ASSOCIATION OF BC FOREST PROFESSIONALS

**SUMMARY REPORT (November 2006)**

# Assessment of the Status of Forest Inventories in British Columbia
# A Summary Report

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*Ensuring BC's Forests Are In Good Hands.*

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## Executive Summary

Our assessment was deliberately focused on perceived problems with the forest inventory. This focus should not be construed to mean that there is nothing good about the inventory. A lot of hard work and thought has been put into the design of the current forest inventory protocol (Vegetation Resources Inventory or VRI) for British Columbia. While there are clearly design-related issues that could be improved with sufficient attention and funding, it is the systemic issues which require immediate attention. The keys to solving these issues are establishing clear lines of responsibility for the forest inventory and supplying sufficient base-line funding for implementing the inventory, appropriately managing the data and producing inventory products.

Forest inventories are needed to develop forest management policies, plans and assessments applicable to large landscapes. In particular, forest inventories are needed as the basis for assessing forest policy alternatives to balance in economic, social and biological sustainability of forest lands. As a consequence, data from forest inventories are critical for many forest management decisions across a broad range of spatial scales and time horizons.

This diversity of potential uses makes designing and implementing effective forest inventories challenging in any jurisdiction. British Columbia faces additional challenges because of the great extent of the forested areas, the large topographic diversity and access challenges for large areas of the province.

Most forest professionals are involved with forest inventory activities in some way. A few design the inventories; others implement the designs through collection, maintenance and analysis of inventory data. Many more are users of inventory products, such as data summaries and maps. In recent years, a number of forest professionals and other users of forest inventory information have raised concerns about the state of the forest inventory in British Columbia.

In this report, we assess the state of the forest inventory in British Columbia. To begin with, we propose a Vision Statement for the BC forest inventory:

*The inventory of BC forests is sufficiently well developed and managed to support the design, development and implementation of timely, efficient and effective forest management practices necessary to produce strategically desired outcomes and impacts, across large landscapes and areas of the province, in perpetuity.*

We then assess the BC forest inventory relative to the following six aspects of good inventory administration:

1) clear lines of responsibility;
2) stable and adequate funding;
3) effective quality assurance system;
4) accessibility of data and products;
5) reporting; and,
6) support of innovation and research.

We also assess the state of the forest inventory relative to the following five criteria:

1) currency;
2) coverage and sufficiency;
3) forecasting and linking historical and spatial data;
4) scalability; and,
5) reliability.

The assessment process included consultation with a number of individuals knowledgeable about aspects of the BC forest inventory.

The assessments conducted were deliberately 'high level.' Detailed technical evaluation of the procedures employed in the various components of the BC forest inventory would require considerable time and was considered to be beyond the scope of this report. Also, higher level considerations are fundamental to determining whether or not the inventory is sufficient to support reasonable and responsible forest management decisions.

As a result of our assessment, we have a number of specific recommendations. These recommendations are organized here under a series of general headings, beginning with the most important issues of governance and funding. (The recommendation numbers correspond to the list in the full report. The full report is available on the ABCFP website www.abcfp.ca).

## Governance Recommendations

#### Recommendation #2

Responsibility for the forest inventory should be returned to the Chief Forester under the *Forest Act*.

#### Recommendation #6

We endorse the formation of a vegetation inventory council and encourage the group to play a major role in strategic planning for the forest inventory as well as providing general advice on inventory issues.

## Funding Recommendations

**Recommendation #1**

Secured, multi-year targeted funding sufficient to support annual inventory costs should be sought, preferably from the BC Treasury Board.

**Recommendation #11**

A component should be included in the baseline inventory budget to support research into possible uses of new technologies and methods that could be used to improve forest inventory procedures.

**Recommendation #5**

Inventory information requirements for specific, local areas, requiring a high level of spatial resolution and detail, should be outside of the base funding for the inventory program.

## Coverage and Currency Recommendations

**Recommendation #3**

Higher priority should be placed on obtaining current, complete coverage of all forest lands, using VRI standards at least at a basic level of forestry inventory information. The basic level inventory information should be sufficient for the Chief Forester's mandate of sustainable forest management at the provincial level.

**Recommendation #4**

For all areas currently under development, complete and current inventory information at a more detailed level should be available that allows the Chief Forester to minimize the risks of decisions at a management unit level.

**Recommendation #17**

Regular periodic reviews of forest information needs in light of present inventory standards and procedures, and expected future changes, should be conducted.

**Recommendation #15**

The existing inventory update program should be supported and used throughout the forested lands of BC.

**Recommendation #13**

The accuracy of inventory updates need to be tracked and future re-inventories need to be scheduled in light of the accuracy of the short-term growth projections and updates for disturbances.

## Forecasting and Linkages Recommendations

**Recommendation #7**

A program to forecast inventory attributes for strategic planning and decision making under a variety of stand conditions should be part of the forest inventory program and included in the strategic plan.

**Recommendation #8**

The program to maintain and measure a system of repeatedly measured ground plots (permanent sample plots) must be continued and augmented as a part of the forest inventory program to support the development of forecast models and to monitor stand dynamics.

**Recommendation #10**

Historical records of past inventory data, procedures and standards should be archived to the greatest extent possible.

**Recommendation #16**

Explicit mechanisms for linking inventory data with other sources of data relevant to a particular area and time are needed.

## Reliability and Quality Assurance Recommendations

**Recommendation #12**

To ensure continuity and develop expertise in the full range of forest inventory activities, including field measurements, photo-interpretation, and data storage, analysis, and reporting, additional permanent staff should be hired within government.

**Recommendation #19**

The quality assurance system needs to be monitored for effectiveness, and modified when necessary, as the inventory system evolves.

**Recommendation #14**

A commitment to moving towards higher resolution of inventory information should be included in the mandate of the inventory program.

## Access and Reporting Recommendations

**Recommendation #9**

Public access to summarized inventory products should be supported.

**Recommendation #18**

A regular series of periodic reports, applicable to broad regions and the province, should be produced to inform the public on the state of the forest. In association with these reports, appropriate metadata should be documented for possible future use by practitioners.

## Introduction

Practising good forest stewardship requires reliable information on the location, amount, and quality of a variety of natural resources found in forests. Inventories of these natural resources are often referred to as 'forest inventories' and are the primary source of this information. Forest inventories are needed to develop forest management policies, plans and assessments applicable to large landscapes. They provide the basis for assessing forest policy alternatives to balance economic, social and biological sustainability of forest lands. Finally, forest inventories are needed to ensure that forest productivity, in its broadest sense, is maintained, and to help ensure that economic resources are available as a foundation for the livelihoods of many in forest resource-based communities.

Data from forest inventories are critical for many forest management decisions across a broad range of spatial scales and time horizons. This diversity of potential uses makes it difficult to design and implement forest inventories. BC faces challenges in obtaining reliable information because of the great extent of the forested areas in the province (approximately 66 million ha), the large topographic diversity, and a relatively small network of roads in some parts of the province which limits access. At the same time, the province's economy is heavily dependent on the wide variety of goods and services provided by the forests.

Most forest professionals are involved with forest inventory activities in some way. A few design the inventories while others implement the designs through collection, maintenance, and analysis of inventory data. Many more are users of inventory products, such as data summaries and maps. In recent years, a number of forest professionals and other users of forest inventory information have raised concerns about the state of forest inventories in BC. This report was produced in response to those concerns.

For many questions regarding forest land, a variety of land and social information is needed. In BC, this includes: 1) base maps, ecosystem maps, and digital terrain models; 2) animal, bird, insect, and disease surveys; 3) hydrological surveys; 4) soils surveys and maps; 5) climate maps; 6) atmospheric monitoring; and 7) vegetation surveys and maps. The focus in this report is on vegetation inventories and maps, collectively termed 'the forest inventory.' Specifically, a situational analysis on the present status of the BC forest inventory[1], and recommendations for improvements are presented. As part of this analysis, we consulted with a number of individuals knowledgeable about aspects of the BC forest inventory.

[1]Technically speaking, there are really a series of BC forest inventories and a set of processes used to obtain the information in those inventories. In the interests of parsimony, we use the singular term 'forest inventory' to refer to that entire collection of data and processes.

One of the key challenges in preparing a report on this subject is to balance the wide diversity of demands for various kinds of information from a forest inventory against the costs of collecting, managing, maintaining and analyzing these data. There is a strong tendency toward wanting to be 'all-inclusive' by answering all of the demands for different kinds of information, which is not feasible. In this report, the broad set of forest inventory information needs and uses is acknowledged. However, the focus is on a much smaller subset of those attributes or characteristics that can be reasonably assessed as being core to most, if not all, of the uses.

Another complicating factor is the historic legacy of the data comprising the provincial forest inventories. The 'age' of the forest inventory varies across the province and different collection protocols were followed depending upon the vintage of the data. This complication is ignored where possible in this report. When it is necessary to refer to existing procedures, the most recent provincial protocol (known as the Vegetation Resources Inventory – VRI) is specifically referenced.

# Background

## Global Perspective

Forest inventories provide base information for all planning and management activities at all spatial scales from the world to a local area, and all time scales from historical to 100 year or longer projections forward in time. The need for current, accurate, and accessible forest inventory data has increased with increasing competition for resources, changes in climate, and greater global interaction and communication. Unlike many other countries, population pressures are localized in Canada. Nevertheless, land use competition has increased with increased world demand for timber products, fossil fuels, minerals, and water. For some areas of BC, forests are being converted to urban areas. In other areas, most recently in northeastern BC, oil exploration has resulted in extensive forest removal and/or pressure to increase forest removal. Increased use of forest land has resulted in more rapid and extensive changes, emphasizing the need for current and accurate forest inventory information. At the same time, changes in climate are affecting natural disturbances, particularly fire, pests and disease in BC, requiring both current and future forest inventory information.

Approaches to conducting forest inventories vary among countries and often between states or provinces within countries. Husch (1965) listed the following steps for designing an inventory (abbreviated and rephrased here):

1) compile and study all existing available information concerning the forest area;
2) decide on what information the inventory will provide (critical phase);

3) evaluate questions regarding the time and funds available, which permeates the entire planning sequence;
4) discuss design details;
5) develop detailed instructions, including instrumentation;
6) provide training;
7) develop field forms; and,
8) design the compilation and calculation procedures before starting 'operational' work.

The main steps involve setting priorities, and designing all aspect of the forest inventory, including analyses, prior to conducting the inventory. Designs are not the same for all inventories, but should follow statistical principles and attempt to provide as good information as possible, within the limitations of budget and time.

Although these steps are largely still relevant for forest inventories today, changes have occurred. In particular, forest inventories have expanded from a primarily timber focus to multipurpose forest inventories (Kohl 2004), which are spatially explicit (Lund 2002b). They are also being used by a variety of groups as inputs to large area analysis for climate change, habitat loss/conversion, and urbanization, rather than just by forest professionals.

In 1998, an international group of forest inventory experts met in a series of IUFRO (International Union of Forest Research Organizations) meetings to prepare guidelines for multipurpose forest inventories (Lund 1998). As part of these discussions, they agreed that multipurpose forest inventories should:

- meet a range of user needs;
- make use of appropriate ecological classifications and assist in determining the value of forest resources and biological diversity;
- provide statements of precision and accuracy;
- stress compatibility of data from different inventories and the use of quality control to ensure data harmony and to avoid duplication, gaps, and inconsistencies;
- collect unbiased data;
- account for all significant components;
- use international and national standards and definitions;
- allow relocation of sampling units;
- evaluate the impact of management activities; and,
- analyze, maintain and present inventory results using technologies such as geographic information systems (GIS) and geo-referenced databases linked to other resource inventories.

In general, multipurpose forest inventories should be easy to use, readily available, comprehensive, defendable, and spatially based.

Common difficulties exist for all agencies in obtaining a well-functioning forest inventory. These include:

- difficulties in defining what is forest land (Lund 2002a);
- difficulties in combining inventory information over time, as standards, procedures and extents of inventories vary;
- difficulties in combining land inventory information obtained and managed by multiple agencies, including private land holders;
- difficulties in combining inventories across spatial scales, and across time, and in projecting inventories forward in time;
- irregular program funding;
- increased demand for current, detailed and accurate information on forests and other lands that is spatially accurate and explicit;
- global concern over energy supplies, local (or regional) timber supply, climatic shifts, and species and habitat extinctions; and,
- increasing global communications of political and environmental issues, particularly through the use of the world wide web, causing greater scrutiny of the information availability and accuracy.

Many agencies have responded to these issues by increasing the use of technology in forest inventory design, data management/use, and display, with very limited ground sampling data. The exception to this trend is smaller countries with low wages, where ground sampling remains a large component of forest inventories. However, even in developing nations, the use of GIS with remotely sensed data is increasing.

## History of Forest Inventory in BC

The purpose of this brief history[2] is to highlight the enduring role that forest inventories have had in the development of forest management policy in BC under a variety of management philosophies.

The first BC Forest Resource Commission (Fulton et al., 1910) noted that inflated estimates of timber supply can lead to careless waste and "…distorted theories of annual destruction, by fire and lumbering, enable alarmists to harm the common-sense campaign for conservation by their exaggerations." This produces uncertainty in the business world and makes the government's task of "creating sound forest policies" more difficult. The commissioners recommended that all provincial government agencies dealing with forestry be consolidated into a Department of Forests, headed by a Chief Forester. In recognition of the need for accurate forest inventory information, it was made quite clear that the Chief Forester would be

[2]The inventory history summarized here, up to the discussion of some of the findings of the Forest Resources Commission (1991) report, was summarized from Parminter's (2000) article entitled, "From Timber to Biodiversity, The Evolution of British Columbia's Forest Inventory Program."

expected to begin a program to inspect, survey, cruise and valuate the provinces forested lands and timber resources.

In 1912, the BC Forest Branch, the predecessor to the BC Forest Service, was created in accordance with the new *Forest Act* (*Forest Act,* 1912). H.R. MacMillan was recruited to the post of Chief Forester in May of that year. Under his direction, forest reconnaissance surveys were undertaken and reported, including information on topography, soil, climate, agricultural and grazing potential, known mineral resources, settlement history, and transportation infrastructure for each area surveyed. Observations of tree species presence, distribution, size, and quality characteristics precede descriptions of forest types and associated estimates of the area and volume of merchantable and other timber resources. During these early years in BC forest policy development, land was classified as being statutory timberland (legally defined as of 1896 based on the timber volume present – at least 8,000 board feet per acre on the West Coast; 5,000 board feet per acre in the Interior), other forest land (mature stands with less volume or immature stands), agriculture, burned over, barren (usually alpine), or other cover (wetlands or lakes).

Under the Commission of Conservation of Canada, a first provincial overview was started in 1913, directed by Dr. Harry N. Whitford of Yale University, who was joined by forester Roland D. Craig in 1914. Their final report was published in 1916 and dealt with geography, physiography, climate, soil, forest types, land tenure, forest administration on provincial and federal lands, forest policy, timber harvesting, and utilization. As well, estimates of timber volume by species, information on land alienation, the history of land use and known natural disturbances were reported.

The Forest Surveys Division was created at the BC Forest Branch's headquarters in 1927, with Fred Mulholland in charge. A new provincial forest inventory was soon begun in the districts. This inventory consisted of both a forest land classification system and a compilation of timber volumes. A forest atlas (at 1 inch to the mile) was developed, consisting of 174 maps, each averaging just under 12 square feet in size, and the accompanying statistics revised in response to harvesting, wildfire, other depletions, reforestation, and stand growth. Forest surveys were recognized to be required for many aspects of forestry (Mulholland 1931).

The science of forest inventory was rapidly advanced when aerial photos were first adopted for use in 1933. In 1949, the *Canada Forest Act* was established that resulted in federal funding to assist with BC inventory work over a seven-year period, starting in 1951 (*Canada Forest Act* 1950).

Revisions to the *Forest Act* in 1979 required the Chief Forester to inventory the province's lands and assess their potential for growing trees, providing for recreation, producing forage for livestock and wildlife, and accommodating other

forest uses. The Forest Service's inventory program became more sophisticated to meet these requirements, using tools such as low-level 70 mm aerial photography, computer-assisted mapping, geographic information systems and satellite imagery.

A Forest Resources Commission was convened in 1990 (Forest Resources Commission, 1991). It was recommended that "a Land Use Commission be created by appropriate legislation and charged with implementing the land use planning process," which ultimately led to the development of the Commission on Resources and the Environment (CORE) in 1992. CORE was charged with devising plans for land use and related resource and environment management throughout the province.

The Forest Resource Commissioners noted the importance of inventories in forest management decision-making and noted that the provincial timber inventory was over 20 years old at that time, it did not provide dependable estimates of site quality, and there was no regular schedule for inventory updates. Ten provincial ministries were identified as maintaining a wide variety of resource data. They stated that government needed to "… examine and implement ways by which the full range of forest related inventories can be made standard and able to be used on compatible systems, while at the same time, retaining the values for which they were originally intended." Finally, they recommended that:

- BC undertake a commitment to complete inventories for all renewable forest resources using standardized compatible systems;
- a provincial Forest Resource Inventory Committee be established to plan and guide the development of a master plan;
- a Timber Inventory Task Force, comprising technical experts from the private and public resource users, be established to design and plan the development of an accurate timber inventory;
- an updated provincial timber inventory, complying with new standards, be completed over the next 10 year period;
- the new inventory program be designed and funded to provide reliable statistically sound data that can be used by local resource planning groups (and other resource interests);
- a system for continuous updating of the provincial timber inventory be established; and,
- a growth and yield program to quantify the growth rates of second-growth forests, for all commercial species in the province, be established on a systematic, priority basis.

Many of the recommendations regarding forest inventories were published in an interim report in 1991 (Forest Resources Commission, 1991: Appendix 4). Phil Halkett, Deputy Minister, Ministry of Forests and Range, responded (March 22, 1991)

by outlining the activities that were either under way or to be initiated such that the concerns of the Commission would be met (Forest Resources Commission, 1991: Appendix 5). In April of 1992, the Resource Inventory Committee, Timber Inventory Task Force published their first report on a review of the current inventory with recommendations for the future. There were over 32 summary recommendations addressing: administrative issues (10 recommendations); forest cover and base mapping (3); forest classification and reporting (12); and volume and size prediction. Progress on at least some of the Forest Resources Commission recommendations was underway.

In the 1989-1990 fiscal year, the Ministry of Forests inventory budget was established at approximately $8 million (Canadian Inventory Committee, 2001), almost all of which was provided by the BC Government. Between April 1991 and March 1995, funding was at or above $15 million, with the majority of funds being provided by the government. During this time, there was a substantial amount of work being done on developing and testing new VRI procedures. Some Tree Farm Licenses (TFLs) had completed inventories using initial drafts of these procedures as early as 1995 (Ministry of Sustainable Resources Management, 2004). A number of inventory audits were also carried out to verify the reliability of inventories in various Timber Supply Areas (TSAs). In 1995, it was envisioned that the entire province would be re-inventoried within 7 to 10 years.

Between April 1995 and March 1997, inventory funding rose to over $26 million, with much of the funding being provided by the provincial government, administered through Forest Renewal BC. However, by the 1999-2000 fiscal year, the budget had dropped to $6 million, with a slight increase at the end of the 2001-2002 fiscal year. As of 2004, only 13 out of 43 forest districts had been re-inventoried, along with two Innovative Forest Practices Agreement Areas (Ministry of Sustainable Resources Management, 2004).

In 2001, the BC Government introduced their 'New Era' reform agenda (Hoberg and Paulsen, 2005). This agenda was driven by "… budget cuts and associated core review, the softwood lumber trade dispute with the Americans, and forces of nature affecting forest health." As part of the agenda, the responsibility for forest inventories was transferred to the new Ministry of Sustainable Resources Management (MSRM). Bill 40 was passed under the *Forests Statutes Amendment Act*, in 2002, wherein the Chief Forester's responsibilities for forest inventories were revoked and transferred to MSRM. This reorganization was done in an effort to centralize all resource inventory functions (Ministry of Forests and Range, 2005a). In the meantime, resource inventory operations had been 'downsized.' Between 1992 and 1995 there were approximately 188 Ministry of Forests inventory related jobs, helping the Chief Forester make informed decisions (Parfitt and Garner, 2004).

In 2000, this number fell to 105 jobs. By 2004, there were less than 50 inventory jobs within MSRM (pers. comm. M. Boyce, 2006; Ministry of Forests and Range, 2005b).

With the recent return of forest inventory responsibilities to the Ministry of Forests and Range, 47 resource inventory positions and three systems support positions were transferred back into the Ministry. It was stated that: "Forest and visual inventories are (to be) maintained to the best possible standards in partnership with agencies and the forest industry; and spatial data are (to be) made available for purposes of key business processes in support of Compliance and Enforcement, BC Timber Sales, tenures, fire protection, forest health and silviculture strategies." (Ministry of Forests and Range 2005b)

The Ministry of Forests and Range (2005c) recently initiated a Forest Inventory Program Review. The review is to focus on: forest cover/vegetation resource inventory, growth and yield, national forest inventory and forest recreation inventories (other than infrastructure).

Not surprisingly, there have been major changes to the process of conducting forest inventories in BC over the almost 100 years that formal inventories have been in place. These changes have resulted from technological developments and an increasing need for information on a wider variety of variables over a larger area of the province. In addition, the funding, managerial structure, and degree of attention paid to aspects of the inventory have fluctuated considerably over this period, generally being driven by the forestry issues of the day, the degree of political support available, and the general satisfaction with the current state of the existing inventory. This has limited the opportunities for a long-standing, well-documented and respected inventory system in BC. The one constant over this period has been the continuing importance of the information provided by forest inventories for making informed forest management decisions.

## Vision

Forest inventory information is the vital link among all the activities conducted in the forest. It is used to represent forest conditions in sufficient detail, at all scales, from intermediate to ground-level activity, as well as at regional, national and global levels. Therefore, the ultimate test of whether a forest inventory is sufficient is how easily and effectively the information can be used for the purposes of developing forest management policies, plans, guidelines and informing practice. Forest inventories are not sufficient when information is unreliable or lacks the details needed to support good forest management practice.

### Vision Statement:

The inventory of BC forests is sufficiently well developed and managed to support the design, development and implementation of timely, efficient and effective forest management practices necessary to produce strategically desired outcomes and impacts across large landscapes and areas of the province, in perpetuity.

In particular, it should:

- provide useful information as needed and on time, allowing managers and practitioners to make effective forest management decisions;
- be supported with sufficient resources to be current, of known standards and degrees of reliability, and represent complete coverage for the forested lands of BC as a whole;
- be continuously improved through investment in research, development and implementation of new technologies and techniques for data acquisition, organization, analyses and reporting of results;
- be routinely assessed with reports made on the current state of the inventory, recent applications, and the progress being made in research, development, and adoption of new technologies and techniques; and,
- be guided by the development and implementation of an annually updated strategic plan, including a forecast of the resources necessary to achieve the plan.

## Administration of the BC Forest Inventory

Appropriate administration of the entire forest inventory process is essential to having an efficient and effective inventory. The current status of the BC forest inventory was assessed relative to six key attributes of good inventory administration. (The recommendation numbers correspond to the list in the full report. The full report is available on the ABCFP website www.abcfp.ca).

### 1) Clear Lines of Responsibility

Difficulties can readily arise if an inventory is fragmented and not well connected across various agencies, with no one group (or individual) having clearly identified responsibility for inventory function, use and maintenance. This has been the case for the BC inventory over the last decade where government responsibility has shifted a few times and much reliance has been placed on the forest industry to implement the inventory.

#### Recommendation #2:

Responsibility for the forest inventory should be returned to the Chief Forester under the *Forest Act*.

As a result of the recent review of the BC forest inventory organized by the Ministry of Forests and Range, the provincial government announced that a vegetation inventory council will be struck. This council should play an active role in advising government on implementation issues surrounding the inventory. It also should have a major role to play in strategic planning associated with the development and implementation of the forest inventory.

**Recommendation #6:**
We endorse the formation of a vegetation inventory council and encourage the group to play a major role in strategic planning for the forest inventory as well as providing general advice on inventory issues.

## 2) Stable and Adequate Funding

Forest inventory ought to be viewed as a continual process, not a campaign for periodic re-inventory. The development and maintenance of a provincial forest inventory requires consistent long-term baseline funding. In recent years, decreases in funding have resulted in a significant decline in the number of people with sufficient inventory experience to meet growing demands for more reliable, up-to-date inventories. Most of the current funding in BC is dependent upon forest licensee support through Forestry Investment Account allocation. This is not consistent across the province or over time. Furthermore, maintaining an update and re-inventory process to ensure currency of information, and effectively storing and managing archival data are difficult without adequate baseline funding.

**Recommendation #1:**
Secured, multiyear targeted funding sufficient to support annual inventory costs should be sought, preferably from the BC Treasury Board.

It is also critical that government have in-house expertise on all aspects of forest inventory design and implementation. This expertise is essential to maintain standards and consistency within the inventory program. These individuals are also needed in primary roles of identifying problems with the present program, recommending changes in standards and procedures as needs change, and implementing new technologies once these are proven through testing.

**Recommendation #12:**
To ensure continuity and develop expertise in the full range of forest inventory activities, including field measurements, photo interpretation and data storage, analysis and reporting, additional permanent staff should be hired within government.

### 3) Effective Quality Assurance System

Some quality assurance systems appear to be in place, such as imagery and topographic mapping protocols associated with VRI, which are implemented by BMGS (Base Mapping and Geomatic Services) and certified under ISO 9001:2000. There has been a movement toward third party measurements, and quality checking is viewed as particularly important. The LRDW (Land Resource and Data Warehouse) is periodically checked for completeness, consistency among variables, etc. All inventory models (e.g. taper equations, the Variable Density Yield Prediction System or VDYP, etc.) are validated using existing data sources.

**Recommendation #19:**

The quality assurance system needs to be monitored for effectiveness, and modified when necessary, as the inventory system evolves.

### 4) Accessibility of Data and Products

Much of the data from the forest inventory are not easy to use. Given the complexity of the inventory process and the fact that inventory methods and standards have changed through time, understanding some of the aspects of the inventory is challenging. However, it helps to know how the data have been collected and what has happened to some of the data through time. This is not well documented since much of the data were collected before the value of metadata was well understood.

Fortunately, the more recent (VRI) inventory information is much easier to access and use than previous information. It is stored and distributed as a seamless spatial coverage with associated information tables. Users can access the information in a number of different ways. It can be viewed directly over the internet using a number of internet mapping framework (IMF) applications. The data can also be downloaded through the LRDW data distribution service. Metadata for the inventory are available now to a limited extent. The standards and procedures for VRI data collection and storage, and the VRI data dictionary have been available on the internet since 2003.

Available inventory information is freely shared among all provincial government agencies and with the federal government for National Forest Inventory reporting. It is distributed to other parties under digital data sales or data exchange agreements. The process for access by public groups is onerous.

**Recommendation #9:**

Public access to summarized inventory products should be supported.

## 5) Reporting

Although reports can be generated from the inventory at a variety of scales, routine reporting may no longer viewed as an inventory function. There is a need to use this function periodically to produce a series of reports, applicable to broad regions and the province, informing the public (and the politicians) on the state of the forest. Some inventory reporting is necessary for public awareness and confidence. This kind of information is also important for documenting standards and protocol used.

**Recommendation #18:**

A regular series of periodic reports, applicable to broad regions and the province, should be produced to inform the public on the state of the forest. In association with these reports, appropriate metadata should be documented for possible future use by practitioners.

## 6) Support of Innovation and Research

To reduce costs and increase accuracies of information from forest inventories, innovation, including the use of new technologies, should be supported as part of any inventory system. This should include all aspects of the system (e.g., data collection, storage, display, analysis across scales forecasting). Current research funding agencies (e.g., NSERC) do not readily support the applied research needed. Short term projects may be funded through the BC Forest Science Program, but this is frequently limited to smaller, lower cost programs, completed in one year's time. Inventory tests often require large investments to obtain the information (ground, remote sensing, etc.) even for small land areas. Some funding ought to be provided as part of the baseline inventory budget.

New methods and technologies should include approaches to updating and projecting stand structural attributes and species changes, as well as better addressing projection of complex stands (i.e., conditions following partial harvesting or in other uneven-aged and/or mixed species conditions). Given the importance of inventory applications, it is necessary that new technologies be thoroughly tested before decisions are made to adopt these technologies. For the most part, this testing is being done. For example, LiDAR and other remote sensing systems are presently being explored for possible use in the inventory. There are projects on inventory update for openings, change detection for insects and disease (e.g., detection of mountain pine beetle attacks), obtaining within-stand structure elements, and improving forecast models. In other countries, some of these technologies are now in production (e.g., stand structure detail using remote sensing data in Finland and US). However, BC has unique issues because of terrain and forest variability and limited access.

**Recommendation #11:**
A component should be included in the baseline inventory budget to support research into possible uses of new technologies and methods that could be used to improve forest inventory procedures.

## Current Status of the BC Forest Inventory

The current status of forest inventories in British Columbia was assessed relative to five criteria. These assessments were deliberately 'high level.' Detailed technical evaluation of the procedures employed in the various components of the inventory would require considerable time and was considered to be beyond the scope of this report. Also, higher level considerations are fundamental to determining whether or not the inventory is sufficient to support reasonable and responsible forest management decisions.

### 1) Currency

Forests change with harvesting and other human disturbances, natural disturbances, and stand-level growth and mortality. Therefore, a forest inventory is never completely current at any time. However, forest inventories become increasingly unreliable over time as the area that has undergone disturbances increases, and as forests grow and develop. For short periods of time, changes to the forest can be incorporated via updates to an existing inventory through acquisition of data on disturbances and by using models to estimate changes in attributes. However, for longer periods of time, or when inventory needs have changed, a re-inventory of an area is needed. The need for a re-inventory depends upon the frequency of disturbance and the rate of growth and evolution of stands. An alternative to a re-inventory schedule is a continuous forest inventory, where some part of the forest is re-inventoried each year.

The currency of the BC forest inventory information varies throughout the province. Between 40 and 50% of the forested area of the province has been classified into forest stands via photo-interpretation to VRI standards (Phase One). For the remaining area, forest stand information is primarily based on photo-interpretation of 20 or more years ago, using the standards of that time.

A mechanism is in place for updating existing inventory records for disturbances and forest growth to the current time. However, since funding has been episodic, there has been an irregular program of updates that apply only to some areas and for some changes. The application of remotely sensed data for detecting natural disturbances and for checking accuracies of updates for human-caused disturbances is presently being researched. In terms of forest growth, the existing inventory is projected annually for changes in age, height, and volume at the stand level.

However, the projections do not account for changes in stand structural attributes, including changes in species composition, which are particularly important in complex stands (mixed species and ages). These attributes are important for a number of inventory activities and uses, including stand projection, habitat assessment and protection, fire, insect and disease risk, and watershed dynamics. For short periods of time since the last inventory, changes in species composition and other structural attributes will be small and updates will be reasonably accurate.

**Recommendation #5:**
The existing inventory update program should be supported and used throughout the forested lands of BC.

For longer periods of time since the last inventory, major structural changes will occur, and the currency of the inventory cannot be obtained through updating alone. There is a process in place in BC for new inventories to be completed by licensees, with approval from government. However, there is no clearly defined governance model identifying the roles played by government, industry, and consultants in this process. Also, a mechanism is needed to prioritize re-inventory work so that scarce resources are used more efficiently.

**Recommendation #13:**
The accuracy of inventory updates need to be tracked and future re-inventories need to be scheduled in light of the accuracy of the short-term growth projections and updates for disturbances.

## 2) Coverage and Sufficiency

Even when multiple vintages of data are considered, there is incomplete coverage of the forested lands of the province, because of missing information on federal lands, provincial parks and private lands. Also, for some provincial lands, information exists, but is of very limited accessibility (e.g. tree farm licenses). Coverage of variables and details (including resolution) vary depending upon when the last inventory was completed. Over half of the province is not complete with respect to the current (VRI) inventory standards. Gaps in the inventory are an impediment to forestry professionals, including the Chief Forester, who must address a wide variety of boundary issues that are central to meeting broader public and private interests. It is likely not possible (nor desirable) to have full provincial coverage at a high level of detail, but there should be a minimum set of inventory information available everywhere and some minimum accuracy level.

The inventory information is adequate for timber supply review analysis at a management or provincial level at present. Base stand-level information may also be reliable, if the inventory data are current, and the VRI photo-interpretation standards

were met. Since this varies across the province, data quality and availability for other applications varies with the issue and the location. Also, inventories need to be flexible since it is unreasonable to assume that the issues of tomorrow will all be readily addressed by the data being collected today.

**Recommendation #3:**
Higher priority should be placed on obtaining current, complete coverage of all forest lands, using VRI standards at least at a basic level of forestry inventory information. The basic level inventory information should be sufficient for the Chief Forester's mandate of sustainable forest management at the provincial level.

**Recommendation #4:**
For all areas currently under development, complete and current inventory information at a more detailed level should be available that allows the Chief Forester to minimize the risks of decisions at a management unit level.

**Recommendation #17:**
Regular periodic reviews of forest information needs in light of present inventory standards and procedures, and expected future changes should be conducted.

## 3) Forecasting and Linking Historical and Spatial Data

There is a process in place to project the current inventory forward for timber-based resources. However, the accuracy of the projections for certain stand types is questionable because existing growth and yield models may not work well for these types or the input data necessary for producing good predictions are not readily available from the inventory. This is the case for mixed species, partially harvested, and/or uneven-aged stands. Further, no direct projection procedures exist for non-timber products and attributes.

**Recommendation #7:**
A program to forecast inventory attributes for strategic planning and decision making under a variety of stand conditions should be part of the forest inventory program and should be part of the strategic plan.

**Recommendation #8:**
The program to maintain and measure a system of repeatedly measured ground plots (permanent sample plots) must be continued and augmented as a part of the forest inventory program to support the development of forecast models and to monitor stand dynamics.

As well as projecting the inventory over time, historical records are often needed, for example, to access changes relative to natural processes and to forest policy. The BC vegetation resources inventory file is available on the LRDW which contains

copies of the inventory updated for each year, beginning with 2002. Records for prior inventory data are not easily obtained. Also, as with many forest inventories, since the methods have changed over time, caution must be applied in comparing inventory records. The changes that are detected may simply be due to changes in the inventory protocol, rather than real change.

**Recommendation #10:**
Historical records of past inventory data, procedures and standards should be archived to the greatest extent possible.

The current trend towards use of GIS has facilitated spatial linkages through geo-registration and cross-referenced databases. The VRI protocol was designed to allow for additional variables to be added to any of the inventory phases. Considerable progress has been made in linking some kinds of silviculture regeneration information to the LRDW through RESULTS (Reporting Silviculture Updates and Land status Tracking System). However, there is, as yet, no system in place to easily link to data from many other kinds of detailed, spatially-limited surveys (e.g., cruise plots, etc.). These other data sources may be useful for error checking of polygon information, imputation for habitat and stand structure projections, and meeting other information needs.

**Recommendation #16:**
Explicit mechanisms for linking inventory data with other sources of data relevant to a particular area and time are needed.

## 4) Scalability

The VRI procedures for collection of basic stand-level data using photo-interpretation are scalable for a wide variety of spatial scales. The protocol for selection of points for ground measures was designed for the scale of the management unit level summaries. Nevertheless, it can be applied at any scale, and has been implemented at a provincial level to satisfy the requirements of the National Forest Inventory as well as at the woodlot level.

Although it may be desirable to have a BC forest inventory that is capable of being scaled down to the stand level for a number of ground-measured attributes, it is not feasible for a provincially funded program. However, the inventory program should include provisions towards improvements in resolution of the inventory data.

**Recommendation #5:**
Inventory information requirements for specific, local areas, requiring a high level of spatial resolution and detail, should be outside of the base funding for the inventory program.

**Recommendation #14:**
A commitment to moving towards higher resolution of inventory information should be included in the mandate of the inventory program.

## 5) Reliability

Because of the number of variables and the complex network of inventory design, analyses and models, it is not possible to provide a simple accuracy statement for the BC forest inventory. However, documentation of the collection and analysis of inventory data helps users to determine the quality of inventory data and products.

The reliability of the inventory information is dependent upon the application. The current BC inventory is largely considered to be sufficiently reliable in currency, scope and detail for strategic analysis, but must be augmented with more information for operational planning. However, for some applications, the basic photo-interpreted stand attributes using the VRI protocol may be reliable at the stand level.

In general, inventory information in BC is most reliable for timber-related attributes. For other purposes (e.g. habitat modelling), attributes may not be available or are not current (and cannot be updated, e.g. shrub cover) for all stands in the areas of interest.

## Concluding Comments

Good forest inventory information is essential for good forest stewardship. Concern has been expressed from a variety of inventory information users that the present status of the inventory in BC is far from ideal. As a consequence, it is likely that forest stewardship can be improved by improving the status of the forest inventory.

Concerns regarding the current state of the forest inventory in BC can be separated into two broad categories: (1) systemic issues and (2) design issues. The former category encompasses issues of support (funding, technical support, etc.) and policy/planning for the inventories. These are key aspects of any forest inventory and must be adequately addressed if an inventory is to provide appropriate information in a timely and cost effective manner. The latter category encompasses issues of sampling, measurement, and analysis. These aspects are generally technical in nature and need to be addressed by individuals with the appropriate expertise and experience.

A lot of good work and hard thought has been put into the design of the current forest inventory protocol (VRI). While there are clearly design-related issues that could be improved with sufficient attention and funding, it is the systemic issues which require immediate attention. The keys to solving these issues are establishing clear lines of responsibility for the forest inventory, supplying sufficient baseline funding for implementing the inventory, appropriately managing the data and producing inventory products. This theme is common to most of the specific recommendations included in this report.

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