of the province. Monitors are provided by the federal government under NAPS but operational and maintenance costs must be borne by MELP, GVRD and industrial partners. This leads to anomalies such as no monitoring in some interior communities (because of limited MELP funding) and three times the number of stations in Prince George where financial support comes from industry.

In terms of the types of information available: PM_{10} is relatively good; $PM_{2.5}$ is very scarce and represents the most important current data deficiency; ozone information is very sparse with not nearly enough stations at a time when research is indicating that ozone is second only to suspended particulates in terms of public health concerns; and there is little or no monitoring of toxics and acid deposition. Health science information (and thus the information medical health officers would like) is progressing faster than monitoring technology and design, particularly in the areas of the effects of different sizes of pollutant particles (it is not possible, for example, to sample for both fine and coarse respirable particulates with one monitor) and the synergistic effects of different pollutants. MOH and MELP are currently cooperating on studies to provide: 1) up-to-date summaries of scientific information on the relationship between common air pollutants (both individually and in mixtures) and human health, and 2) risk assessment methods that have been or could be used to estimate impacts of air pollution on human health. These studies would be used to up-grade monitoring techniques and abatement priorities.

Global Climate Change: Monitoring associated with global climate change is currently in very rapid development and change. The Climate Change Business Plan calls for improvements to monitoring in three areas. First, the province will work with the federal government and industry to improve the accuracy of greenhouse gas inventories. Second, MOFor will work to develop a forest carbon accounting framework and forest carbon budget modelling, and MOFor/MAF will develop programs to monitor carbon sequestration and release in forest and agricultural soils. Third, the Corporate Policy Branch of MELP in cooperation with other agencies has initiated a contract to determine relevant ecological and economic indicators of climate change for long-term monitoring.

4.2. Terrestrial Environment Monitoring

Business Drivers

Terrestrial environment monitoring involves the generation of time-series data for soils, vegetation and wildlife and wildlife habitat resources.

Soil Resources: BC currently has no specific, comprehensive program to monitor the condition of the provincial soils resource (e.g., amount of erosion, organic content, soil moisture, etc.), although MOF's Vegetation Change Inventory and Monitoring Initiative (driven by the National Forest Inventory initiative) should include some site-level, time-series monitoring of selected forest soils attributes. In addition, some local / regional information (e.g., Kamloops forest region) may be available, for example, on turbidity levels which would be an indication of soil erosion. As well, some time-series data is available that enables an interpretation of soils condition, vis a vis certain land use activities (primarily forestry). For example, existing time-series information on the area of land that has been subject to timber harvesting, or the length of new forestry roads constructed, enables inferences to be drawn about soil condition.

The business drivers for collecting this sort of data are based primarily in agencies' administrative / management programs – there is no direct legal drivers that explicitly require agencies to monitor soil condition (other than what might occur at the site / tenure level where soil / erosion control may be an explicit permit condition that requires some site-level monitoring for the life of the permit / tenure). There are, however, implicit requirements in certain statutes that may serve as business drivers for soil monitoring initiatives. In particular, the *Forest Practices Code of British Columbia Act* and Code regulations and guidelines would suggest a need to track soil condition over time. Also, if a higher level plan is adopted under the code that makes reference to soils management, then there is an implied requirement for soils monitoring, although this would likely occur through the strategic land use plan (LRMP) effectiveness monitoring program. Operational planning under the Code requires forest planners to consider soils information (terrain stability / hazard mapping) but monitoring of soils *per se* is not a requirement of operational planning.

A further, recent potential business driver for soils monitoring (and other environmental resources) are the environmental goals defined in the *Growth Strategies Act*, now incorporated into the new municipal act (*Local Government Act*), the *Islands Trust Act*, the *Agricultural Land Commission Act,* and the *Vancouver Charter*. These statutes now require local government planning to accommodate provincial goals of protecting environmentally sensitive areas, maintaining the integrity of the resource base, and reducing and preventing air, land and water pollution. Again, although there is no explicit requirement in this for soil, air, water, etc. monitoring, there certainly is an implied requirement.

Finally, with respect to business drivers for soils, legislation does exist to regulate contaminated sites, and this involves record-keeping on the number and location of contaminated sites in BC. It should be possible to produce time-series information on

contaminated sites from this information to satisfy the legislation's implied need to assess program effectiveness in controlling soils contamination.

Vegetation Resources: As noted above, program has been recently initiated to monitor change in vegetation resources condition – the "Change Inventory and Monitoring of Vegetation Resources" initiative. This is in addition to standard MOF vegetation resources inventory, from which some limited time-series information on vegetation condition may be derived.

The Change Inventory and Monitoring initiative is driven primarily out of the business need to provide data to meet National Forest Inventory (NFI) goals that are aimed, among other things, at supporting the Canadian Council of Forest Minister's (CCFM) commitment to produce national level reports on the status and trends of the sustainable forest management (SFM). This monitoring initiative is also being undertaken to contribute to in-province programs such as timber supply analysis, forest certification and provincial State of the Forests reporting, which are important business drivers in their own right. Data from this program should also be able to support assessments of the effectiveness of the Forest Practices Code in achieving the sustainable forest use goals that underlie the Code, as expressed in the *Forest Practices Code of British Columbia Act* preamble (e.g., "conserving biological diversity, soil, water, fish, wildlife, scenic diversity and other forest resources; restoring damaged ecologies"). At present, no provincial organization is directly assessing the various aspects of the Code (e.g., biodiversity guidebook old forest retention percentages, identified wildlife conservation strategies, riparian buffer standards, watershed assessment provisions designed to protect soil / water resources, etc.) in terms of the extent to which these provisions are achieving the Code's basic goals. The Forest Practices Board, however, reports that it is considering identifying performance indicators that would be used for this purpose.

Wildlife Resources: Although various wildlife inventory data is available for BC, there is relatively limited time-series monitoring data on wildlife populations and habitats. Perhaps the most comprehensive information on wildlife condition is held by MELP's Conservation Data Centre which retains information on rare, threatened and endangered species. Collecting this information is driven out of MELP's wildlife management program needs, and to contribute to national level information that, in turn, is collected to meet Canada's international biodiversity convention obligations.

Time-series information on wildlife habitat availability will eventually be available through the Vegetation Change Inventory and Monitoring Initiative (see above) – i.e., forest cover by species, forest age, etc. – and some strategic-level habitat monitoring information (i.e., changes in broad vegetative patterns) can be derived from MELP's baseline thematic mapping (BTM) initiative. The BTM program has been primarily driven out of a need to serve strategic land use planning requirements.

Population trends information is available for certain bird species as a result of historic and current surveys that are done by and in cooperation with the Canadian Wildlife Service (e.g., breeding bird, migratory bird surveys). Internal and international resource conservation priorities are the primary business drivers for the collection of this monitoring information.

Again, the above-noted new *Local Government Act* is another potential implicit business driver for wildlife and wildlife habitat resources monitoring. Non-legislative business drivers include forest certification and the various trends interpretation / effectiveness monitoring initiatives.

Indicators

Provincial agencies have expressed a need / desire to monitor the following terrestrial resource indicators. See Appendix 4 for a detailed description of indicators and associated environmental information requirements.

Issue	Pressure Indicators	Condition Indicators	Impact Indicators	Response Indicators
Soils	• road density • harvesting or road building activity on steep slopes or unstable terrain • number and distribution of landslides • number and distribution of contaminated sites	• soil fertility (organic matter, nitrogen and phosphorus content, etc.)	• number and distribution of land slides and erosional landscapes	• number and distribution of watershed rehabilitation projects • number and distribution of contaminated sites remediation projects
Vegetation	• area / volume harvested (by various silviculture systems)	• area and distribution of forest types (by biogeoclimatic zone and ecoregion) • age class / seral stage distribution • patch / gap distribution • total biomass levels • rate / volume of forest growth • timber harvesting land base vs area managed for protective functions	• forest health (area and distribution of diseased forest) • distribution and aerial extent of degraded and converted terrestrial ecosystems • area / distribution of forest vegetation disturbed • number and distribution of plant species at risk	• number and distribution of vegetation restoration projects • numbers of plans, designations, etc. to protect sensitive vegetative resources
Wildlife	• wildlife harvest (hunting and trapping)	• population status and trends for selected species	• number and distribution of animal species at risk • change in population levels for selected species (e.g., birds, amphibians, mammals)	• nature and distribution of harvest restrictions • number of species classified as “at risk” / “identified wildlife”
Wildlife Habitat	• habitat degradation (changes to structural and spatial diversity)	• distribution and trends in habitat availability for selected wildlife	• trends in the historical range of selected species	• area and distribution of administrative wildlife habitat

Issue	Pressure Indicators	Condition Indicators	Impact Indicators	Response Indicators
	• destruction of "keystone" habitat features (wetlands, old growth, grasslands, nest sites, mineral licks, hibernacula, etc.) • habitat fragmentation (road density)			designations (e.g., ungulate winter range, wildlife habitat areas, sensitive ecosystems)

Sources of Information

Soil Resources: No comprehensive monitoring information is presently being collected on the condition of the province's soil resources. Soil and surficial geology surveys have been carried out in many areas of the province, but there is no reliable, time-series information on change to the condition / quality of either forest or agricultural soils. The Vegetation Change Inventory and Monitoring Initiative (see below) is expected to provide time series measurements on some selected soil indicators. The Pollution Prevention and Remediation Branch, MELP maintains a comprehensive register of contaminated sites in the province.

Vegetation Resources: Forest type maps (focusing on commercial timber species) have been maintained by the Ministry of Forests for many years. Terrestrial ecosystem maps (TEM) and predictive ecosystem maps (PEM) have been produced by the Resource Inventory Branch of MELP. A proposed new initiative is the provincial participation in the national forestry database program which is expected to begin to soon generate time-series information. — the Vegetation Change Inventory and Monitoring initiative involves measuring the condition of various forest attributes at 2,400 permanent, 2 km by 2 km, air photo assessment plots on a 20 km grid covering the province. Existing GIS data will be assigned to the photo assessment plots (e.g., TRIM, BEC). Re-measurement will occur every 10 years to detect change in forest condition within the plots and this sample information will then be extrapolated to define forest conditions more broadly throughout the province. Data derived from the air photo plots is intended to address up to 30 of the CCFM criteria and indicators for SFM.

To obtain stand-level information that cannot be generated from the air photo plots, over 300 fixed ground sample plots (0.4 ha in size) will be established to measure full vegetation resources inventory attributes such as vegetative species, tree height, decay, coarse woody debris, etc. This level of monitoring, repeated every five years, will produce information that will enable reporting on an additional five CCFM indicators. This monitoring data will also be used in provincial growth and yield monitoring, which is used ultimately for AAC determination purposes.

Wildlife Resources: The Wildlife Branch, MELP has historic population information on a large number of wildlife species derived from both regular and irregular wildlife surveys. The Canadian Wildlife Service (CWS) maintains similar records for migratory birds and marine mammals. The Conservation Data Centre, MELP is part of a national and

international network. It accepts and utilizes data from MELP, CWS and any other verifiable sources to assess population status for a whole array of species, and produces regular assessments of the status of red and blue listed species.

Terrestrial Habitat: Historic habitat capability maps are available from MELP, primarily for ungulate winter ranges. Terrestrial and predictive ecosystem maps (TEM and PEM) are available from MELP and are used to make interpretations on habitat capability and present condition for a broad array of species. The "Identified Wildlife Strategy" under the Forest Practices Code delineates important habitat areas for red and blue listed animals, vascular planTs and plant communities. Several initiatives have been completed or are underway to identify "sensitive ecosystems" in relation to local government planning. The east coast of Vancouver Island, the Gulf Islands, and Greater Vancouver Regional District have been completed, and an inventory of the Sunshine Coast is now underway. These sensitive ecosystem inventories will provide templates for private lands in the rest of the province. All of these habitat inventories taken together may provide a baseline for long-term monitoring of terrestrial habitat, but they do not represent time-series monitoring initiatives per se.

Primary Information Users

Primary users of terrestrial environmental information will be MELP program managers (Water, Pollution Prevention, Habitat, Lands, Parks), MOH, MOFi, MOF, MEM, MMA, FiRBC, ForBC, EC, DFO, Local government, and a wide array of industrial operations.

With respect to the Vegetation Change Inventory and Monitoring Initiative, the resultant information will be used primarily to construct national and provincial-level reports on the state of Canada's / BC's forests (using CCFM criteria and indicators, and BC State of the Forests indicators frameworks). This monitoring information may potentially also be used by a number of other potential users for various applications, including:

- other provincial-level reporting initiatives (e.g., Environmental Trends, LRMP and landscape unit plan effectiveness monitoring);
- land use planning initiatives to describe the planning base-case and to assess optional land use scenarios;
- FRBC to assess the effectiveness of their investments in achieving their goals to increase forest productivity;
- the Forest Practices Board to assess the effectiveness of the Forest Practices Code in achieving it's stated aims;
- the Ministry of Forests and the Chief Forester to improve the quality of AAC determinations.
- forest companies and forest certification auditors in assessing forest management performance in relation to forest certification standards, and
- BC's model forest boards in assessing the condition of their forests in relation to local-level SFM criteria and indicators that they have identified for their forests.

Data Deficiencies and Needs

Soil Resources: The Ministry of Agriculture and Food identified a need for government to monitor the amount of carbon sequestration in soils (agricultural and forest soils) in order to assess the degree of Canada's contribution to the Kyoto protocol. Although this Ministry would like to be able to monitor the organic and nutrient content of agricultural soils in order to better understand the effectiveness of programs / initiatives to improve or maintain soil quality, there are currently no programs in place to provide such data. Monitoring data should be available in future for forest soils through the Vegetation Change Inventory and Monitoring Initiative. "Pressure" and "impact" information relating to soil erosion and landscape instability may be available from BTM thematic mapping produced by Geographic Data BC.

The Ministry of Forests, as part of the State of the Forests reporting initiative, has indicated a need for monitoring information on the percentage of harvested areas with significant soil compaction, displacement, erosion, puddling and loss of organic matter. There is also interest in monitoring the area and distribution of soil restoration activity. Given that time-series measurements of forest soils condition is an element of the CCFM criteria and indicators for SFM, these MOF information needs should eventually become available through the MOF / National Forestry Database "Change Inventory and Monitoring Initiative for Vegetation Resources".

Vegetation Resources: Forest type maps focus primarily on commercial timber species, are of uncertain reliability in some locations and are lacking in some locations (e.g., older protected areas). As well, forest inventories have been incrementally upgraded over time, thus losing the capability of providing trends in vegetation change over time. Terrestrial and predictive ecosystem (the distinction relates to the greater amount of ground-truthing TEM mapping) mapping by MELP is much more ecologically relevant, but currently covers only 25% of the province and is useful as a baseline only. Complete provincial coverage and some time-series information on the general spatial distribution / patterns of broad forest age classes within ecoregions is available through the BTM and Watersheds BC initiatives. This monitoring source is potentially very useful for provincial or regional level assessments of vegetative condition; there are, however, limitations on the level of detail that is appropriately interpreted form this monitoring information given that it is derived primarily from satellite imagery. As well, although BTM coverage exists for all of the province (1992-98 data), a second "pass" is only approximately 20% complete, and this limits the ability to interpret time-series change.

The currently-being-developed "Change Inventory and Monitoring Program for Vegetation Resources" should, in future, be able to produce solid monitoring information for a variety of indicators of forest vegetation condition, both at the broad level of measuring spatial patterns, and at the stand level of measuring structural characteristics. This initiative may potentially also provide information on non-commercial species for which information has been historically limited. The ability to use this monitoring data may have some limitations, however, when it comes to reporting on all indicators of interest. For example, accurate provincial-level measurements of forest cover distribution by BEC variant, or forest cover distribution in

protected areas (both of which are proposed State of the Forest monitoring indicators) may be limited on account of the non-random grid pattern of monitoring measurements.

Finally, some non-spatial information on vegetation resources (e.g., harvestable volumes) are available from MOF analyses that are conducted on a five year cycle for timber supply review planning purposes. This information may be valuable for measuring or verifying certain indicators of interest for province-wide state of forests reporting purposes.

Wildlife Resources: Historic wildlife surveys, whether by MELP or CWS, are difficult to interpret as trend information, except over very long time periods, because the number of animals counted at any time is primarily dependent on conditions (i.e., weather) at the time of the survey. Relatively little data compiled by the Conservation Data Centre is true "time-series" information; most is from single-point-in-time inventories which, in aggregate, are used to assess trends. CDC information is not yet really monitoring data, but can be used to develop indicators and monitoring programs. Time-series information for measuring pressure and response indicators for wildlife resources are generally available from MELP administrative records.

4.3. Aquatic Environment Monitoring

Water Quantity: The primary drivers of water quantity monitoring are:

1) the need to provide a context for water allocation decisions under the Water Act and waste discharge permitting under the Waste Management Act;
2) estimation of in-stream flow requirements for fish and other aquatic resources;
3) annual flood forecasting and local government flood prevention zoning; and
4) hydrologic design information for infrastructure, industrial and residential facilities.

Water Quality: The principle drivers for water quality monitoring are:

1) drinking water safety (i.e. standards related to regulated water utilities, water quality objectives for community watersheds relating to provisions under the Forest Practices Code Act, and water quality of domestic wells); and
2) the need to provide a context for industrial and municipal waste discharges in terms of guidelines and objectives for designated water uses (drinking, recreation, irrigation, livestock watering, aquatic life and wildlife). An informal driver in relation to drinking water quality was the 1999 Auditor General's report that was very critical of the provincial government's efforts to ensure drinking water safety.

Fisheries: The primary driver for fish stock and habitat quality monitoring is the Fisheries Act (Canada) and a Ministerial memorandum of understanding by which the federal government has delegated the management of sports-fish to the province. A recently-established Pacific Fisheries Resource Conservation Council has the responsibility to report publicly to the two levels of government on stock status and habitat quality on the

basis of inventory and monitoring information provided by MOFi and Fisheries and Oceans Canada. Secondary legal drivers are the International Convention on Biological Diversity, the federal legislation protecting species at risk (if passed) and the provincial Wildlife Act in relation to non-commercial and non-sport fish. Two major initiatives funding fisheries rehabilitation - Fisheries Renewal BC and a new provincial proposal for Watershed-based Fish Sustainability Planning (WFSP) will also generate significant demand for monitoring information.

Aquatic Habitat: Until recently, aquatic habitat inventory and monitoring has been primarily fisheries-focused. The new provincial Fish Protection Act, however, places increased emphasis on aquatic habitat and is thus likely to generate special monitoring requirements on designated "sensitive streams". Some water bird and aquatic mammal habitat inventories have been carried out to meet federal Migratory Bird Convention Act and provincial wildlife program requirements. The international biodiversity convention and the proposed federal species-at-risk legislation may stimulate a more holistic approach to aquatic habitat inventories and monitoring.

Indicators

Issue	Pressure Indicators	State Indicators	Impact Indicators	Response Indicators
Water Quantity	• number and volume of water licences and licence applications • number and distribution of requests for hydrological design information	• hydrometric network • snow survey network	• frequency, extent and distribution of economic losses due to hydrological events	• number and extent of water allocation plans
Water Quality	• number, quality and compliance records of point-source discharges • land area occupied by uses with potential water quality impacts	• surface water and groundwater quality monitoring network (dissolved solids, hardness, trace elements, chlorophyll a, nutrients, nitrate, pH, sediments, fecal coliforms, cyanide, AOX, temperature, dissolved gases and dissolved oxygen) • drinking water quality monitoring of regulated utilities (microbiology, protozoans, metals, major ions, nitrate)	• public health statistics on frequency and distribution of water-borne disease	• frequency and distribution of "boil water" advisories • number and distribution of community watershed plans
Fisheries	• fish harvest information	• population status and trends for anadromous, sport, non-commercial and at-risk species	• population declines • declines in fisher effort, total catch and catch/unit effort	• number and distribution of stock recovery programs

Issue	Pressure Indicators	State Indicators	Impact Indicators	Response Indicators
Aquatic habitat	• watershed stability (land use, land cover, road and stream crossing densities and hydrological characteristics)	• productivity and biodiversity indicators for aquatic and riparian ecosystems • fish habitat inventories • length of streams by watershed • length of known salmon / sportfish / other fish streams • lengths of streams with gradient<20%	• extent, distribution and trends in riparian and aquatic ecosystem degradation	• number and distribution of watershed, stream and fish habitat rehabilitation projects

Sources of Information

Water Quantity: Hydrometric information for the province currently comes from a network of approximately 490 stations (down from over 600 five years ago). Stations are operated by MELP, EC, B.C. Hydro, local governments and industrial operations, with data stored and managed by Resource Inventory Branch, MELP.

Water Quality: Water quality information is available from two primary sources: general environmental monitoring programs; and drinking water utility monitoring. General environmental monitoring includes:

1) a long-term federal / provincial monitoring agreement assessing trends for 29 sites on major lakes and rivers;
2) community watershed objectives-setting baseline monitoring on 64 of the province's 450 designated watersheds;
3) yearly groundwater monitoring on 120 wells; and
4) extensive ambient water quality monitoring associated with permitted industrial and municipal waste discharges.

Drinking water quality monitoring is a requirement of the Ministry of Health for the approximately 3,500 water systems serving 15 or more connections. The primary focus of this program is tap water (i.e., after treatment and distribution). Availability and quality of water source (or ambient environment) information is highly variable. MOH aims to have, as a minimum, a baseline measurement consisting of a broad scan of biological and chemical parameters and at least one annual sample for each regulated utility.

Fisheries: Fisheries inventory and monitoring information is available from the Ministry of Fisheries for sport and non-commercial fish and from the Department of Fisheries and Oceans for commercial anadromous and marine fish.

Aquatic Habitat: Ecological aquatic inventory information is available on stream-specific basis from the Ministry of Fisheries and the Fisheries and Oceans Canada. This information covers only a relatively small portion of the province and is not time-series. Some "pressure" information on aquatic habitats can be determined from analyzing some existing information sets (e.g., road densities, terrain stability mapping, watersheds at risk), however, there is a need to ensure inter-agency agreement on data and analysis of that information. The physical information on total stream length and stream lengths by gradient and known fish presence are contained in the Fish Information Summary System (FISS) component of the Atlas (see the section on Land Tenure and Use for a fuller discussion of the Watersheds Atlas project).

Primary Information Users

Water Quantity: MELP managers (Water, Pollution Prevention, Habitat, Lands), MOFi, MOFor, MOEM, MOTH, MOMA, ForRBC, FiRBC, EC, DFO, Local Government, B.C. Hydro, wide array of industrial operations.

Water Quality: MELP managers (Water, Pollution Prevention, Habitat, Parks), MOH, Regional Medical Health Officers, MOFi, MOFor, MOEM, FiRBC, ForRBC, EC, DFO, Local Government, wide array of industrial operations.

Fisheries: MELP managers (Water, Pollution Prevention, Habitat, Lands), MOH, MOFi, MOFor, MOEM, MOMA, FiRBC, ForRBC, EC, DFO, Local Government, wide array of industrial operations.

Aquatic Habitat: MELP managers (Water, Pollution Prevention, Habitat, Lands, Parks), MOH, MOFi, MOFor, MOEM, MOMA, FiRBC, ForRBC, EC, DFO, Local Government, wide array of industrial operations.

Data Deficiencies and Needs

Water Quantity: Hydrometric data is of high quality, carried out to national standards established by federal / provincial agreement, however, these standards make hydrometric monitoring very expensive, thus limiting the number of stations that can be established. The province currently has about 490 stations. United Nations' criteria for developing countries indicate that for a jurisdiction as climatically and geographically diverse as B.C. a minimum of 800 (and ideally 1,400) stations would be appropriate. There is a need for a federal / provincial protocol to allow simpler stations to be established, linked to the comprehensive network, to extend coverage at an affordable cost. Much of the cost of current monitoring is borne by FRBC and if this funding support is removed, MELP will be unlikely to fill the gap. There is an urgent need to develop a long-term funding arrangement, requiring all users to contribute, for this important monitoring function.

Water Quality: Despite the large number if sampling sites described above, most have not been sampled frequently enough (sites vary from periodic grab samples to established stations) to provide real time-series information. The last water quality trends analysis

(2000) prepared jointly by Environment Canada and MELP was based on 5-10 years of monthly sampling on 68 sampling sites, and represents the best trend information available for BC water bodies. Because of cost-cutting by both agencies, fewer than 20 of these stations are still being monitored. Beyond these stations, where water quality monitoring is issue / problem driven and permit-focused, the data is reasonable, though monitoring is much less frequent and, because it's largely reactive, is not broad enough to detect emerging problems.

Drinking-water quality monitoring is far too infrequent to be adequate, particularly for microbial and protozoan measurements which tend to vary widely over short time periods in response to discrete storm and run-off events. MOH intends to increase the number and frequency of source-water sampling but existing source information can't be melded with the MELP database because it isn't geo-referenced to any recognized watershed or stream coding system. MELP and MOH are currently cooperating to correct this problem.

Fisheries: Freshwater fish population monitoring has in the past been focused on specific stocks, and was largely project and crisis driven (i.e. sturgeon, steelhead, Kokanee). There has been no organized, standardized long-term monitoring program. DFO is currently revising its monitoring programs (particularly escapement) to impose standard methodologies and is "quality-labelling" previous data to determine what can be incorporated in the new system. MOFi may adopt these DFO methodologies. In addition MOF has recently submitted proposals to FRBC to fund a project to develop indicators of fish sustainability in forest ecosystems, a component of which centres on trends in population status for recreational / commercial and "keystone" non-managed species.

Aquatic Habitat: Currently there is no accepted aquatic ecosystem classification system in B.C. that can provide a context for either inventory or monitoring. In 1994 a sub-committee of RIC proposed a classification hierarchy (ecoregion; biogeoclimatic unit; aquatic ecosystem; stream segment or lake; channel or lake unit; microhabitat) but this proposal was not pursued. Subsequent work has been done regarding watershed and stream reach classification as part of the ForRBC resources inventory, watershed restoration program and FPC implementation, however these often have a forest management rather than a fisheries/aquatic ecosystem focus. MOFi has recently proposed to ForRBC fund for a project that would build upon existing experience to develop an aquatic ecosystem classification system and a broad, province-wide (1:50,000) description of habitats that "will provide a baseline documenting the amount and distribution of aquatic ecosystem types for application to the monitoring of habitat productivity and biodiversity". The proposal stresses the need to link aquatic and terrestrial environments through watershed unit descriptions because "aquatic ecosystems are dependent on conditions and processes in the surrounding watershed". The pressure and state indicators provided in the Geographic Data B.C. watershed atlas provide much of this watershed information.

4.4. Land Tenure and Use

Business Drivers

Information on land tenure (private and crown) and land use / and cover is fundamental to all levels of resource planning from provincial policy and program planning, to regional, sub-regional, landscape and local area plans. Reliable, time-series information on tenure, use and cover was one of the most frequently cited monitoring need by interviewees in this study.

Indicators

Provincial agencies have expressed a need / desire to monitor the following land tenure / use indicators. See Appendix 4 for a detailed description of indicators and associated environmental information requirements.

Issue	Pressure Indicators	State Indicators	Impact Indicators	Response Indicators
Land administration	• number and distribution of tenure applications for Crown land	• land tenure (private) and administrative zonation (Crown)	• alienation of important habitat. • encroachment on riparian areas and floodplains • pressure on water resources	• number and distribution of crown land disposition plans
Land use / land cover.	• area of harvesting (total and by harvesting systems), by elevation and by steep slopes) • road density (total, steep slopes and within 100m of streams)	• land use and land cover (mapping and statistics for 20 land use and vegetation cover classes)		

Sources of Information

Land Administration: Information on land tenure and jurisdiction is available from the crown lands registry information system. The Crown Lands Branch and Crown Land Registry Services of MELP have produced land administration statistics for the province for two reporting periods (1989 and 1996). The reports contain information on land tenure issuance, land in private ownership, and various land use designations. The BC Assets and Lands Corporation can provide information on the number and distribution of applications by tenure type for Crown lands, with information derived from the Crown Land Registry Information System.

Land Use / Land Cover: Geographic Data B.C.'s Baseline Thematic Mapping (BTM) program provides comprehensive, province-wide information (mapped and statistical) on land use / land cover based, variously across the province, on sources from 1992 to

1998. Work is presently underway to produce a second generation of this data which will enable some time-series interpretation.

Primary Information Users

Information on both land administration and land use / land cover is required by: MELP managers (Water, Pollution Prevention, Habitat, Lands, Parks), MOH, MOFi, MOFor, MOEM, MOMA, FiRBC, ForRBC, EC, DFO, Local Government, wide array of industrial operations.

Data Deficiencies and Needs

Land Administration: The last report on land administration statistics produced by MELP was in 1996. There is a need to up-date this publication, particularly in view of the significant changes in crown administration resulting from the protected areas strategy and recent crown land dispositions by BC Crown Lands and Assets Corporation.

Land Use / Land Cover: The Geographic Data B.C. Watershed Atlas utilizes the MOFi watershed coding system to summarize and present information. The atlas incorporates road, waterbody and topographic (slope, aspect, and elevation) information from 1:20,000 TRIM base mapping, and land use / land cover information in 20 broad use / cover classes for units down to 15 ha in size from 1:250,000 BTM. The maps and statistics also document fish distribution and habitat, location of all community watershed as defined under the Forest Practices Code, biogeoclimatic and ecosection zonation, producing mines and mining-related activities and Crown vs private land.

Geographic Data BC has produced a map series and associated spread sheets which utilize the Ministry of Fisheries watershed coding system to summarize and present information on a watersheds basis. Maps incorporate road, water body and topographic (slope, aspect and elevation) information from 1:20,000 TRIM base mapping, and land use / land cover information in 20 broad use / cover classes for units down to 15 ha in size from 1:250,000 BTM. The maps and statistics also document fish distribution and habitat, location of all designated watersheds, as defined under the Forest Practices Code, biogeoclimatic and ecosection zoning, producing mines and mining-related activities, and Crown versus private land. Some time series information will be available from the next generation of this material, anticipated in 2002. In addition to the basic use / cover data, a number of interpretive themes have also been developed such as percent of watershed logged, percent logging on steep slopes, percent residual old growth, kms of streams logged to bank, road density, road density on steep slopes and road / stream crossing density.

4.5. Summary of Current Status of Monitoring Initiatives

Interviews carried out during the course of this study, with both data users and data providers, indicate that there are very few established monitoring programs, and that other types of environmental information applicable to monitoring programs vary widely in both reliability and

spatial coverage. The following tables summarize our interpretation of the current status of environmental monitoring initiatives according to the following six categories:

1) Monitoring programs well established and under continual review. Reliable, time-series information available for 5 years or more.
2) Time-series information exists. Requires compilation and interpretation.
3) Reliable, extensive inventory information exists that could provide a baseline for monitoring.
4) Inventory information fragmented and incomplete, but collected to consistent standards. Could function as a reliable baseline with extended coverage.
5) Inventory information fragmented and collected to inconsistent standards. Does not provide a reliable baseline.
6) Firm initiatives underway to establish monitoring indicators and design monitoring programs.

Atmospheric Environment Monitoring

Environmental Issue	Pressure	State	Impact	Management Response
Air Quality	2	1	2	2
Climate Change	1, 6	1	6	6

Terrestrial Environment Monitoring

Environmental Issue	Pressure	State	Impact	Management Response
Vegetation	3	3,4,5,6	3,4,5,6	2
Soil	3	4,6	3	2
Wildlife	1	5,6	5,6	2
Terrestrial habitat	3	5,6	5,6	2

Aquatic Environment Monitoring

Environmental Issue	Pressure	State	Impact	Management Response
Water Quantity	2	1	2	2
Water Quality	2,3	1	2	2
Fisheries	1	5,6	2	2
Aquatic habitat	3	3,4,5,6	4	2

Land Tenure and Use

Environmental Issue	Pressure	State	Impact	Management Response
Land administration.	2	1	2,3	2
Land use/land cover.	3	3		

The main conclusions from this summary and the preceding chapter four analysis are:

1) There is very little reliable, time-series monitoring information currently being collected in the province.

2) The demand for such information is increasing on a number of fronts, especially in the areas of environmental trend interpretation and effectiveness monitoring.

3) The few monitoring programs that are currently producing reliable, time-series information (e.g., air, water) are becoming increasingly vulnerable (budget pressures) and this may threaten their effectiveness.

4) There are a number of initiatives underway to begin to collect environmental monitoring information (e.g., vegetation change, wildlife / terrestrial habitat), and these offer the potential to contribute significantly to the supply of reliable, time-series environmental data, provided they can be sustained over time. However, achieving a long-term commitment to these new initiatives may be difficult to achieve unless they are enabled through formalized, non-discretionary business drivers.

5. PROVINCIAL INITIATIVES THAT INTERPRET AND REPORT ENVIRONMENTAL MONITORING INFORMATION

Aside from monitoring and interpretation of monitoring information that agencies may undertake for their own internal program planning and ongoing resource management decision-making purposes (e.g., hydrometric surveys, monitoring anadromous fish escapements – see chapter 4), there are a number of other existing or proposed initiatives in BC that are major potential users of environmental monitoring data (and certain inventory and research information – see chapter 2 definitions).

These initiatives use environmental monitoring information to interpret and report publicly on environmental, sustainability and effectiveness trends. Most of these initiatives are cross-sectoral in the sense that they analyze and report on trends for multiple environmental resources. For example, MELP's environmental trends initiative reports on trends for atmospheric, aquatic, terrestrial and land use / condition indicators, as does strategic land use plan effectiveness monitoring and reporting. Other initiatives are somewhat more narrow in scope such as the kind of analysis and reporting that MELP's Conservation Data Centre does, or LUCO's tracking of protected area statistics. Some initiatives analyze and report on province-wide environmental trends (e.g., State of the Forest), whereas others are interested in tracking environmental indicators for defined geographic areas (e.g., state of parks, landscape unit plan effectiveness monitoring, or model forest monitoring). The things that all of these trends interpretation/ effectiveness reporting initiatives have in common, however, are that they all:

1) employ environmental indicators to measure trends in environmental quality, or to assess the effectiveness of policies and plans in achieving stated environmental goals and objectives;

2) employ a mix of environmental indicators including: pressure, state, impact and management response indicators;

3) select indicators for which data is generally already available, or there is a prospect of obtaining reasonable data;

4) obtain the environmental data for measuring and assessing their indicators from a diversity of available sources, most likely from multiple agencies. Their sources may include: information from monitoring networks that are designed specifically to generate high quality time-series information; inventory information that is not time-series, but provides a snap-shot of environmental conditions at a particular point in time; research information that is generated from the study of a particular resource(s) at a particular location(s); and various administrative records that are retained in government registries or annual reports that provide a historical record of human activities pertaining to environmental / resource management; and

5) are often reliant on the line-ministry data custodians to help explain or interpret technical information as a basis for ensuring that proper trends interpretation and analysis occurs.

These trends interpretation / effectiveness reporting initiatives are discussed below and are summarized in Table 4. In addition, Appendix 3 provides a more detailed description of these initiatives.

Table 4: Summary of Trends Interpretation and Effectiveness Reporting Initiatives

Initiative	Geographic Scope / Focus	Status	Contact
1. Environmental Trends	• province-wide • 15 primary environmental indicators (land, air, water, natural diversity and ecosystem health), and a number of secondary indicators	• two public reports released to-date (1998 and 2000), with plans to continue to report bi-annually.	Dr. Risa Smith, MELP
2. State of Forests in British Columbia	• province-wide • 40 environmental indicators of sustainable forest management (plus 40 socio-economic indicators and 12 policy and administration indicators).	• early stages of development; draft list of indicators and proposed monitoring / reporting structure now being considered	Tom Niemann, MOF
3. British Columbia Land Statistics	• province-wide • historical and current statistics on provincial land base (status, condition and use), including: agriculture, forestry, range, mining, settlement, protected areas, etc.)	• two public reports released to-date (1989 and 1996), with tentative plans to release an updated version(s)	Godfrey Archbold, MELP
4. Commissioner for Environment and Sustainability	• province-wide • ecological health monitoring / reporting • Commissioner reports to Legislature	• specifics as yet undetermined, other than commitment to issue bi-annual reports on provincial ecological health, and annual reports on government, ministry and Crown corporation performance against sustainability commitments. Initial focus on "ecological integrity" issue. Environmental Commissioner now being recruited	Maurice Sydor, Office of Auditor General
5. State of Parks in British Columbia	• provincial protected area system (terrestrial and marine)	• early stages of development; draft list of indicators and proposed monitoring / reporting structure now being considered	Lynn Kennedy, MELP
6. Strategic Land Use Plan Effectiveness Monitoring	• regions / sub-regions (e.g., LRMPs) • monitoring strategic land use plans' effectiveness in achieving "desired outcomes" for agriculture, biodiversity, forestry, range, water, wildlife, etc.	• provincial (LUCO) monitoring guidelines / procedures in place • one monitoring report released (Kamloops); several other IAMC regions developing / considering monitoring indicators and monitoring / reporting structure	Warren Mitchell, LUCO
7. Landscape Unit Plan Effectiveness Monitoring	• landscape units • monitoring landscape unit plans' effectiveness in achieving biodiversity conservation objectives, and associated timber supply impacts	• early stages of development; draft list of indicators and proposed monitoring / reporting structure now being considered	Allan Lidstone, MOF
8. Model Forest Sustainable Forest Management (Local Level) Monitoring	• provincial model forests (McGregor and Long Beach model forests)	• both provincial model forests have developed draft monitoring indicators that are continuing to be refined.	Bodo von Schilling (Long Beach) Kevin Petterson (McGregor)

Initiative	Geographic Scope / Focus	Status	Contact
	• indicators developed for BC's model forests have potential application to local-level monitoring at other BC forest management units	• Long Beach model forest would like to report annually	
9. Forest Certification Auditing / Monitoring	• forest management units (e.g., TSA or portion of TSA, TFL, woodlot, community forest) • sustainable forest management as assessed by independent third party using certification standards (i.e., sustainable forest management criteria / indicators) established under various certification systems (e.g. CSA, FSC)	• approximately 10 forest certification approvals issued to-date by independent auditors, with numerous other proposals in stream and growing interest by other forest managers • FSC regional standards (i.e., performance measures) now being developed	Harry Drage, MOF

Note that in addition to the initiatives listed in Table 4, other organizations are currently considering monitoring approaches for assessing their organizational effectiveness. For example, the Forest Practices Board has expressed an interest in developing indicators for measuring trends in the effectiveness of the Forest Practices Code in achieving the specific sustainability goals that are identified in the preamble to the *Forest Practices Code of British Columbia Act*. As well, Forest Renewal BC is presently trying to develop indicators as part of its "sustainable forest management (SFM) initiative" that would enable FRBC to track the extent to which its investments are achieving SFM and forest productivity objectives. Finally, individual organizations are interested at varying levels in tracking selected environmental indicators as a basis for meeting their own program responsibilities and / or for strategic planning purposes and / or to fulfill annual (or periodic) reporting requirements.

Note as well that Table 4 excludes national-level environmental / sustainability monitoring initiatives for which some provincial environmental data may be needed. For example, Natural Resources Canada reports periodically on the State of Canada's Forests[1] and this report benefits from BC contributions of forest-related information. Similarly, the Canadian Council of Forest Ministers reports periodically on criteria and indicators for sustainable forest management in Canada[2] and provincial level inputs to the national forestry database are needed for this purpose (e.g., provincial data that is / will be entered into the national forest information system according to CCFM obligations). Also, Environment Canada's Pacific and Yukon Region Environmental Indicators initiative[3] provides public reporting on various measures of BC's environmental quality (e.g., marine ecosystems, species health, toxic contaminants, climate change, urban air quality, stratospheric ozone depletion, and water use and quality). These indicators too may benefit from the availability of certain provincial information.

[1] The State of Canada's Forests. 1999 – 2000 Forests in the New Millennium. Available at http://nrcan.gc.ca/cfs/proj/ppiab/sof/common/latest.shtml

[2] Criteria and Indicators of Sustainable Forest Management in Canada. National Status 2000. Available at http://nrcan.gc.ca/cfs/proj/ppiab/ci/indica_e.html

[3] Environment Canada. Pacific and Yukon Region Environmental Indicators. Available at www.ecoinfo.org/env_ind/default.htm

Analysis of Information Requirements

Appendix 4 provides the master list of environmental indicators and associated environmental information that provincial agencies have identified that they need for trends interpretation, effectiveness reporting, and strategic planning or program delivery purposes. We stress, however, that this statement of need is *preliminary* for a number of agencies / initiatives. Many agencies that are involved in these activities are at an early stage of developing assessment indicators and reporting methodologies / systems. The listings in Appendix 4 must, therefore, be seen as tentative and subject to change. Note also that this list excludes social and economic indicators that may be related to environmental condition. Nonetheless, if we accept that Appendix 4 represents an approximate current picture of agencies' environmental information needs for these purposes, a number of observations can be derived from this Appendix 4, as discussed in the following sections.

5.1. Number and Type of Environmental Indicators that Provincial Agencies Want To Track

In total, provincial agencies are interested in measuring trends for 226 indicators of environmental quality[4]. Table 5 provides a breakdown according to resource category and indicator type (pressure, condition, impact and response).

Table 5: Indicators for Which Provincial Agencies Require Environmental Information

Resource Category	Pressure	Condition	Impact	Response	Total
Atmospheric Resources	8	6	7	1	**22**
Aquatic Resources	11	15	13	14	**53**
Cultural / Heritage Resources	1	0	0	2	**3**
Land / Resource Use	25	20	6	22	**73**
Terrestrial Resources	16	37	13	9	**75**
Total	**61**	**78**	**39**	**48**	**226**

Although 226 indicators have been identified during this study, more than one provincial initiative (agency) is typically interested in measuring most indicators. If this multiple interest in indicators is taken into account, there could be an aggregate tracking / interpretation (and in most cases also public reporting) on about 346 environmental / resource indicators in BC – see Table 6. This does not include trends interpretation / effectiveness reporting initiatives that will be applied to multiple monitoring / reporting units (e.g., LRMPs, landscape units, forest management units in the case of forest certification). Nor does it include any existing federal initiatives, or new initiatives such as the proposed BC Commissioner for Environment and Sustainability.

[4] Note that many of these indicators are at an early stage of consideration by agencies. This number does not reflect final determinations of indicators that will be measured and reported on over time by provincial agencies.

Table 6: Initiatives and Number of Indicators

Initiative	No. Indicators
Strategic Land Use Plan Effectiveness Monitoring	59
CCFM criteria & indicators of Sustainable Forest Management	54
Model Forest Monitoring	48
State of Forests	46
Environmental Trends	37
Agency strategic planning purposes	32
Forest Certification	27
British Columbia Land Statistics	23
State of Parks	11
Landscape Unit Plan Effectiveness Monitoring	9
total	**346**

At present, only a few provincial initiatives have actual experience in tracking and reporting on environmental indicators (i.e., MELP's Environmental Trends and BC Land Statistics initiatives, and a few forest certification initiatives). The other initiatives are under development and are expected to "roll out" in the near term. Quite clearly, the whole field of environmental and sustainability trends / effectiveness reporting is poised for explosive growth in BC. This will be particularly true if the requirements of the *Budget Accountability and Transparency Act* are fully implemented. This raises questions about: (1) the need for so much trends / effectiveness reporting activity by so many organizations; and (2) assuming that this level of need can be rationalized, the ability to adequately support this level of activity with adequate time-series environmental information. These issues are discussed further in following sections.

As can be seen from Table 5, the greatest demand is for environmental information to support the use of indicators that pertain to *land and resource use* (73 indicators), and for *terrestrial resources* (75 indicators). Each of these categories represents about 32% of all indicators, and in total account for 64% of all indicators. The high level of interest in land and resource use indicators is likely explained in part by the relative availability of existing information to measure land / resource use characteristics (i.e., 47 of the 73 land and resource use indicators are for pressure and response indicators, for which information is generally more available than condition or impact indicators). In the terrestrial resources category, the main interest lies in measuring *forest vegetation attributes* (52 of 75 indicators), as discussed further in 5.2 below.

In terms of indicator types, the greatest demand is for *condition indicators* (78 out of 226, or 35%). This is also not too surprising, given that most environmental trends and effectiveness monitoring initiatives would prefer, if possible, to measure the actual condition or state of environmental resources, as this provides the best representation of actual environmental outcomes. Other types of indicators (i.e., pressure, impact and response) are often selected for use in trends / effectiveness monitoring and reporting programs due to the lack of data that can be used to describe ultimate environmental condition.

There is, however, an argument to be made in favour of measuring and reporting on some of all four indicator types, as this provides a more complete picture for environmental decision-making purposes. *Pressure indicators* define the nature and extent of environmental stressors; *impact*

indicators provide insights into the environmental impacts that result from the stressors; *condition indicators* identify the ultimate state of environmental resources as a result of stressors and impacts; and *response indicators* shed light on what is being done to address environmental issues – see chapter 2 for further detail. In general terms, it would appear that, among BC's various environmental trends interpretation and effectiveness monitoring initiatives, there is a suitable mix / balance in indicator type.

5.2. Environmental Information Priorities

The full description of provincial agencies' information requirements is provided in Appendix 4. From that appendix and also from Tables 7 and 8, it is possible to draw out a few highlights regarding the key environmental information priorities for trends interpretation, effectiveness reporting and agencies' strategic planning purposes.

The greatest evident "need" (as inferred from the environmental indicators that agencies wish to track over time) is for access to information for measuring indicators related to *forest vegetation and forest land use activities*. This high level of interest is not surprising, given the number of trends interpretation and effectiveness monitoring initiatives that relate to sustainable forest management, at a range of geographic levels. Provincial agencies would like to measure and report on 72 indicators in the forest vegetation and forest land use categories. Of these, 36 are condition indicators, 16 are pressure, 6 are impact, and 14 are response indicators.

The specific types of information required to measure trends in forest vegetation and forest land use activity is highly varied. For example, condition information is needed on: forest productivity, the broad spatial composition of forests such as the distribution of forest types, ages, patches / gaps, and structural attributes of forests such as biomass levels and extent of coarse woody debris. As well, various information are needed to report on forest ecosystem stressors (e.g., fire, disease, harvesting rates / locations, roading, exotics, land conversion), and forest management responses (e.g., restoration, forest land reserve).

In general terms, the level of detail of required forestry-oriented information appears to be roughly commensurate with the geographic scope of the monitoring initiatives. For example, local monitoring initiatives such as forest certification or model forest monitoring are more interested in stand-level forest attributes (i.e., structural attributes) than are provincial-level monitoring initiatives where information on general spatial patterns is of more interest. This stands to reason and reflects the greater ability of more localized monitoring initiatives, from a cost-effectiveness point of view, to collect more detailed information for smaller geographic areas.

Table 7: Indicators According to Resource Category / Theme

Category	Theme	No. Indicators
Atmospheric	Air Quality	10
	Climate Change	12
	sub-total	*22*
Aquatic	Fish	13
	Water Quality	18
	Water Quantity	8
	Water Use	8
	Habitat	6
	sub-total	*50*
Cultural/Heritage		3
Land/Resource Use	Agriculture/ Rangeland	13
	Conservation Land	3
	Forest Land	20
	Planning	3
	Tenures	2
	Mining & Energy	4
	Pesticides & Toxics	4
	Protected Areas	8
	Recreation & Tourism	8
	Solid Waste	1
	Transportation / Utilities	2
	Settlements	5
	sub-total	*73*
Terrestrial	Vegetation / Forests	52
	Wildlife	14
	Soils	9
	subtotal	*75*
	total	**226**

Table 8: Indicators According to Resource Category / Theme — Descending Order

Category	Theme	No. Indicators
Terrestrial	Vegetation / Forests	52
Land/Resource Use	Forest Land	20
Aquatic	Water Quality	18
Terrestrial	Wildlife	14
Land/Resource Use	Agriculture/ Rangeland	13
	above 5 information categories / themes account for over one-half of all indicators and associated information needs	*sub-total 117*
Aquatic	Fish	13
Atmospheric	Climate Change	12
Atmospheric	Air Quality	10
Terrestrial	Soils	9
Land/Resource Use	Recreation & Tourism	8
Land/Resource Use	Protected Areas	8
Aquatic	Water Use	8
Aquatic	Water Quantity	8
Aquatic	Habitat	6
Land/Resource Use	Settlements	5
Land/Resource Use	Pesticides & Toxics	4
Land/Resource Use	Mining & Energy	4
Cultural/Heritage		3
Land/Resource Use	Planning	3
Land/Resource Use	Tenures	2
Land/Resource Use	Conservation Land	2
Land/Resource Use	Transportation / Utilities	2
Land/Resource Use	Solid Waste	1
	total	**226**

Second to information on forest vegetation and forest land use, the next greatest business need, as interpreted from the number of existing or proposed monitoring indicators (see Tables 7 and 8), is for technical information on *aquatic resources*. Fifty indicators of fish, water quantity / quality / use, and aquatic habitat have been identified. Over half of these are for information pertaining to the condition of water resources or impacts on water resources. Twenty-two atmospheric indicators of *air quality and climate change* are identified, also mainly in the condition and impact indicator categories.

Half of all identified indicators and associated information requirements relate to only five resource categories / themes: *forest vegetation, forest land use, water quality, wildlife, and agriculture / rangeland use*. The other half of information requirements pertain to the other 18 resource categories / themes (see Table 8).

Getting more specific, some environmental indicators and associated information needs are more in demand than others. Table 9 shows that, while almost 60% of indicators are being

implemented / proposed by only one initiative (agency), the remainder are being implemented / proposed for use in more than one initiative.

Table 9: Number of Indicators by Initiatives

Number of indicators being applied / proposed by **ONE** initiative		134
Number of indicators being applied / proposed by **TWO** initiatives		49
Number of indicators being applied / proposed by **THREE** initiatives		26
Number of indicators being applied / proposed by **FOUR** initiatives		10
Number of indicators being applied / proposed by **FIVE** initiatives		5
Number of indicators being applied / proposed by **SIX** initiatives		1
Number of indicators being applied / proposed by **SEVEN** initiatives		1
	total	**226**

The single piece of information that is clearly in greatest demand from provincial agencies for trends interpretation and effectiveness monitoring / reporting purposes is information on *ecosystem protection in BC* — in particular, the extent to which BC's ecosystems (BEC zones / eco-sections) are represented in protection status. Seven separate initiatives, at various geographic scales, are interested in this reporting measure, namely: Environmental Trends (MELP), State of Parks (MELP), LUCO's protected area system (PAS) monitoring and reporting initiative; strategic land use plan monitoring at the regional / sub-regional level; CCFM criteria and indicators monitoring and reporting at the national level; and forest certification monitoring and model forest monitoring, although the interest of these last two initiatives is in tracking "protected" areas within "working" forest management units. In addition, the State of Forests initiative is interested in ecosystem protection information in so far as the level to which forest types and ages are represented in protected area status.

Table 10 identifies the indicators / information requirements that four or more provincial trends interpretation, effectiveness reporting or strategic planning initiatives are, or are interested in, pursuing (i.e., approximately the top ten percent of all indicators). If level of agency demand is accepted as the sole criterion, then the information requirements identified in Table 10 could be assumed to be the provincial corporate priorities for information provision. While Table 10 is of interest in showing relative level of demand for information, it would be a mistake to necessarily conclude that these are, in fact, the province's information priorities for generating environmental monitoring information. It is likely that the information in these categories is what is readily available for these purposes, and that this has influenced agency selection of indicators. Also, as mentioned earlier, many of agencies' proposed indicators are not finalized, and associated information needs may shift as their indicator selections become firm.

In addition, the monitoring indicators and associated information needs shown in Appendix 4 and Table 10 are essentially a reflection of individual sectors' programs. These, in turn, reflect agency or program mandates. There has not been a cross-sectoral, integrated assessment of sustainability monitoring and reporting requirements that define government's corporate list of environmental indicators and information needs. In 1995/96 the Commission on Resources and Environment started on such an initiative, but was unable to complete it before being dissolved. Although it remains to be seen, the proposed Commissioner of Environment and Sustainability may be able to encourage a more corporate perspective, and this may allow a more definitive description of environmental information requirements.

Table: 10: Environmental Monitoring Information in Greatest Demand

Level of Demand	Resource Category	Resource Theme	Information Requirements
7 initiatives	Ecosystem Protection	ecosystem representation	percent of area of BC ecosystems (BEC, Eco-sections) in protected status
6 initiatives	Landscape Fragmentation	road density on forest land	km per km2 of roads, reported by various land units (e.g., watersheds, zones, landscape units)
5 initiatives	Protected Lands	amount of BC in protected status	total terrestrial and marine areas secured in protected area status by federal and provincial designations.
	Climate Change	temperature trends	temperature "sums" and other meteorological parameters (e.g., precipitation)
	Forest Type and Age	forest age class / old growth distribution	area of forest that occurs in various forest age classes (e.g., 1-40 years, 41-80 years, etc.), by forest type (e.g., dominant species). Also, areas of old growth, younger forest, and non-forest; amount of old growth that is accessible for timber harvesting, amount inaccessible for timber harvesting, and amount protected.
	Timber Harvest	approved versus actual harvest levels	total provincial AAC and actual harvest levels per type of regulated forest – province-wide and by management units. Also, actual harvest on regulated land versus harvest on unregulated land.
	Forest Species at Risk	rare, threatened and endangered species	percentage of known forest-dependent or grassland-associated species (fish, amphibians, mammals, plants, birds, reptiles) that are red- or blue-listed.
4 initiatives	Surface Water Quality	water quality index	water quality index results at monitoring sites (reported as improving, deteriorating, or no change in quality), reported by watershed grouping. Also, other unspecified water chemistry parameters
	Surface Water Quality	turbidity	turbidity in watersheds (or selected sampling sites). Also, turbidity in paired watersheds, with and without logging.
	Forest Recreation Facilities	sites and trails	number of forest recreation sites an km of recreation trails, province-wide and by region
	Protected Forest	forest age per age class, by forest type in protected status	area of various forest age classes, by forest type that are in protected status, and percent of total provincial forest in those age classes / types that are protected
	Old Growth	protected old growth forest	area of old growth versus younger forest and non-forest land in protected status, by BEC zone. Percent of protected old growth of total old growth. Also, area of old growth forest retained, by BEC, by landscape units (and at forest level) compared to biodiversity guidebook old growth retention targets
	Forest Disturbance	amount of forest disturbed	area of forest disturbed by fire (natural and human-caused) versus pests, versus harvesting.
	Harvesting Systems	area of timber harvest using different harvesting systems	forest land area subject to clear cutting versus alternative harvesting systems
	Forest Regeneration	forest regeneration method and timing	area regenerated by natural versus artificial means. Also, area not regenerated within ten or more years following harvest
	Threat to Species at Risk	land use threats to threatened and endangered vertebrates	relative importance of various threats to red-listed (including riparian) vertebrates, and forest-dependent species
	Viability of Selected Species	historical range in which species are extirpated or declining	percentage of historical range in which selected species (caribou, sharp-tailed rouse, mule/black-tailed deer, moose, grizzly bear) are extirpated versus declining. Also "observed changes" in fauna.

5.3. Overlapping Indicators and Initiatives

As discussed above, Appendix 4 shows that agencies have an interest in tracking 226 environmental indicators in 22 resource categories. In one category (forest vegetation resources) 50 separate indicators are identified, while another 20 are identified for forest land use activities. While these are the most extreme examples, there is interest in tracking ten or more indicators in seven other resource categories. While these numbers may be justified, they raise the question of whether or not so many indicators are needed, particularly in certain resource categories, to gain a sufficient understanding of the environmental issues.

As well, is it necessary for there to be so much overlap for so many indicators, as is evidenced by the fact that 40% of all indicators are being implemented / pursued by more than one initiative (agency)? Even though a lot of this overlap can be explained by the fact that the same indicator is being reported on at different geographic scales, there still appears to be enough of an overlap issue to question the efficiency of a “silo” approach to developing and implementing trends interpretation / effectiveness monitoring initiatives.

Responding to these questions lies well outside the terms-of-reference of this study. They are raised here only because the study data draws attention to them, and because they are the sorts of questions that LIICC will no doubt want to consider in the development of a corporate environmental baseline system.

6. KEY ISSUES, CONCLUSIONS AND RECOMMENDATIONS

6.1. Summary of Key Issues

Supply – Demand Imbalance: In BC, as in many other jurisdictions, there have traditionally been only a relatively small number of agency programs that produce environmental monitoring information. These are agencies with traditional, "core" resource management / regulatory responsibilities where monitoring data has been required mainly as a context for permitting / licensing decisions. For example, MELP's air / water quality and water flow monitoring programs; DFO's monitoring programs for fish abundance have been driven out of their regulatory responsibilities.

Recently, however, there is rapidly increasing interest from other agencies / initiatives to access programs' monitoring information – mainly for sustainability trends interpretation and effectiveness assessment purposes, and to respond to national / international initiatives that require environmental monitoring data (e.g., Montreal process for sustainable forest management, Kyoto protocol on climate change, biodiversity convention). In the absence of good time-series environmental monitoring information, these initiatives use various environmental inventory and research information, but they would ideally prefer reliable and repeatable monitoring information that has been derived from proper monitoring networks. There is a growing divergence between the demand for high quality, time-series environmental monitoring information and the availability of it.

Lack of Formalized Business Drivers: One of the main reasons why environmental monitoring has / is limited is because it is a discretionary activity that must compete with other environmental management initiatives for scarce budget dollars. Resource *inventories* are more amenable to "slugs" of money that may become available, whereas environmental *monitoring* requires an ongoing, long-term, and disciplined commitment that does not fit well with the cyclical nature of political priorities and associated budget allocations. If we are to lessen the gap between environmental monitoring supply and demand, there will be need for a much stronger provincial commitment to environmental monitoring. This could possibly take the form of some legalized requirements for identifying and reporting on performance measures (for example, such as those identified in the new *Budget Transparency and Accountability Act*), the increasing significance of national / international protocols (e.g., Kyoto), or potentially the creation of some standing institution that has a responsibility for coordinating environmental monitoring investments.

Technical Capacity for Managing and Interpreting Environmental Monitoring Data: Agency programs that are implementing environmental monitoring networks are doing so to generate data that is needed for their own regulatory purposes. As such, only certain data is collected and it is collected in a way that is relevant to the program needs. Non-program users of environmental monitoring data (e.g., trends interpretation

initiatives) may be able to directly employ program data, but they often need the data to be varied and / or interpreted to suit their own particular requirements. Data providers are increasingly being called on to manipulate and interpret their data to service the needs of other users. There is the potential that limited program staff will be unavailable to fulfill this demand and that non-program data users will perform their own interpretation and analysis of technical data that they do not fully understand, which could lead to inaccurate reporting.

Technical Capacity for Designing and Implementing Environmental Monitoring Systems: Designing and implementing environmental monitoring sampling systems that produce statistically valid and credible data requires a high level of technical expertise. So too does the proper management and interpretation of the resultant data. In recent years, this capacity has been significantly eroded in most of BC's resource management agencies, mainly as a result of program reductions and retirement of staff that have not been replaced. If government wishes to respond to the increasing demand for high quality environmental monitoring data, these technical capacity gaps will have to be addressed. It is likely that there will have to be an increasing involvement of academics and consulting experts to help with the design and delivery of monitoring networks, and also the management and interpretation of monitoring data.

Indicator Proliferation: There is an explosion in the number and type of specific environmental indicators that agencies want to track over time. There are two issues associated with this proliferation. Firstly, it is unlikely that we need so many indicators, many of which are only slightly different from each other, in order to understand BC's environmental quality, although this is perhaps questionable since there has been no coordinated, corporate assessment of what core environmental indicators should be measured. Secondly, there are overlaps among agencies / initiatives that are interested in tracking the same indicators, or minor variations on an indicator. This creates a potential inefficiency (and also overload problems for data providers - see above capacity issue.)

Lack of Coordination: Past and existing environmental monitoring initiatives have all evolved independently as agencies have pursued initiatives in relation to their specific mandated responsibilities. Whereas this has historically not presented too many problems — because monitoring information was being developed and used almost exclusively by agencies for program delivery purposes — the broadening interest in acquiring environmental monitoring data for trends and effectiveness interpretation purposes suggests that a far higher level of inter-agency coordination in developing monitoring systems will be needed.

The primary responsibility for collecting monitoring data will almost certainly continue to reside with the agencies with program delivery responsibilities (i.e., Air, Wildlife, Water, Resource Inventory branches). However, the other agencies with an interest in monitoring data (e.g., Ministry of Health in the case of air quality data; regional health officers in the case of water quality data; BC Parks, BC Wildlife, forest certification applicants in the case of vegetation change inventory data) need to be able to input into and shape the design of monitoring systems that can measure environmental parameters that are important to them. Presently, there is no good forum that enables coordinated decisions — for example, coordinated decision-making on: a core set of

environmental indicators that are the corporate priority for information capture; the standards for measuring and reporting on those indicators; roles and responsibilities for data interpretation; mechanisms for data access / distribution, etc.

Links to Decision-making: The fundamental purpose behind monitoring environmental conditions is to improve the quality / effectiveness of environmental management decision-making. To-date, however, there are few bridges between the results / findings of environmental monitoring and the policy responses of decision-makers. The "pressure-state-impact-management response" model for selecting environmental indicators provides a useful framework for establishing the needed bridges; more formalized incorporation of that framework within ministries' strategic planning initiatives would be valuable.

Opportunities for Partnerships: Provincial agencies are not the only organizations in BC with an interest in collecting environmental monitoring data. The federal government has important environmental monitoring responsibilities, as do local governments, First Nations governments, universities and institutes and the private sector. Without coordination among all of these players there lies the potential for major inefficiency and overlap in monitoring, interpretation and reporting. Any initiatives that are adopted to increase coordination and to adopt corporate governance of environmental monitoring systems will need to take into account non-provincial initiatives and requirements.

6.2. Conclusions and Recommendations

Responding to Increasing Demand for Environmental Monitoring Information

Whereas the demand for environmental monitoring information is high and growing, the supply is low and has historically been shrinking. BC has plenty of environmental data, but it is generally not the right kind that is needed for interpreting trends in environmental condition or for assessing program / policy / plan effectiveness. BC mainly has *inventory* data, as opposed to *monitoring* (i.e., time-series) data. Although the need for improvements in the supply of environmental monitoring data is being increasingly recognized and some action is being taken (e.g., vegetation change monitoring) it remains to be seen if provincial environmental monitoring programs can be sustained over time. This is because there are few, if any, senior-level, formal commitments to undertake long-term environmental monitoring. Historical and current business drivers behind environmental monitoring programs are informal and non-obligatory. As a result, they are highly vulnerable to competing spending priorities.

Recommendation 1: Government should institutionalize some more formal business drivers for environmental monitoring — i.e., mechanisms that establish an explicit, non-discretionary requirement for the collection of environmental monitoring information.

Coordinated Design and Delivery of Environmental Monitoring Systems

There is a critical need for improved coordination in determining corporate environmental monitoring priorities and planning the design and delivery of monitoring programs. Program-

level monitoring activities need to be more closely linked to trends interpretation / effectiveness monitoring initiatives. A corporate forum is needed to answer questions like: "What resources / issues should we be monitoring with our limited environmental monitoring budgets: air quality, drinking water, sustainable forest management, biodiversity, etc."; What technical standards will be applied in the collection and application of monitoring data; How will data be accessed? Who will be responsible for interpretation and reporting-out on the findings; etc? "

Agencies' demands for environmental monitoring information that will permit them to track trends in various environmental parameters have not been rationalized in relation to government's broader corporate priorities. As a result, we see multiple agencies proceeding independently with their own initiatives, all of which have major ongoing, and sometimes overlapping, data acquisition implications. Do we really need all of these independent trends interpretation / effectiveness reporting initiatives in order to provide decision-makers with an adequate understanding of environmental conditions? Can we combine some of these initiatives, or somehow create better linkages among them, so that we are measuring / tracking fewer environmental criteria and indicators? If it was possible to do some ranking and integration through a corporate institutional mechanism, then costs of environmental monitoring data acquisition, interpretation, and reporting should be reduced; gap and overlap issues addressed; and risks associated with conflicting interpretations of monitoring data reduced.

The importance of taking a corporate perspective in inventory programs for efficiency and effectiveness reasons has been explicitly recognized in BC, as evidenced by the CRII and RIC initiatives – why not do the same for environmental monitoring initiatives?

> ***Recommendation 2:*** Environmental monitoring programs should be explicitly brought under the umbrella of LIICC or a similarly corporate-minded coordinating structure. Coordination should not be limited to provincial government agencies — the coordinating body should include representatives from all parties with a monitoring interest (federal, First Nations, local governments; Crown corporations, universities and institutes; private sector).

Partnering Opportunities

The province's internal capacity for designing and implementing environmental monitoring programs that are capable of producing high quality, statistically-valid results is limited, and may reasonably be expected to remain that way. Government should be looking for ways to enhance the availability of monitoring data by involving outside organizations / interests in designing monitoring systems and collecting and interpreting monitoring results. This would require a highly coordinated approach (see above recommendation).

> ***Recommendation 3***: Partnership opportunities should be explored with other levels of government, universities and institutes and the private sector, as a way of leveraging a cost-effective increase in the availability of reliable environmental monitoring information.

Using Monitoring Information to Enhance Environmental Outcomes

Recent increases in trends interpretation / effectiveness reporting initiatives are all aimed ultimately at improving environmental sustainability. These initiatives are based on the presumption that the findings that they produce will be used by decision-makers to change laws or policies, or to trigger new or amended plans or programs. Yet, we see little evidence that there are, in fact, any good mechanisms to ensure that environmental monitoring investments actually feed into environmental decision-making at the policy level. Unless this occurs, the entire motivation for environmental monitoring, and the public investment into it, is in question. The new *Budget Transparency and Accountability Act* should help to produce a better link between monitoring of performance indicators and strategic level environmental decision-making, although the extent to which this occurs will depend on the performance measures that the environmental / resource management agencies set for themselves.

> ***Recommendation 4:*** As one component of its efforts to oversee the development of a "corporate environmental baseline", LIICC should investigate institutional options for ensuring that the findings from environmental monitoring programs are actually integrated into environmental decision-making.

APPENDIX 1: SURVEY QUESTIONNAIRE

The following questions were asked of agency contacts to determining the environmental information that agencies need to support their environmental monitoring initiatives:[5]

1. What environmental monitoring[1] initiatives is your division/branch currently involved in, or contemplating? Describe objectives and scope of monitoring initiative (e.g., purpose, monitoring scale, reporting frequency, audience, funding source, staffing / organization, etc.)

2. Why are you engaged in this monitoring activity? (E.g., to comply with legislation, meet an international or national level commitment, meet an internal programming or planning commitment, etc.?)

3. What basic question(s) are your monitoring initiatives attempting to answer?

4. What environmental criteria/indicators do you use (or want to use) to answer your questions, in number 3 above?

5. What data do you require in order to measure these criteria/indicators, and where do you currently (or expect to) obtain this data?

6. How adequate is the data that you currently use, or expect to use? (E.g., is desired data available? If so, is it reliable, current, correct scale, etc.?)

7. What key things should the providers of environmental information be doing to support users who require information for strategic-level environmental monitoring purposes?

[5] *Environmental monitoring*, in this case, measures environmental condition relative to long-term environmental management goals / objectives, and when measured in time series determines trends in condition. Monitoring findings allow environmental managers to compare current conditions to past conditions, and to the desired future condition. Results may be used by decision-makers to reinforce management actions or to suggest modified management actions, as a basis for constructing a management system that is capable of achieving the desired environmental outcomes.

APPENDIX 2: STUDY CONTACTS

The following individuals were contacted to obtain information on agencies' environmental monitoring initiatives and associated information requirements. Comments were provided by personal / telephone interviews or by written submission.

ORGANIZATION	CONTACT NAME
Provincial Ministries	
Ministry of Aboriginal Affairs, Implementation and Settlement Legislation Branch	Peter Nakken
Ministry of Agriculture and Food, Resource Planning Branch	Rob Menes
Ministry of Energy and Mines,	
Southwest Regional Office	Ted Hall
Kootenay Regional Office	Andrew Whale
BC Geological Survey	Ray Lett
Ministry of Environment, Lands and Parks	
Executive	Margaret Ekenfelder, Rodger Hunter
Air Resources Branch	Lynn Bailey, Hu Wallis, Liz Lilley, Bob Beatty, Robert Marsh, Warren Bell, Rick Williams
Corporate Policy Branch	Dr. Risa Smith, Lee Thiessen
Crown Lands Branch	Godfrey Archbold, Neil Hamilton, Eric
Geographic Data BC	Malcolm Gray, Bill Anderson
Habitat Branch	Rod Davis, Dr. Jenny Feick
Parks Division	Denis Moffat
Pollution Prevention	Ron Driedger, Doug Walton, Dave Douglas, Harry Vogt
Resource Inventory Branch	Fern Schultz, Ted Lea, Wilf Dreher, Bruce Letvak, Andrew Harcombe
Water Management Branch	Jim Mattison
Ministry of Fisheries	
Fisheries Management Branch	Jamie Alley
Information Services Branch	Peter Lewis
Sustainable Economic Development Branch	Al Martin
Ministry of Forests	
Corporate Policy and Planning Branch	Sue Stephen
Forest Practices Branch	Tom Niemann
Forest Practices Branch	Tom Hall
Forest Practices Branch	Shane Ford
Forest Practices Branch	Harry Drage
Resources Inventory Branch	Jon Vivian
Kamloops District Office	Gary Reay
Kamloops Regional Office	Peter Lishman

ORGANIZATION	CONTACT NAME
Ministry of Health	
Public Health Protection Branch	Barry Boettger
Risk Assessment and Toxicology Branch	Dr. Ray Copes
Ministry of Municipal Affairs, Growth Strategies Office	Erik Karlsen
Ministry of Small Business, Tourism and Culture, Tourism Policy and Land Use Branch	Dick Butler, Nancy South, Stephen Connally
Ministry of Transportation and Highways, Engineering Branch	Mike Kent
Other Agencies	
BC Hydro	Louise Goullet
Environmental Assessment Office	Jan Hagen
Fisheries Renewal BC	Angus Mackay
Forest Practices Board	Grant Loeb
Forest Renewal BC	Janet Gagne
Green Economy Initiative	Ken Baker, Lawrence Alexander
Land Reserve Commission	Julie Glover
Land Use Coordination Office, Vancouver Island IAMC	Lindsay Jones
Land Use Coordination Office, Prince Rupert IAMC	Elizabeth Zweck and Tom Chamberlain (consultant)
Land Use Coordination Office	Warren Mitchell
Long Beach Model Forest	Bodo von Shilling
MacGregor Model Forest	Kevin Petterson

Note: names listed in a group were interviewed together.

APPENDIX 3: PROVINCIAL TRENDS INTERPRETATION / EFFECTIVENESS REPORTING INITIATIVES

This appendix provides an overview of the main provincial environmental trends interpretation and effectiveness reporting initiatives that are currently being implemented or developed in BC. Each initiative is described in terms of its basic purpose, business driver, key characteristics, current status, and the responsible government agency and contact person.

1. Environmental Trends in British Columbia

Purpose of Initiative: Three objectives are identified in the Environmental Trends in British Columbia 2000 report: (1) provide an overview of the condition of BC's environment, important links between seemingly disparate issues, and a picture of the way in which British Columbians are collectively responding to environmental challenges; (2) measure progress towards the Ministry's goals; and (3) respond to the BC Auditor General's calls for enhanced accountability of government by developing performance measures that focus on the ultimate outcomes of government efforts.

Business Driver: This initiative is policy driven, and is reflected in the Ministry's annual business plan.

Key Characteristics: Fifteen indicators of environmental condition are reported: green economy, protected areas, domestic waste, air quality from fine particulates, greenhouse gases, effects of global warming, surface water quality, groundwater quality, water use, species at risk, forest species, wildlife species, status of fish stocks, development in riparian ecosystems, and toxic contaminants.

The focus is on trends in condition, as opposed to measurement of pressure or response indicators. Available data is assembled to support the indicator reporting from a wide variety of existing and historical sources. No environmental monitoring programs are being implemented to produce data specifically for the purposes of this initiative.

Status: To date, two Environmental Trends Reports have been released: 1998 and 2000. The intent is to continue to release reports on a bi-annual interval and thereby continue to build a time-series picture of environmental condition in BC.

Responsible Agency and Contact: Ministry of Environment, Lands and Parks, State of Environment Office, Dr. Risa Smith.

2. State of the Forest in British Columbia

Purpose of Initiative: The October 6, 2000 mock-up draft of the State of the Forest in British Columbia 2001 report identifies a series of objectives for this initiative:

- demonstrate accountability for outcomes
- provide an overview of the current state of BC's forests with factual information on the topics of greatest interest to domestic and international audiences,
- show the trends of important indicators of sustainability
- provide MOF interpretation and analysis of the facts and trends
- summarize MOF balanced conclusions and actions to ensure sustainability,
- stimulate and inform public discussion of sustainable forest management,
- motivate public and private action to ensure sustainability
- provide links to other local, provincial, national and international efforts to ensure sustainability
- facilitate access to more detailed information
- identify gaps in information and knowledge

Business Driver: This initiative is policy driven. It is linked to the Canadian Council of Forest Ministers' initiative to define and report on sustainable forest management (CCFM criteria and indicators for sustainable forest management). It is also driven out of a need for BC to be able to provide factual, objective information on provincial forest management outcomes in response to ongoing questions and criticisms about those outcomes.

Key Characteristics: The initiative is currently being developed. Decisions on indicator selection and methodologies, reporting frequency, roles and responsibilities, etc. have not been finalized. The initial thinking is to report on 40 environmental indicators of sustainable forest management (in 10 categories), 40 socio-economic indicators (in 10 categories) that relate to forest management and use, and 12 policy and administration indicators (in 6 categories). The environmental and socio-economic indicators would emphasize "outcomes" whereas the policy and administration indicators would emphasize "input, output and process indicators". Examples of proposed environmental indicators of sustainable forest management include: AREA OF forest PER age class by dominant forest species, area of old growth forest, area of land use conversion, area of forest per age class in protected status, area of forest disturbance from fires, pests and harvesting, area of riparian zone disturbed, threatened or endangered species, number of exotic species, areas planted with genetically improved and hybrid tree species, turbidity, distribution of fine particulates from prescribed fires and forest industry mills, carbon stock changes.

The focus would be on reporting recent and historical trends for each indicator, to the extent that data is available to support indicator reports. No new monitoring programs are being contemplated for delivering this initiative, although data from the MOF program for monitoring change in vegetative conditions will be employed. Other data requirements are expected to come from an array of existing sources, primarily housed within the Ministry of Forests, although final assessments of data availability and reliability have not been made.

Status: Under development; no written reports on indicators have been generated, other than for several "mock ups". Draft indicators, as above, are being considered / refined.

Responsible Agency and Contact: Ministry of Forests, Forest Practices Branch, Tom Niemann.

3. British Columbia Land Statistics

Purpose of Initiative: To provide a synopsis of historical and current statistics pertaining to the administration of Crown land, and to give an overview of specific resource uses

Business Driver: The initiative is policy-based. MELP has prepared this document out of a perceived need to track high-level statistics on land use / land administration activities.

Key Characteristics: The BC Land Statistics document provides information on a variety of land administration and land uses, including: general land status, amount of land in private ownership, area of Crown land tenures, agricultural land and land use, forest land productivity, timber harvesting, rangeland status, protected area status, heritage land, petroleum and natural gas lands and tenures, and settlement lands. Thirty-six statistical tables are provided, together with interpretation of the data. The information has been compiled from a wide variety of sources.

Status: MELP has released two versions of this report for two points in time: 1989 and 1996. There is no pre-defined reporting interval for future releases of the document, although MELP has expressed a desire to proceed with a third release in the near term.

Responsible Agency and Contact: Ministry of Environment, Lands and Parks, Crown Lands Branch, Neil Hamilton.

4. State of British Columbia's Parks

Purpose of Initiative: Report on the extent to which BC's protected area system goals for ecological integrity, recreational resources and cultural-heritage resources are being achieved over time; and provide the ability to assess how well park management and administrative techniques are working to sustain the protected area system.

Business Driver: It is expected that legislation will provide the driver for State of the Parks reporting, although such legislation is not yet in place. This expectation arises out of government's acceptance of recommendations made by the BC Parks Legacy Panel in 1999. The Panel suggested that legislation be enacted to publicly report on the State of the BC Parks every three years.

Key Characteristics: The initiative envisions the development and application of a number of key indicators for assessing how effective management efforts in provincial protected areas are in achieving protected area system goals (for ecological, recreational, and cultural-heritage resources). The indicators would be applied within protected areas and would be system wide. It's expected that the initiative would largely parallel the

federal State of the Parks monitoring / reporting program. It is unknown at this time if the program would initiate systematic, time-series data collection to support the program, however, indications to-date are that BC Parks would be more interested in selecting indicators for which existing data exists.

Status: This initiative is presently being considered by BC Parks. Some preliminary work has been done on potential indicators. Thirteen tentative indicators were proposed in a 1999 consultant's study for BC Parks' consideration: 7 indicators pertaining to ecological integrity, 3 to recreational values, 1 to cultural-heritage values, and 2 to economics. These indicators were proposed on the basis (among other things) that existing data was generally available to enable reporting on the majority of the suggested indicators. Examples of potential environmental indicators include: amount of BC in protected status, ecosystem representation, connectivity among protected areas, species at risk, ecological restoration efforts, water quality, and risk to natural / recreational values.

Timing for final development and implementation is uncertain.

Responsible Agency and Contact: Ministry of Environment, Lands and Parks, BC Parks, Lynn Kennedy.

5. Strategic Land Use Plan Effectiveness Monitoring

Purpose of Initiative: Assess the extent to which goals and objectives contained in Strategic Land Use Plans (i.e., LRMPs, regional plans) are being achieved over time.

Business Driver: Strategic Land Use Plan (SLUP) monitoring / reporting is driven by the plan monitoring provisions that are contained in individual approved SLUPs. Inter-agency Management Committees (IAMCs) are responsible for monitoring and reporting on plan implementation status and effectiveness for the plans located within their IAMC region. They undertake plan monitoring in accordance with general policy and procedural direction from the Land Use Coordination Office (LUCO). In 1999, LUCO published a "Provincial Monitoring Framework for Strategic Land Use Plans" and in 2000 released a set of procedures that advise staff on monitoring / reporting methods.

Key Characteristics: Each LRMP contains its own provisions directing how the plan will be monitored to assess (1) the extent to which plan commitments have been implemented, and (2) the extent to which plan goals and objectives are being achieved over time. The intent is to report annually on plan implementation status, and every 3 to 5 years on plan effectiveness. LUCO's policy is that IAMCs should select and apply effectiveness monitoring indicators for which existing data is generally available. Therefore, no special, plan-specific data collection / monitoring programs are envisioned to support the SLUP monitoring initiative.

Status: The Kamloops IAMC, having produced one of the earliest LRMPs, has progressed furthest on SLUP monitoring and reporting. In 2000 they released an effectiveness monitoring report that assessed conditions in the plan area as of 1999 using 69 indicators: 28 indicators for environmental resources and 41 for human activities related to resource use.

Other IAMCs are considering / developing programs to monitor SLUP implementation status and overall plan effectiveness. For example, the Prince Rupert IAMC has formed a regional monitoring coordinating group that is currently developing a proposed suite of effectiveness monitoring indicators that individual LRMP Tables (Bulkley, Kispiox, Lakes and Casiar LRMPs) may select from. The Lakes and Maurice Districts are part of an Innovative Forest Practices Agreement pilot project that will develop indicators as part of their sustainable forest management planning process. As another example, the Vancouver Island IAMC has developed a tentative list of 32 indicators for measuring the effectiveness of the Vancouver Island Regional Land Use Plan.

Responsible Agency and Contact: Land Use Coordination Office, Warren Mitchell.

6. Landscape Unit Plan Effectiveness Monitoring

Purpose of Initiative: To determine the extent to which landscape unit plans have been completed according to established landscape unit planning procedures (i.e., program or compliance monitoring); and to determine the overall effectiveness of the plans in achieving underlying program goals (i.e., effectiveness monitoring).

Business Driver: Ministry of Forests' and Ministry of Environment, Lands and Parks' policy is the business driver, although the sustainable forest use goals defined in the preamble of the *Forest Practices Code of British Columbia Act* provide the context for the effectiveness monitoring component of the landscape unit plan monitoring initiative, specifically the biodiversity conservation goal. The two ministries have prepared a Landscape Unit Planning Guide (an official Forest Practices Code guide book) that references a policy commitment to monitoring the effectiveness of landscape unit plans.

Key Characteristics: This monitoring initiative would primarily assess the extent to which biodiversity conservation is being achieved at the landscape level and, to a lesser degree, the stand level. There are approximately 1,300 landscape units defined for British Columbia. As the monitoring program is in the early stages of development, it is not known if monitoring reports will be prepared for individual landscape units, or if monitoring results will be reported on a Forest District (or other) basis. The monitoring frequency has not yet been determined for the program, although it may be that different indicators may have different monitoring and reporting intervals.

It is possible that as the future scope of landscape unit planning expands to capture other forest resources (e.g., water, recreation), the scope of the monitoring initiative will also expand. (At present, the scope of landscape unit planning is limited to identifying old growth management areas and wildlife tree patches, as these are assumed by government to be the primary elements that are required to conserve biodiversity at this planning scale.)

Status: An initial scoping review of landscape unit plan monitoring issues and considerations was completed by a consultant in October, 2000. That review identified a variety of potential pressure, state and response indicators that might be considered for monitoring biodiversity condition at the landscape and stand levels. Subsequently,

another consulting study was initiated (and was still in progress at the time that this report was written) to recommend specific biodiversity condition monitoring indicators.

Seventeen indicators are currently under consideration, although these still need to be assessed against criteria such as data availability and reliability, cost, repeatability, etc. Some examples of monitoring indicators being considered include: area of old growth forest by ecosystem type, area of old growth maintaining interior stand conditions, area of wildlife tree retention, wildlife tree retention stand structure, coarse wood debris, percent of environmentally sensitive areas retained, area of riparian buffer, degree of fragmentation.

It is intended that much of the information required to support monitoring and reporting on these potential indicators would be generated from data tables that are compiled by staff at the time that landscape unit plans are initially prepared. Procedures for generating these data tables from existing MOF and MELP data sources are being developed. To enable indicator trends monitoring it would be necessary to replicate these data tables at the desired reporting interval.

Once a set of monitoring indicators is selected, they will be piloted in one or more locations before the monitoring initiative is applied more broadly.

Responsible Agency and Contact: Ministry of Forests, Forest Practices Branch, Allan Lidstone.

7. Model Forest Sustainable Forest Management (Local Level) Monitoring)

Purpose of Initiative: To measure progress towards sustainable forest management (SFM) at the local forest level, in relation to defined local level SFM indicators. Although there are only two model forests in BC, the indicators that are developed at this level are likely to have relevance to other forest-level SFM monitoring initiatives.

Business Driver: The initiative is founded in the national federal-provincial model forest network. All model forests across Canada are in the process of developing regionally-relevant criteria and indicators of SFM, using the CCFM criteria and indicators as a basis.

Key Characteristics: All model forests in the Canadian model forest network have been working for the past few years on developing and applying local level indicators. There is an expectation that there would be regular, periodic reporting on SFM performance, relative to the indicators. Data would come from existing available sources, but also from sampling plots / field surveys within the model forests.

Status: The Long Beach Model Forest embarked on an initiative to develop local level SFM criteria and indicators in 1998. They have a comprehensive list of indicators, and intend to report on biological indicators for which monitoring information is available. They have not yet screened their indicator list against the availability of information. They are in the process of developing some permanent sample plots for data collection

for a few model forests, in cooperation with the licensees in the area. They would ultimately like to produce a report annually that reports on indicator trends -- a "Clayoquot Report". The MacGregor model forest has an initial selection of indicators in place and are beginning to apply them in cooperation with the forest licensee (CanFor).

Responsible Agency and Contact: Long Beach Model Forest, Bodo von Schilling; Macgregor Model Forest, Kevin Petterson.

8. Forest Certification Auditing / Monitoring

Purpose of Initiative: To assess whether or not performance standards that forest managers are expected to achieve as a condition of obtaining / maintaining forest certification are, in fact, being achieved.

Business Driver: Access to markets is the primary driver behind forest companies' certification initiatives. Some international buyers of wood products are requiring producers to provide assurances (as provided by an independent auditor) that the products being sold originate from sustainably managed forests.

Key Characteristics: Forest certification may be obtained under one or more certification systems. IN BC, the main performance-based certification systems being implemented are those offered by the Canadian Standards Association (CSA) or the Forest Stewardship Council (FSC). Certification is voluntary — forest managers apply for it if they think it will help them market their products. An approved, independent certifier assesses applicants' forest management performance against pre-defined standards of sustainable forest management. Annual audits are conducted to determine if certification status may be retained or modified.

Under the CSA system, sustainable forest management performance indicators for specified categories are developed through a public participation process. These constitute the standards that the forest manager is audited against. Many of these tend to be compliance-oriented indicators, however a number are condition-oriented indicators that will require time-series environmental data to enable effective auditing. Examples of CSA performance indicators of environmental condition that have been recently developed for the Kamloops TSA include: levels of coarse woody debris retained at cutblocks, forest regeneration following harvest, percent of old forest retained in landscape units relative to LRMP-approved levels, levels of riparian protection relative to Forest Practices Code requirements, percentage of harvested areas in permanent roads and landings, harvest levels relative to AAC and cut control requirements.

Under the FSC system, auditors assess performance against a checklist of ten defined sustainable forest management principles and 56 criteria. Examples of auditing criteria for which information on environmental condition is required include: yield of all forest products harvested; forest growth rates and regeneration; composition and observed change in flora and fauna; extent of rare, threatened and endangered species and habitats; extent of non-forest uses; harvest rates.

A BC regional standard for the FSC system is presently being developed to more closely match performance standards with the province's unique forest conditions. This regional standard will define specific BC performance indicators and thus the information requirements that will be required to facilitate FSC implementation in BC.

Status: To-date in BC, seven CSA certifications and three FSC certifications have been approved for various woodlands operations. These low numbers understate the degree of interest that exists among forest companies (and government) to achieve certification. A number of processes are underway throughout the province at the individual operator level and at the wider TSA level to implement forest certification under both systems. For example, in the Kamloops TSA, a CSA process is underway to develop a sustainable forest management plan that resulted in the identification of 27 sustainable forest management indicators, the auditing of which for some will require data on the condition of environmental resources.

Responsible Agency and Contact: Although monitoring that is conducted in connection with forest certification is conducted on a voluntary basis by individual forest companies and approved certifiers, the Ministry of Forests is closely following forest certification activities in BC. It can be expected that provincial data, especially in TSAs, will be called upon to supply audit information for certification implementation. (Forest Practices Branch, Harry Drage).

APPENDIX 4: CURRENT AND PROPOSED MONITORING (TIME-SERIES) INFORMATION FOR TRENDS INTERPRETATION & EFFECTIVENESS REPORTING INITIATIVES OF PROVINCIAL AGENCIES

(See End of Appendix for Explanatory Notes)

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
ATMOSPHERIC RESOURCES				
Air Quality	Fine Particulates	communities exposed to health risks from fine particulates (Impact)	fine particulate levels (PM10 and PM 2.5, NOX, SO2, TRS) in communities of concern	Environmental Trends, MELP / GVRD / MOH strategic planning
	Fine Particulates	concentration of fine particulates in selected protected areas (Impact)	fine particulate levels (as above) in high use / urban protected areas, compared to target / safe particulate levels.	State of Parks
	Fine Particulates	air quality from prescribed fires and mills (Impact)	tonnes of fine particulates (PM10 emissions) from prescribed fires and forest industry mills, by year, and map distribution of fine particulates	State of Forests
	Fine Particulates	causes / sources of fine particulates emissions (Pressure)	sources of fine particulate emissions (tonnes), by type (e.g., burning, mills, other urban sources), for Lower Mainland and rest of BC. Also, sources of emissions (mobile, point source, area sources)	State of Forests, Environmental Trends
	Smoke / Particulates	prescribed burning activity (Pressure)	area of prescribed fires, by year	State of Forests
	Health Impacts	morbidity and mortality (Impact)	public health statistics on morbidity and mortality from respiratory diseases	MOH strategic planning, Regional Medical Health officials
	Gaseous Contaminants	gaseous contaminant concentrations (Impact)	levels of: ground-level ozone, nitrogen dioxide, sulphur dioxide, hydrogen sulphide, carbon monoxide, carbon dioxide (exceedances relative to provincial objectives)	Environmental Trends
	Gaseous and Particulate Contaminants	dispersion (Pressure)	area / distribution of dispersion of contaminants	MELP / GVRD / MOH strategic planning
	Air Quality Impacts on Forests	percentage of forest land subjected to levels of specific air pollutants that may negatively impact forest ecosystems (Impact)	atmospheric levels of sulphates, nitrate, ozone, ultraviolet B in forest ecosystems	CCFM C&I
	Ozone	ozone depletion (Condition)	ozone concentrations in forested regions	CCFM, criteria and indicators, MELP / MOH strategic planning
Climate Change	Global Warming	greenhouse gas emissions (Pressure)	megatonnes of CO2 equivalents discharged into the atmosphere, and sectoral source of discharges – total for BC	Environmental Trends
	Global Warming	green house gas emission sources (Pressure)	inventory of greenhouse gas emission sources and amounts	MELP / GVRD / MOH strategic planning

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Global Warming	forest industry emissions (Pressure)	trends in fossil fuel / carbon product emissions from forest sector. Also percentage of forest sector energy usage from renewable sources.	CCFM C&I, Model forest monitoring
	Global Warming	temperature increases (Condition)	BC temperature change over past century, by region (and at forest level)	Environmental Trends, Model forest monitoring
	Global Warming	temperature increases (Condition)	temperature "sums"; meteorological parameters (precipitation, etc).	CCFM C&I, Model forest monitoring, MELP strategic planning, BC Hydro, Emergency Planning
	Global Warming	water temperature (Condition)	change in water temperatures over time at selected sites	Model Forest monitoring
	Global Warming	glacier retreat (Impact)	change in position of glacier front relative to 1900 at selected BC glaciers	Environmental Trends, MELP strategic planning
	Global Warming	BC forests as carbon sinks (Condition)	carbon stock changes (tonnes) – absorption and release- by forest type and for total forest	State of Forest, CCFM C&I
	Global Warming	BC forests as carbon sinks (Condition)	carbon pools i.e., tree vs. non-tree biomass volume estimates (tonnes). Also, area of forest depletion, and percentage of canopy cover, as indicators of carbon sequestration. Also, biomass loss due to fire	State of Forest, CCFM C&I, Model forest monitoring
	Global Warming	BC forests as carbon sinks (Response)	Kyoto protocol accounting effects	State of Forest
	Global Warming	carbon sequestration / release in agricultural systems (Pressure)	dynamics of carbon sinks and sequestration in agricultural systems	MELP, MAF strategic planning
	Global Warming	Forestry CO2 emissions (Pressure)	CO2 emissions (tonnes) from the forest sector	CCFM C&I, Model forest monitoring
AQUATIC RESOURCES				
Fish and other Aquatic Fauna	Species at Risk	threatened or endangered fish species that are "forest dwelling" (Impact)	percent of known of species that are threatened or endangered, according to degree of forest dependency (high, medium, low). Also resident fish species and stocks at risk for various regions (e.g., red-listed aquatic species in Kamloops LRMP area)	Environmental Trends, State of Forests, CCFM C&I, Land use plan monitoring (Kamloops)
	Salmon Stocks	salmon stock extinctions and risks of extinction (Impact)	number of known salmon stocks (by species) that are extinct, at moderate to high risk of becoming extinct, or of special concern.	Environmental Trends
	Anadromous Fish	anadromous fish species escapement (Condition)	historic record of annual numbers of salmonids that return to spawn at selected locations (e.g., Coho, steelhead)	Land use plan monitoring (Kamloops)
	White Sturgeon	age distribution of white sturgeon (Condition)	percentage of white sturgeon population that is juvenile vs. sub-adults vs. adults in Fraser and Nechako Rivers	Environmental Trends
	Kokanee	spawning activity (Condition)	number of Kokanee spawners in streams of Okanagan Lake	Environmental Trends
	Bull Trout	population status (Impact)	percent of watershed groupings where Bull Trout populations are sable versus declining	Environmental Trends
	Selected Stocks	status of selected stocks (Condition)	fish populations and trends for anadromous, sport, non-commercial and species at risk) i.e., number of fish counted annually at selected permanent monitoring sites (e.g., steelhead smolts, coho escapements, resident trout, etc.)	Land use plan monitoring (e.g., Vancouver Island), MELP, MoFi strategic planning
	Selected Stocks	stock recovery plans (Response)	number and distribution of stock recovery programs / plans	MoFi, MELP strategic planning
	Selected Species	species composition, abundance and distribution (Impact)	changes in fish species composition and abundance and distribution (as an indicator of climate change)	MoFi, MELP strategic planning

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Selected Species	fishing effort and catch (Impact)	declines in fisher effort, total catch and catch / unit effort	MoFi, MELP strategic planning
	Selected Species	fish harvest (Pressure)	number of fish harvested according to species, stocks	MELP, MOFI strategic planning
	Aquatic Fauna	abundance and distribution of aquatic fauna (Condition)	changes in distribution and abundance of unspecified species of aquatic fauna	CCFM C&I
	Lake Classifications	trends in lake classifications (Response)	number of lakes that have been classified, using the MOF Lake Classification System, as class A (most restrictive) to class E (least restrictive)	Land use plan monitoring (Kamloops)
Water Quantity	Hydrological	water flow at selected drainages (Condition)	summer low flow and peak flow at selected permanent stream gauging stations	Land use plan monitoring (e.g., Vancouver Island, Kamloops), CCFM C&I, Model forest monitoring
	Hydrological	snow pack (Condition)	snow pack / survey trends	MELP strategic planning
	Hydrological	surface water area in forested areas (Condition)	long-term trends in area of surface water in forested areas	CCFM C&I, Model forest monitoring
	Hydrological	watershed assessments (Response)	number of watershed assessments and, of those, the number of watersheds identified as requiring rehabilitation	Land use plan monitoring (Kamloops)
	Surface Water Availability	fully allocated streams (Response)	number of water supplies that are fully recorded (i.e., community watersheds; major basins; creeks, brooks and lakes; springs, ponds and gulches)	Land use plan monitoring (Kamloops)
	Ground Water Availability	water levels (Condition)	average water levels at observation wells in major provincial aquifers (and in aquifers in model forests)	Model forest monitoring
Water Quality	Surface Water Quality in Watersheds	water quality index (Condition)	water quality index results at monitoring sites (reported as improving, deteriorating or no change in quality), reported by watershed groupings. Also, water quality ratings at monitored sites (i.e., excellent, good, fair, borderline or poor ratings). Also, other unspecified water chemistry parameters (CCFM C&I, and FSC certification)	Environmental Trends, Land use plan monitoring (e.g., Vancouver Island), CCFM &I, FSC forest certification
	Surface Water Quality	water quality parameters (Condition)	surface water quality as indicated by measurements of: dissolved solids, hardness, trace elements, chlorophyll a, nutrients, nitrate, pH, sediments, fecal coliforms, cyanide, AOX, temperature, dissolved gases.	MELP strategic planning, MOH strategic planning
	Drinking Water Quality	drinking water health parameters (Condition)	drinking water quality of regulated utilities (microbiology, protozoans, metals, major ions, nitrate) – surface water and groundwater	MELP, MOH, regulated utilities strategic planning
	Drinking Water Quality	boil water advisories (Response)	frequency and distribution of boil water advisories	MELP, MOH, Regional health officers strategic planning
	Drinking Water Quality	community watersheds (Response)	number and distribution of community watershed plans	MELP, MOF strategic planning
	Waterborne Disease	waterborne disease parameters (Impact)	frequency and distribution of water-borne diseases	MELP, MOH, Regional health officers strategic planning
	Compliance	compliance at point-source discharges (Pressure)	number, quality and compliance records of point-source discharges	MELP strategic planning
	Land Use	land uses with potential water quality impacts (Pressure)	land area occupied by uses with potential water quality impacts	MELP strategic planning
	Forestry Impacts	road deactivation for water	kilometers of road that have been deactivated for purposes of water quality	Land use plan monitoring

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
		management purposes (Response)	control	(Kamloops)
	Forestry Impacts	turbidity (Impact)	turbidity in watersheds (or at selected sampling sites, e.g., Kamloops). Also, turbidity in paired watersheds, with and without logging.	State of Forests, CCFM C&I, Land use plan monitoring (Kamloops), Model Forest Monitoring
	Forestry Impacts	channel change, hydrology, particle size distribution (Impact)	extent of changes in these attributes, over time, at forest level	Model forest monitoring
	Water Quality at Marine Parks	fecal coliform levels at marine park / boat anchorages, or shellfish closures (Impact)	number of days that fecal coliform levels exceed provincial standards at selected marine parks / anchorages; or, number of days of shellfish closure at selected marine parks due to fecal contamination	State of Parks
	Water Quality at Shellfish Growing Areas	marine water quality at existing and potential shellfish growing areas (Impact)	area of foreshore areas closed to shellfish harvesting; percentage of foreshore areas with high and moderate shellfish capability that are closed to shellfish harvesting; and percentage of foreshore areas with high shellfish farming suitability that are closed to shellfish production – due to fecal or dioxin contamination	Land use plan monitoring (i.e., Vancouver Island)
	Pulp and Paper Mill Effluent	chlorinated organic compounds in pulp and paper effluent discharge (Impact)	tonnes / day of absorbable organic halide (AOX) discharges inn pulp and paper effluent	Environmental Trends
	Ground Water Quality	quality of well water (Impact)	groundwater quality at observation wells (e.g., nitrate and pesticides). Also, number of groundwater wells with water quality concerns, or number classed as highly vulnerable according to aquifer classification / mapping methods	Environmental Trends, Land use plan monitoring (Kamloops), MELP strategic planning
	Ground Water Quality	aquifers at risk of contamination (Condition)	number of BC aquifers with reported groundwater quality concerns; number vulnerable to contamination	Environmental Trends
	Monitoring Effort	number and location of water quality monitoring stations (Response)	number and location of water quality monitoring stations	Sate of Forests, CCFM C&I
	Management Effort	forest management designations to protect water quality (Response)	forest land area that is managed for soil and water protection, by type (e.g., community watersheds, netdowns for terrain instability, riparian zones).	State of Forests, CCFM C&I
Water Use	Licensed water use	number and volume of surface water licensed (Pressure)	volume of surface water (m3 / yr) licensed for various consumptive uses (agriculture, thermal power, mining, manufacturing, municipal)	Environmental Trends, MELP strategic planning
	Water Use	hydrological design (Pressure)	number and distribution of requests for hydrological design information	MELP strategic planning
	Per Capita Water Use	volume of water used per capita (Pressure)	per capita water consumption (litres per person per day)	Environmental Trends
	Stream Restrictions	stream restrictions (Response)	number of restrictions registered against streams	Environmental Trends
	Bottled Water	water licensed for bottle sales (Pressure)	volume of water licensed for bottled water sales in BC	Environmental Trends
	Community Watersheds	status of community watersheds (Response)	number and area of community watersheds, in size categories	BC Land Statistics
	Groundwater Use	water use from BC aquifers (Pressure)	percentage of BC aquifers that are at risk from heavy water use	Environmental Trends
Habitat	Urban Streams	Lower Fraser Valley stream damage (Pressure)	percent of streams in Lower Fraser Valley that have been lost, or are threatened and endangered	Environmental Trends
	Productivity	presence / absence of habitat attributes (Condition)	stream habitat characteristics change over time at selected local streams (e.g., coarse woody debris, pooling, stream structure, stream side vegetation)	Model forest monitoring

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Crossings	stream crossings (Pressure)	number and type of stream crossings	Model forest monitoring
	Habitat Condition	watershed integrity (Pressure)	land use, land cover, road and stream crossing densities and hydrological characteristics in watersheds	MELP, MoFi strategic planning
	Habitat Amount	fish habitat condition and amount (Condition)	distribution and quality of fish habitats; amount / length of known salmon, sportfish and other fish streams	MELP, MoFi strategic planning
	Habitat Condition	aquatic habitat degradation (Impact)	extent, distribution and trends in riparian and aquatic ecosystems degradation	MELP, MoFi strategic planning
	Habitat Restoration	aquatic habitat rehabilitation projects (Response)	number and distribution of watershed, stream and fish habitat rehabilitation projects	MELP, MoFi strategic planning
CULTURAL / HERITAGE RESOURCES				
	Cultural / Heritage Resources in Protected Areas	risk to cultural heritage values (Pressure)	number / percent of protected areas where 'highly significant' cultural / heritage resources are assessed by park managers to be at a high, moderate or low risk of deterioration from any cause	State of Parks
	Traditional Use	traditional use studies (Response)	number and location of traditional use, knowledge studies completed / underway	State of Forests
	Heritage Designations	*Heritage Conservation Act* designations (Response)	area of land managed and protected under the *Heritage Conservation Act* (e.g., trusts, archaeological sites)	BC Land Statistics
LAND & RESOURCE USE				
Agriculture & Rangeland	Agricultural Land Protection	agricultural land reserve (Response)	area of land retained in agricultural land reserve, by region and provincially	Land Reserve Commission reporting; BC Land Statistics; and Land use plan monitoring (Kamloops, Vancouver island)
	Agricultural Land Protection	agricultural capability classes in ALR (Condition)	area of various agricultural capability classes that are protected by the ALR (i.e., class 1-7), and percent of total area in ALR	BC Land Statistics
	Agricultural Activity	farm numbers (Condition)	number / area of farms in & out of production, locations, types, sizes, etc., by region and province-wide	MAA strategic planning, Land use plan monitoring (Kamloops)
	Agricultural Activity	farming and ranching activity in BC (Pressure)	location and amount of farming / ranching activity in BC, including: ground manipulation, crop types, irrigated vs. dryland, fertilizer and herbicide applications, improvements, etc.	MAA strategic planning, and "State of Agriculture in BC" reporting, Land use plan monitoring (Kamloops)
	Agricultural Potential	agricultural use parameters (Condition)	various data on factors that determine the ability to farm / ranch in BC in a cost-effective manner, including: soil fertility, extent of weeds, water availability to support agriculture, soil erosion levels, etc.)	MAA strategic planning and "State of Agriculture in BC" reporting
	Farmland Use	type of farmland in BC (Condition)	type of farmland according to major classifications (improved for field crops, improved pasture, summer fallow vs. unimproved land vs. other land)	BC Land Statistics
	Rangeland Use	number of grazing permits and licenses issued, and animal unit months (Pressure)	number permits / licenses issued annually, and number of animal unit months that are available annually for grazing activity, by region and provincially. Also, estimate of future AUM harvest to 2100. Also, number of grazing tenures and AUMs that overlap with protected areas	State of Forests; Land use plan monitoring (Kamloops); BC Land Statistics

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Rangeland Use and Cover	amount of range use according to land cover types (Pressure)	area of Crown range being used, and number of AUMs, within land cover categories (e.g., open range, wetland, alpine, dry forest, clearings, etc.)	BC Land Statistics
	Rangeland Type	rangeland classes(Condition)	area of Crown rangeland (grassland, open forest and early seral forest)	State of Forests, LRMP monitoring reports (Kamloops) ; and MOF/MAA strategic planning purposes
	Irrigation for Agriculture	irrigation water licensing (Response)	number of irrigation licenses in place, by region and provincially	Land use plan monitoring (Kamloops), and MAA / MOF strategic planning purposes
	Noxious Weeds	occurrence of noxious weeds (Pressure)	area and degree of infestation with noxious weeds, by species (e.g., knap weed, toadflax, etc). Also mapping of location of noxious weeds	State of Forests, Land use plan monitoring (i.e., Kamloops)
	Aquaculture Activity	aquaculture farm numbers (Pressure)	number of operating finfish and shellfish farms	Land use plan monitoring (i.e., Vancouver Island); BC Land Statistics
	Aquaculture Land Use	land allocation for aquaculture (Response)	foreshore area with land use priority assigned to aquaculture development, and area of Crown land held under aquaculture tenures	Land use plan monitoring, Ministry of Fisheries and BCAL strategic planning purposes
Conservation Land	Instruments for Conservation	selected conservation designations (Response)	area of Crown land secured for conservation uses under various *Land Act* and *Greenbelt Act* instruments (e.g., designations, reserves, leases)	BC Land Statistics
	Wetlands and Peat lands	occurrence of wetlands and peat lands in BC (Condition)	total area in wetlands and peat lands	BC Land Statistics
	High Conservation Value Forests	maintenance of high conservation value forests over time (Condition)	extent to which conservation attributes in “high conservation value forest” areas are maintained or enhanced over time	FSC forest certification
Forest Land	Productivity	forested area in primary productivity classes (Condition).	area of land in primary forest management classes: productive (available and unavailable) versus non-productive. Also area of immature versus mature forest in good, medium, poor, low site class, according to management unit type	BC Land Statistics
	Productivity	mean annual increment (Condition)	mean annual increment by forest type and age class	Model forest monitoring
	Productivity	nutrient fluxes (Condition)	nutrient fluxes by stand type (i.e., at the BEC subzone level)	Model forest monitoring
	“Working Forest”	forest land reserve (Response)	land area in the forest land reserve	Land use plan monitoring
	“Working Forest”	area for growing and harvesting timber (Condition)	timber harvesting land base, per age class by forest type, by timber productivity. And area of old growth in AGHT as a percentage of old growth, by BEC zone	State of Forests, CCFM C&I, Land use plan monitoring
	Conservation lands	forest area managed for soil and water (and other ecological) protection (Response)	percentage of total forested area that is managed primarily for soil and water protection. Also, effectiveness of forest operations to protect integrity of “high conservation vale forests” (FSC certification)	CCFM C&I, FSC forest certification
	Conservation lands	protected forest by degree of protection (Response)	area and percentage of protected forest land, according to IUCN protection classifications	CCFM C&I
	Ownership	area of forest land in various classes of ownership (Condition)	area of forest, by ownership (e.g., provincial, federal, Aboriginal, private)	State of Forests

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Ownership	corporate concentration, by year (Condition)	percentage of provincial AAC controlled by top 10 companies	State of Forests
	Management	area of forest land in various management unit classifications (Condition)	area of forest land in managed forest units (units where an AAC is established), by manager	State of Forests
	Management	area covered by multi-attribute inventories (Response)	percentage of forest land that is covered by multi-attribute resource inventories	CCFM C&I
	Management	participatory management planning (Response)	percentage of forest land under completed management plans that have included public participation	CCFM C&I
	Restoration	habitat restoration (Response)	area of habitat restored following forest development activity	State of Forests
	Permanent Conversion	forest land conversion (Pressure)	area of forest land permanently converted to non-forest use from 1800 to 2000, estimated by decade	State of Forests, CCFM C&I, Model Forest monitoring
	Semi-Permanent Conversion	forest land conversion (Pressure)	area of forest land in semi-permanent or temporary loss / gain (e.g., grasslands or agriculture)	CCFM C&I
	Semi-Permanent Conversion	forest land conversion (Pressure)	percentage of harvested areas that are converted to permanent roads and landings (at TSA level)	Forest Certification monitoring (e.g., CSA Kamloops TSA), Model forest monitoring
	Forest Land Utilization	utilization of forest land for non-market goods and services (Pressure)	area of forest land that is used for commercial versus non-commercial purposes, including forest land use for subsistence. (Also, losses due to land failure such as landslides and flooding)	CCFM C&I, Model forest monitoring
	Waste Residues	waste residue on harvested sites (Impact)	amount of forest waste retained on harvested sites	Model forest monitoring
	Landslide Activity	frequency of landslides in selected watersheds (Impact)	annual number of landslide events (natural versus human induced) in selected watersheds	Land use plan monitoring (i.e. Vancouver Island)
	Development on Fragile Terrain / Habitat	road building on unstable terrain / steep slopes and within 100 me of streams (Pressure)	amount of road building activity on steep slopes and / or unstable terrain and / or within close proximity to streams	MELP, MOF strategic planning, Environmental Trends
Land / Resource Use Planning	Planning Effort / Zones	strategic land use planning status / designations (Response)	area and location of strategic land use plans based on consensus, by year ; and trends in land use plan zoning designations (Response)	State of Forests, CCFM C&I, LUCO strategic planning
	Disposition Plans	Crown land disposition plans (Response)	number and distribution of Crown land disposition plans	BC Assets and Lands strategic planning
	Land Use / Cover	Land use and land cover statistics (Condition)	trends in area and distributional changes in general land use and land cover (mapping and statistics for 20 land use and vegetation cover classes)	MELP, MOF, MAF, MoFi (and other agencies') strategic planning
Land / Resource Use Tenures	Land Administration	land tenure issuance (Pressure)	number and distribution of applications for Crown land	MELP, BC Assets and Lands strategic planning
	Land Administration	encroachment / conflicts with sensitive lands (Impact)	alienation of important habitat, encroachment on riparian areas and floodplains, and into water-short areas	MELP, BC Assets and Lands strategic planning
Mining and Energy	Mineral Land Disturbance and Restoration	disturbed and restored mineral land (Condition, Response)	area of land disturbed and restored by coal and metal mines (cumulative hectares over time)	BC Land Statistics

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Mineral and Energy Exploration	mineral / coal and petroleum and natural gas tenures / projects (Pressure)	number and area of mineral and coal, and petroleum and natural gas tenures and projects (e.g., exploration and drilling activity vs. development), province-wide and by regions	BC Land Statistics, Land use plan monitoring (Kamloops, Vancouver Island)
	Energy Consumption	total versus alternative energy consumption (Pressure)	petajoules of total energy consumed versus alternative energy consumed in BC	Environmental Trends
Pesticides and Toxic Contaminants	Pesticide Use on Crown Land	use of pesticides on Crown land (Pressure)	use of chemical pesticides on forest land	FSC forest certification
	Persistent Organic Pollutants	levels of toxic contaminants in a colony of Great Blue Herons (Impact)	levels of PCBs and DDEs in Great Blue Herron eggs	Environmental Trends
	Contaminated Sites	site remediation (Response)	number of contaminated sites remediated over time	Environmental Trends
	Contaminated Sites	on-site toxic substance releases (Pressure)	tonnes of on-site toxic substance releases	Environmental Trends
Protected Areas	Protected Lands	amount of BC in protected area status (Response)	total terrestrial and marine areas secured in protected area status by federal and provincial designations. Also area and number broken down by protected area status (federal, provincial)	Environmental Trends; State of Parks; LUCO's PAS monitoring; BC Land Statistics, Land use plan monitoring
	Ecosystem Protection	ecosystem representation in protected areas (Response)	percent of area of BC ecosystems (BEC, Ecosections) in protected status, provincially, regionally, and at landscape / forest levels	Environmental Trends; State of Parks; LUCO's PAS monitoring; Land use plan monitoring, CCFM C&I, FSC forest certification, Model forest monitoring
	Protected Area Connectedness	connectivity between / among protected areas (Condition)	assessment of extent of connective function between protected areas within specified land units (e.g., expressed as good, moderate or poor connectivity). Province wide, and for regions	State of Parks; Land use plan monitoring (e.g., Vancouver Island)
	Ecological Restoration	ecological restoration projects in BC's parks (Response)	type and number of ecosystem rehabilitation projects, over time	State of Parks
	Risk to Park Values	risk to natural values, recreation resources, and cultural / heritage resources in protected areas (Pressure)	number / percent of 'highly significant' natural. recreational, cultural / heritage values in protected areas that are assessed by park managers to be at high, moderate or low risk of deterioration from any cause	State of Parks
	Risk to Park Values	significant environmental occurrences in protected areas (Impact)	number of environmental occurrences in protected areas (e.g., fire management, insect / disease outbreak, weed infestations)	Land use plan monitoring (Kamloops)
	Park Use	visitation rates (Pressure)	number of overnight campers, number of day use visitors, and total number of visits in protected areas, provincially and by region	State of Parks, Land use plan monitoring (Kamloops)
	Park Safety	incidence of injuries / fatalities in parks (Impact)	number of injuries / fatalities in protected areas	State of Parks
Recreation and Tourism	Forest Recreation Use	visitor days, by year (Pressure)	number of recreation visitor days in provincial forests, by activity, annually, province-wide and by region	State of Forests, CCFM C&I, Land use plan

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
				monitoring (Kamloops),
	Forest Recreation Facilities	sites and trails, by year (Response)	number of forest recreation sites, and km of recreation trails, by year, province-wide and by region	State of Forests, CCFM C&I, Land use plan monitoring (Kamloops), Model forest monitoring
	Visual Quality	visual quality objectives (Response)	forest area in various categories of visual quality objectives (e.g., retention, partial retention, etc.) Also, region-wide percentage compliance / contravention of visual quality objectives (Kamloops LRMP)	State of Forests, CCFM C&I, Land use plan monitoring (Kamloops)
	Visual Quality	visual attractiveness of areas that have been established as 'scenic areas' (Condition)	percentage of designated 'scenic areas' (under FPC) that are in an existing visual condition of preservation, retention, or partial retention.	Land use plan monitoring (i.e., Vancouver Island)
	Recreation Opportunity	recreation opportunity spectrum (Response)	forest area in various categories of the forest recreation opportunity spectrum (ROS, i.e., rural, roaded natural, roaded modified, semi-primitive motorized, semi-primitive non-motorized, primitive)	State of Forests, CCFM C&I, C&I, Land use plan monitoring (Kamloops, Vancouver Island)
	Crown Recreation Dispositions	recreational Crown lands under the *Land Act* (Response)	area of Crown land secured for recreation purposes (e.g., alpine skiing, mechanized ski guiding, backcountry recreation, marinas, etc.) using various *Land Act* instruments (leases, licences, reserves)	BC Land Statistics, Land use plan monitoring (Vancouver Island, Kamloops)
	Resource-based Tourism	rates of growth for resource-based tourism operations (Pressure)	annual growth rates for facilities and visitors for various types of resource-based tourism (e.g., skiing, sport fishing, fishing resorts, guide-outfitters)	Land use plan monitoring (Kamloops)
	Recreation Angling	trout stocking (Response)	annual number of trout stocked in various locations for recreation angling purposes	Land use plan monitoring (Kamloops)
	Recreation Angling / Hunting	angling and hunting effort (Pressure)	annual angling effort (angler / hunter days), based on licensed sales for various locations	Land use plan monitoring (Kamloops)
Solid Waste	Solid Waste Generation	solid waste generation per capita (Pressure)	kilograms per person, by region, of solid waste disposed to landfills and incinerators, by waste type. Also litres of waste oil recycled and number of lead-acid battery units recycled	Environmental Trends
Transportation and Utilities	Road and Rail	road and rail infrastructure (Pressure)	kilometers of provincial highways and forest roads; and kilometers of main line tracks	BC Land Statistics
	Utilities	oil and gas line infrastructure (Pressure)	kilometers of crude oil and natural gas pipelines in BC	BC Land Statistics
Settlements	Urban Sprawl	"build-up" land in BC (Pressure)	area of land in BC used for urban and rural settlement, transportation, and farmstead	BC Land Statistics
	Urban Sprawl	rural land conversion (Pressure)	hectares of rural land converted to urban use	BC Land Statistics
	Private Land	Crown land transferred to private ownership (Condition)	area of Crown land transferred to private ownership by Crown grant, over time	BC Land Statistics
	Municipal Statistics	areas assessed and exempted from taxation (Pressure)	land area that is assessed for taxation, and exempt from taxation (i.e., parks, water, streets, roads, playgrounds, other)	BC Land Statistics
	Industrial Land	availability of industrial land (Condition)	area of industrial land that is available for industrial use and area of land that is occupied for industrial use (and total)	BC Land Statistics
TERRESTRIAL RESOURCES				
Vegetation / Forests	Productivity	mean annual increment (Condition)	mean annual increment by forest type and age class	CCFM C&I
	Productivity	productivity increases associated with	timber volume increases that are attributable to FRBC investments into forest	FRBC strategic planning /

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
		intensive silviculture investments (Condition)	productivity	monitoring
	Productivity	rate of forest growth (Condition)	volume of annual growth at forest level; and years to reach free growing	FSC certification, Model forest monitoring
	Forest Type and Age	forest age class / old growth distribution (Condition)	area of forest per age class (e.g., 1-40, 41-80, etc.) by forest type (i.e., dominant species). Also, area of old growth, "younger" forest, and non-forest. Also, amount of old growth that is accessible for timber harvesting, inaccessible for timber harvesting, and protected	State of Forest, CCFM C&I, Land use plan monitoring, FSC forest certification, Model forest monitoring
	Forest Type and Age	presence of old growth (Condition)	area of old growth (251+ years for coastal, all forest types; 141+ years for interior for most forest types; and 121+ years for stands dominated by lodgepole pine or deciduous species. Alternatively simply use 250+ years for all forest types)	State of Forest, CCFM C&I
	Forest Age Distribution	seral stage distribution by forest type, by management unit (e.g. TSA); and by landscape units by BEC variant (Condition)	area / percent of landscape unit in various seral stages (i.e., presence of old growth vs. mature vs. mid-seral vs. early seral forest), relative to seral stage distribution targets established in Biodiversity Guidebook and in LRMPs and in Landscape Unit Plans. Also need ability to report seral stage distribution in Landscape units by BEC variant	Landscape Unit Plan Monitoring; Land use plan monitoring, CSA certification process (e.g., Kamloops TSA)
	Old Growth Interior Stand Condition	amount of old growth vs. mature forest that has "interior stand condition" (Condition)	area and percentage of old growth / mature forest in landscape units that have interior stand condition (i.e., area of old growth management areas / recruitment areas minus old growth / mature forest buffer areas), by landscape unit. Also, monitoring of "forest dynamics" – FSC certification	Landscape Unit Plan Monitoring, FSC forest certification
	Tree Species	tree species composition (Condition)	tree species composition by forest type (species distribution over time)	Model forest monitoring
	Wildlife Tree Retention	wildlife tree patches / gap distribution (Response)	area of wildlife tree patches that are retained from harvesting, by landscape unit, and at forest level. ("Forest dynamics" – FSC certification; "gap dynamics – model forest monitoring)	Landscape Unit Plan Monitoring, FSC forest certification, Model forest monitoring
	Wildlife Tree Retention (Cut blocks)	wildlife tree patch retention (Response)	percentage of harvested blocks greater than 5 ha that have wildlife tree patches and / or individual wildlife / leave trees identified in operational plans. Or, size and number of island remnants of undisturbed forest in harvested areas	Forest certification monitoring (Kamloops), Model forest monitoring
	Wildlife Tree Patch Structure	crown closure / transparency in wildlife tree patches (Condition)	percentage of crown closure in wildlife tree patches that have been retained, by landscape unit. Also, percentage crown transparency by class	Landscape Unit Plan Monitoring, CCFM C&I
	Wildlife Tree Patch Structure	secondary species in wildlife tree patches (Condition)	number? of secondary vegetative species contained in wildlife tree patches by landscape unit	Landscape Unit Plan Monitoring
	Wildlife Tree Patch Structure	site quality at wildlife tree patches (Condition)	percent of area of wildlife tree patches according to various site index classes, by landscape unit	Landscape Unit Plan Monitoring
	Wildlife Tree Patch Structure	vegetation retained in wildlife tree patches (Condition)	number of stems per hectare / basal area retained in wildlife tree patches, by landscape unit	Landscape Unit Plan Monitoring
	Wildlife Tree Patch Structure	amount of old vegetation retained in wildlife tree patches (Condition)	area / percentage of forest cover in cutblocks that is retained to maintain late-successional habitat elements and attributes	Land use plan monitoring (e.g., Vancouver Island)
	Shape Index	shape index in different opening sizes (Condition)	percentage of shape index in different opening size classes	Model forest monitoring
	Stand Stress	stand susceptibility class (Condition)	area (in various classes) of stands that are susceptible to significant biological and abiotic agents (leading to infestations)	Model forest monitoring

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Stand Stress	insect and disease incidence (Impact)	insect and disease incidence by age class and forest change process	Model forest monitoring
	Stand Stress	stress-related forest insect and disease attach (Impact)	frequency and distribution of stress-related forest insect and disease attack	MELP, MOF strategic planning
	Fire Hazard	area of hazard (Condition)	area of high to severe fire hazard	Model forest monitoring
	Fire Hazard	natural wildfire (Impact)	frequency and distribution of natural wildfires (as an indicator of climate change)	MELP, MOF strategic planning
	Coarse Woody Debris	presence of coarse woody debris (Condition)	area / percent of landscape unit where coarse woody debris has been retained (information may be required at TSA level, forest level, or landscape unit level)	Landscape Unit Plan Monitoring, Forest Certification monitoring, Model Forest monitoring
	Environmentally Sensitive Areas	sensitive area / riparian buffer retention in landscape units (Response)	area / percentage of ESA 1 and ESA 2 and riparian buffers that are constrained from harvesting in landscape units. Also, areas of "high conservation value forest" that are protected	Landscape Unit Plan Monitoring, FSC forest certification
	Constrained Lands	land area constrained from harvesting (Response)	area / percentage of landscape units that are partially or fully constrained from harvesting	Landscape Unit Monitoring
	Forest Age and Type in Protected Areas	forest age per age class, by forest type (BEC) (Condition)	ha of area in protected areas in various forest age classes, by forest type; and percent of total provincial forest in those age classes / types that are protected	State of Forests, CCFM C&I, Land use plan monitoring, FSC forest certification
	Forest Age and Type in Protected Areas	old growth in protected areas (Condition)	area of old growth, younger forest and non-forest in protected area status, by BEC zone; and percent that this represents of all provincial old growth. Also area of old growth retained, by BEC zones, by landscape units (and at forest level), compared to biodiversity guidebook old growth retention targets	State of Forests, CCFM C&I, Land Use plan monitoring, FSC forest certification
	Forest Age Distribution	forest age by type in TSAs (Condition)	area of mature vs. immature forest cover in TSAs, by leading species	BC Land Statistics
	Fragmentation	road density on forest land (Pressure)	km per km2 of roads per watershed groupings and by landscape units (Pressure)	State of Forests, Environmental Trends, Landscape Unit Plan Monitoring, Land use plan monitoring, CCFM C&I, Model forest monitoring
	Forest Disturbance	amount of forest disturbed (Pressure)	area of forest disturbed by fire (natural and human-caused) vs. pests vs. harvesting. Also, amount of area affected by different insect defoliators (Kamloops LRMP)	State of Forests, CCFM C&I, Land use plan monitoring, Model Forest monitoring
	Recent Harvesting	amount of land subject to recent logging (Pressure)	hectares and percentage of land area that has been logged (within 20 years, Vancouver Island plan)	Land use plan monitoring (i.e., Vancouver Island)
	Forest Disturbance (Riparian Areas)	amount of disturbance in forested riparian zone (Pressure)	area of forested riparian zone disturbed by fire, pests and harvesting, 1970 to 2000, by watershed groupings	State of Forests, CCFM C&I, Environmental Trends
	Exotic Species	exotic tree plantations (Pressure)	area of exotic tree plantations, by species	State of Forests, CCFM C&I, FSC forest certification
	Exotic Species	exotic species threat (Pressure)	number of exotic species by type of threat (i.e., no threat, threat to native trees, animals, human health	State of Forests, CCFM C&I

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Forest Genetics	genetically improved stock (Pressure)	area planted with genetically improved and hybrid trees, by species	State of Forests, CCFM C&I, FSC forest certification
	Forest Genetics	genetic variance (Impact)	genetic variance of trees in primary and secondary forests (measured in tree height or disease resistance)	State of Forests, CCFM C&I, FSC forest certification
	Forest Genetics	genetically modified organisms (Pressure)	number of genetically modified organisms used in forest management (e.g., re-planting)	State of Forests, CCFM C&I, FSC forest certification
	Timber Harvest	approved versus actual harvest levels (Pressure)	total provincial AAC (m3) and actual harvest (m3) per type of regulated forest (i.e., TSA, TFL, WL), province-wide and by management units. Also, actual harvest on regulated versus unregulated harvest, by year	State of Forest, CCFM C&I, Forest Certification, Land use plan monitoring (Kamloops, Vancouver Island), FSC certification (yield)
	Timber Harvest	fall down estimates (Condition)	estimated future AAC on regulated forest over next 100 years (m3). Also, percentage reduction in estimated AAC from peak to 2100, by forest management unit	State of Forest
	Timber Harvest	cutting levels relative to growth rates (Pressure)	ratio of volume harvested in given area (e.g., management unit, landscape unit), compared to total MAI for that area	Model forest monitoring
	Timber Harvest Systems	area of timber harvest using different harvesting systems (Pressure)	forest land area subject to clear cutting versus partial cutting	BC Land Statistics, State of Forests, MOF Annual Reports, Land use plan monitoring
	Timber Harvest Systems	cut block size distribution (Condition)	distribution of cut block sizes, in various size classes	Land use plan monitoring
	Forest Regeneration	backlog and non-sufficiently restocked (NSR) land (Condition)	area of NSR land over time	Land use plan monitoring, Model forest monitoring
	Forest Regeneration	forest regeneration and regeneration method and timing (Response)	area regenerated by natural versus artificial means, by year. Also, area not regenerated within 10 or more years following harvest, by year	State of Forests, CCFM C&I, FSC forest certification, Model forest monitoring
	Forest Regeneration	logged area in free growing condition (Condition)	ratio of areas reaching free to grow status on an annual basis, to annual area harvested (input / output)	Model forest monitoring
	Forest Regeneration	regeneration timing (Condition)	years to reach free to grow status	Model forest monitoring
	Forest Regeneration	stocking levels (Response)	reforestation stocking levels (stems per ha)	Model forest monitoring
	Forest Restoration	plantation forest areas restored to natural forest cover (Response)	amount of forest area in plantation forest that is restored to its natural forest cover	FSC forest certification
	Grasslands and Openings	area of grasslands and other openings (open range) (Condition)	area of Crown versus private land in various classifications of grasslands / openings (i.e., open range, alpine, meadow, swamp, hayfield, clearing)	Land use plan monitoring (i.e., Kamloops)
	Range Condition	plant communities (Condition)	trends in plant community changes at specified photo-points	Land use plan monitoring (Kamloops)
	Forest	forest regeneration timing (Response)	area / percentage of harvested sites that are / are not regenerated within three	CSA Forest certification

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Regeneration		years of harvest. Also ratio of regenerated sites to natural site index	(Kamloops TSA), Model forest monitoring
	Mycorrhizae	presence and colonization (Condition)	presence of mycorrhizae and colonization of roots (at selected sampling sites)	Model forest monitoring
	Nitrogen	forms of nitrogen (Condition)	forms of nitrogen by seral stage	Model forest monitoring
Wildlife	Species at Risk	threatened and endangered species (Impact)	threatened or endangered species as a percentage of known species, by species category. Also, regional location of species at risk	Environmental Trends, Land use plan monitoring, CCFM C&I
	Species at Risk in Protected Areas	rare, threatened and endangered species (Impact)	number and percent of species in protected areas (by major protected area classification that are red or blue-listed	State of Parks
	Forest Species at Risk	rare, threatened or endangered forest-dependent and grassland-associated species (Impact)	percentage of known forest-dependent or grassland-associated species (fish, amphibians, mammals, plants, birds, reptiles) that are blue or red-listed	Environmental Trends, State of Forests, CCFM C&I, Land use plan monitoring, Model forest monitoring
	Threats to Species at Risk	land use threats to threatened and endangered vertebrates (Pressure)	relative importance of various threats to red-listed vertebrates, including riparian-dependent vertebrates (agriculture, urban development, logging, etc.). Also, relative threats to forest-dependent species	Environmental Trends, State of Forests, FSC forest certification, Model forest monitoring
	Forest Dwelling Mammals	historic range trends (Impact)	number of mammal species (wildlife tree users versus non-wildlife tree users) where their known range is contracting versus expanding	Environmental Trends, CCFM C&I, Model forest monitoring
	Forest Dwelling Birds	forest dwelling bird populations (Condition)	percentage increase or decrease in forest dwelling bird populations (coastal versus interior)	Environmental Trends, Land use plan monitoring (Vancouver Island, Kamloops), CCFM C&I
	Riparian-dwelling Vertebrates	riparian-dwelling vertebrates at risk (Impact)	percentage of known riparian dependent vertebrates (includes mammals, amphibians, fish, birds, reptiles) that are threatened or endangered	Environmental Trends, CCFM C&I
	Marbled Murrelets	nesting habitat (Condition)	percentage of natural range of marbled murrelet terrestrial habitat that is in “suitable” condition for nesting (e.g., amount of age class 8 / 9 that is located in patch sizes of 200 ha or greater	Land use plan monitoring (i.e., Vancouver Island), CCFM C&I
	Ungulates	existence of ungulate winter range (Condition)	percent of land area in primary watersheds that is retained as ungulate winter range	Land use plan monitoring (i.e., Vancouver island), CCFM C&I
	Aquatic Fauna	distribution and abundance (Condition)	change over time in the distribution and abundance of aquatic fauna at forest level	Model forest monitoring
	Viability of Selected Species	historical range in which species are extirpated or declining (Impact)	percentage of historical range in which selected species (caribou, sharp-tailed grouse, mule/black-tailed deer, moose, grizzly bear) are extirpated versus declining. Also, “observed changes in fauna” (FSC certification)	Environmental Trends, CCFM C&I, FSC forest certification, Model forest monitoring
	Populations	populations of selected species (Condition)	trends in population estimates for various species (e.g., deer, moose, caribou, goats, wolf, furbearers, grizzly bears, waterfowl, harbour seals, sea lions, killer whales, sea otters, etc)	CCFM C&I, Land use plan monitoring (Kamloops)
	Wildlife	hunter / trapping effort (Pressure)	number and distribution of hunter days, bag levels, furbearer harvests	MELP strategic planning

RESOURCE CATEGORY	THEME	ENVIRONMENTAL INDICATOR and INDICATOR TYPE	ASSOCIATED INFORMATION REQUIREMENTS	INTIATIVE / USER
	Exploitation			
	Extirpated / Extinct Forest-Dependent Species	extirpated and extinct forest-dependent species (Impact)	number of such species	State of Forests, CCFM C&I
Soils	Soil Disturbance	soil disturbance in harvested areas (Pressure)	area / distribution of soil disturbance in areas that have been subject to harvesting, by year	State of Forests, CCFM C&I
	Soil Disturbance	soil disturbance by harvest system (Pressure)	percent of soil disturbance that is attributable to various harvest systems	State of Forests
	Soil Disturbance	construction of new forest roads (Pressure)	length of new forest roads constructed	Land use plan monitoring (i.e., Kamloops)
	Landslides	landslide occurrences (Impact)	number / area of natural versus human caused landslides	Land use plan monitoring, Model forest monitoring
	Soil Productivity	productive losses (Condition)	m3/ha/year that are estimated to be lost to productivity, according to various harvesting systems	State of Forests
	Soil Productivity	harvesting impacts on soils (Impact)	percentage of harvested area having significant soil compaction, displacement, erosion, pudding, loss of organic material	CCFM C&I, FSC forest certification
	Soil Restoration	soil restoration in harvested areas (Response)	area / distribution of soil restoration in areas that have been subject to harvesting, by year	State of Forests, CCFM C&I
	Organic Content	carbon sequestration / release, organic content in soils (Condition)	amount / distribution of organic content / carbon in forest / agricultural soils	MOF, MAA strategic planning, Kyoto protocol commitments
	Soil Fertility	soil fertility parameters (Condition)	levels / distribution of soil fertility parameters (e.g., acidity, cation exchange)	MAA strategic planning

EXPLANATORY NOTES

This appendix lists the environmental information that agencies need, potentially need, or would like to have to implement their trends interpretation and / or effectiveness reporting and / or strategic planning initiatives. This appendix was generated through study interviews and reference to agencies' documentation, including:

Provincial-level Environmental Sustainability:

1. State of Environment Report, 1993, MELP and Environment Canada
2. Environmental Trends Report 2000, MELP

Provincial-level Sustainable Forest Management:

3. Canadian Council of Forest Ministers (CCFM), Criteria and Indicators (C&I) for Sustainable Forest Management, 1996
4. State of the Forest in British Columbia (Report Proposal), October 2000, MOF

Local-level Sustainable Forest Management:

5. Potential Local Level Indicators for McGregor Model Forest, August 1998
6. Canadian Standards Association, Forest Certification System (CSA Z808-96) Guidance Document for
7. Draft Sustainable Forest Management Plan (CSA system) for Kamloops TSA
8. Forest Stewardship Council Forest Certification System, Principles and Criteria

Land / Resource Plan Effectiveness Monitoring:

9. Strategic Land Use Plan Monitoring Guidelines and Procedures, 2000, LUCO
10. Kamloops LRMP Monitoring Report, 1999, Kamloops IAMC
11. Monitoring Implementation and Effectiveness of the Vancouver Island Land Use Plan, Consultant's Report, September 2000, Vancouver Island IAMC
12. Landscape Unit Plan Monitoring, Draft Monitoring Indicators, January, 2001, MOF / MELP

Protected Area Sustainability:

13. Performance Indicators for Reporting on the State of British Columbia's Parks, Draft Report, February 2000, MELP

Provincial Land Statistics

14. British Columbia Land Statistics, 1996, MELP

Note that many agencies are currently engaged in a process to develop their indicators, and associated information / data requirements. Therefore, many of the information requirements identified in this appendix should be regarded as tentative / preliminary, and subject to change. Initiatives that are currently under development and for which final monitoring indicators and environmental information requirements have not yet been established include: BC State of the Forest monitoring / reporting, Model forest monitoring, all strategic land use plan effectiveness monitoring initiatives other than the Kamloops LRMP, landscape unit plan monitoring, and provincial State of the Parks monitoring. At the forest certification level, the Forest Stewardship Council certification system is presently developing performance standards for BC, however, these are not yet final. For CSA certification, each applicant develops their own monitoring indicators through a public participation process; therefore, environmental information needs for this initiative cannot be fully anticipated.