ASSOCIATION OF BC FOREST PROFESSIONALS

BACKGROUND REPORT (November 2006)

Assessment of the Status of Forest Inventories in British Columbia - Background Report

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Ensuring BC's Forests Are In Good Hands.

Contents

Preamble

This report was commissioned by the Association of British Columbia Forest Professionals (ABCFP) to evaluate the current state of BC's forest inventories. These include the Vegetation Resource Inventory (VRI), Terrain Resource Information Mapping (TRIM) and Terrestrial and Predictive Ecosystem Mapping (TEM, PEM). Other kinds of inventories, hydrology, soils, air quality, forest pests, pathogens, wildlife and biodiversity, while important, were not included in this evaluation. However, many of the issues associated with these inventories also relate to the inventories addressed in this report.

The purpose of this background paper is to document the process used to develop the criteria for assessment, summarize the results obtained from the survey and to provide an outline of the final recommendations. In order to make this process transparent, this document has not been extensively altered from the original based on the survey comments. Instead, a separate report has been developed as a follow-up to this background document, incorporating the results derived from the findings described herein, as well as our own knowledge of the current state of forest vegetation inventories in British Columbia.

After reviewing inventory practices from both a global and a historical perspective, we developed a set of evaluation criteria and associated questions. These were reviewed and approved by the ABCFP Forest Stewardship Inventory Task Force[1] prior to incorporating them into a survey. This survey was then sent to selected individuals to solicit their opinions on the current state of BC's forest inventory. These individuals were invited to participate based on their knowledge of the components and applications of vegetation inventories, and our desire to have broad sector (government, industry, consulting) and regional representation. Several people were interviewed, including BC's Chief Forester. Appendix I provides a list of the people who contributed their opinions and expertise. Their responses provided the basis for our evaluation of the BC forest inventory and our subsequent recommendations.

1 Forest Stewardship Inventory Task Force Members: Gerry Fraser, RPF; John Andres, RPF; John Deal, RPF; Keith-Tudor, RPF; Ken Zielki, RPF; Nick Smith, RPF; Norm Shaw, RFT; Ruth Edwards, RPF.

Introduction

Forests are important for societies, providing food, shelter, forest products, recreation and health benefits for people, and habitat for many species. The Food and Agricultural Organization (FAO) of the United Nations stated that,

> *"Forests are crucial for the well-being of humanity. They provide foundations for life on earth through ecological functions, by regulating the climate and water resources, and by serving as habitats for plants and animals. Forests also furnish a wide range of essential good such as wood, food, fodder and medicines, in addition to opportunities for recreation, spiritual renewal and other services" (FAO, 2000).*

For some countries, a fundamental use of forests by people is as a supply for fuelwood for cooking. In other countries, such as Canada, forest resources provide extensive economic, social, and environmental values.

Information obtained from forest resources inventories provides critical input to many forest management decisions across a broad range of spatial scales. This diversity of potential uses makes it difficult to design and implement forest inventories and to store and update appropriately the data collected. BC faces additional challenges due to the sheer magnitude of the forested areas in the province, the ecological diversity present, difficulties in accessing remote areas, and the heavy dependence of the provincial economy on a variety of goods and services provided by the forests.

This report was commissioned by the Association of British Columbia Forest Professionals (ABCFP) in response to concerns raised by some of their members, and others, about the present state of forest resources inventories in BC. Its purpose is to provide:

- a vision for BC's future natural resources inventory;
- a situational analysis for the resource inventory systems in BC; and,
- recommendations on: (i) the general nature of the inventory systems; (ii) the process to collect, store and retrieve data; (iii) the data itself and (iv) other aspects of the inventory and its use.

This background information was used to develop an associated report documenting our evaluation and recommendations.

For many questions regarding forest land, a variety of land and social information is needed. In BC, land information includes: 1) base mapping, ecosystem mapping and digital terrain modelling; 2) animal, bird, insect and disease surveys; 3) hydrological

surveys; 4) soils surveys and maps; 5) climate mapping; 6) atmospheric monitoring and 7) vegetation surveys and maps. The focus in this report is on vegetation surveys and maps, termed 'the forest inventory.' However, in practice forest inventory information will be used in concert with the other information listed above to address a broad set of questions.

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 the underlying data. There is a strong tendency toward wanting to be 'all-inclusive' by answering all of the demands for different kinds of information. The end result is that the cost and complexity of collecting such data overwhelms our ability to collect, manage, maintain and update it. In this report, we acknowledge the broad set of forest inventory uses, but in so doing it focuses 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. When it is necessary to refer to existing procedures, the most recent provincial protocol (the Vegetation Resources Inventory – VRI) is specifically referenced.

A vision statement for BC's natural resources inventory system was identified as central to providing the criteria necessary to assess the present status of this system and for providing a context for making suggestions for improving the present system. For this background document, our vision for the BC forest inventory is:

> *The ideal natural resources inventory system will provide information on an array of natural resources, to a wide variety of users and uses, at an appropriate level of detail and accuracy, in a timely manner, at a reasonable cost. The inventory will recognize the dynamic nature of much of the information collected and procedures will be in place for tracking and predicting change over time. Information provided by the inventory will be kept current, via standardized updating procedures applied annually and periodic re-inventory. Processes and information will be appropriate for a variety of scales and consistent across scales and through time. Procedures will be adaptable to allow measurement of new variables, when needed, and to allow incorporation of new technologies, when appropriate. The inventory system will be widely recognized and supported as a valuable asset, which is key to good natural resources management in the province.*

The next section of this report provides a context to the development of criteria for assessing the current inventory situation in British Columbia. This includes a brief overview of what forest inventories are, why they are important, and generally how they have been conducted elsewhere in the world. This is followed by a brief history of forest inventories in BC. The third section of the report presents a set of criteria and best inventory management practices for evaluating the current BC inventory, as well as a summary of the responses to those criteria. The final section of this report will contain our recommendations for improving the inventory.

The vision we present of a desirable forest inventory, the set of criteria used for evaluating the current BC inventory, and the actual evaluation itself have all benefited from discussions held with, and feedback received from numerous individuals, both within and outside BC. This feedback has helped us immeasurably in formulating the material presented in this report, and the associated summary report.

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 grown 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 forest inventory vary among countries and often between states or provinces within countries. Husch (1965), coauthor of one of a few famous books on forest mensuration (Husch et al., 1972 and other editions), listed the following steps for a forest inventory process before conducting the inventory (abbreviated and rephrased here):

1. Compilation and study of all existing available information concerning the forest area.
2. Decisions on what information the inventory will provide (critical phase).
3. Questions regarding the time and funds available, which permeates the entire planning sequence. “A fixed amount of money may be available for an inventory, and it is then necessary to fit the entire inventory to this limitation… Sometimes it may become necessary to have results of lower accuracy available in a short time rather than spending a longer period obtaining more accurate estimates.”
4. Design details discussed.
5. Detailed instructions developed, including instrumentation.
6. Training.
7. Develop field forms.
8. Design the compilation and calculation procedures before starting ‘operational’ work.

Under design details, Husch (1965) noted that:

> *"The sampling design for obtaining measurements requires the integration of information desired from the inventory, the forest, topographic and logistic conditions, and the ingenuity of the designer to prepare a statistically sound sampling scheme which will provide the desired information within the limits of the allowable error and desired probability with the available resources in the required time. It is in the planning stage that the creative ability of the inventory planner is given full play. There can be no one recommended procedure since many designs can be prepared depending on the skill, intelligence, and experience of the designer."*

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 do follow statistical principles and attempt to provide as good of information as possible within the limitations of budget and time.

Although these steps are largely still relevant for forest inventory today, changes have occurred. In particular, forest inventories have expanded from a focus on primarily timber to multipurpose forest inventories (Kohl 2004), and to spatially explicit inventory data (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 forestry 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 listed the fundamental principles for designing and implementing multiple resource inventories and monitoring programs. Multipurpose forest inventories should:

- meet a range of user needs;
- utilize 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 – resources and their classifications, ownerships, community and conservation aspects;
- utilize international and national standards and definitions;
- allow relocation (remeasurement) 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.

The procedures used for forest inventory vary. For example, the Finnish National Forest Inventory has a long history of repeated funding and a reputation of being a well-executed inventory using innovative methods. One of the principle researchers and project leaders, Erkki Tomppo, won the Marcus Wallenburg prize for his work on this inventory in 1997[2] . The main purposes of the Finnish forest inventory are stated as timber and industry, but the data have been used for other purposes, including analysis of biodiversity. The US has developed a National Forest Inventory (FIA) system to be used across the country (Bechtold and Patterson 2005). As with the Finnish inventory, changes in the inventory specifications, data collection and analyses have occurred over time. Field procedures also vary among countries and regions. The Food and Agricultural Organization of the United Nations published a manual outlining field procedures for inventory (FAO 2004), which is often used for inventories funded in whole or partially by the United Nations.

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,

2 The citation for the prize reads in part: "…for his pathbreaking achievement within the field of forest assessment. In a multi-source forest inventory system, this methodology integrates data collected from remote sensing, ground sampling and other sources to improve the quality of forest information. His scientific accomplishments provide new directions for forest assessment and ecological monitoring and an important tool for achieving sustainable world forests." (http://www.mwp.org/prizewinners.cfm Accessed July 11, 2006.)

- increasing global communications of political and environmental issues, particularly through the use of the Internet, 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 often limited to 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.

A Brief History of BC Forest Inventories

The purpose of this brief history[3] is to highlight the enduring role that forest inventories have had in the development forest management policy in BC under a variety of management philosophies (Multiple Use Management, Integrated Resource Management, Ecosystem-Based Management). All of these philosophies require comprehensive information on the current state of forests and how that will be impacted by management activities and natural and human-induced disturbances. This information is principally provided by forest inventories. The inventory is the foundation for establishing good forest management policies, guidelines and practices.

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 expected to begin a program to inspect, survey, cruise and valuate the province's 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

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

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. After completing surveys in 66 geographic units in both coastal and interior regions, their final report was published in 1916. Their report dealt with geography, physiography, climate, soil, forest types, land tenure, forest administration on provincial and federal lands, forest policy, timber harvesting, and utilization. Along with a breakdown of land classification were estimates of timber volume by species, information on land alienation, the history of land use, and known natural disturbances.

The next major advance occurred when the Forest Surveys Division was created at the BC Forest Branch's headquarters level 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. Mulholland considered forest surveys to be required for many aspects of forestry (Mulholland, 1931, p. 185, cited in Parminter, 2000):

> *"A timber cruise, however detailed and thorough is simply a crop survey; how much wood? How and at what cost can it be moved to the manufacturing plant? A forest survey is an economic survey, concerned with all branches of forestry; policy, management, silviculture, regulation of the cut, utilization, protection. Its ultimate object is to provide information to enable a forest to be administered for permanent wood production."*

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). As of 1950, forestry work was carried out exclusively at the headquarters level.

Revisions to the *Forest Act* in 1978 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 even 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 in the late 1970s and early 1980s.

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 Commission noted the importance of inventories in forest management decision making (p. 75):

> *"Accurate and up-to-date inventories of all forest values are critical to the success of any resource management policy. They form the basis for land use classification decisions and provide the raw materials used to determine the appropriate level of enhanced stewardship called for in the Vision Statement. Without this information, Land Use Planners and forest managers are severely hampered in making intelligent choices and recommendations. Sadly, the state of renewable forest resource inventories in this province is inconsistent at best, and woefully inadequate at worst."*

The Commissioners recognized that at that time the provincial timber inventory was over 20 years old, it did not provide dependable estimates of site quality, nor was there a regular schedule for inventory updates – continuous forest inventory updating should be the norm. The Commission identified ten provincial ministries that maintained a wide variety of resource data (see Appendix 2). 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." They recommended that a Ministry of Crown Lands be responsible for coordinating all forest resource inventories on Crown lands in the province. They further stated that:

> *"Improved inventories of wildlife and fisheries habitat, range, water, soils, timber, recreation and tourism potential are needed to assist in the preparation of sound, reasoned Land Use Plans and renewable forest management plans. They will also be useful in helping to quantify what benefits accrue to society from land use decisions that involve value trade-offs."*

> *"An overall master plan is essential for the development of the inventories of renewable forest resource values. These inventories should be developed within a framework that enables all data essential to forest resource planning is collected. The* inventories must also satisfy the needs of resource user groups, and the public must have ready access to the information contained in them."

The Commission recommended, among other things, 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, comprised of 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 must 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 must be established; and,
- a growth and yield program to quantify the growth rates of second-growth forests, for all commercial species in the province, must be established on a systematic, priority basis.

The Commission also recommended development of a system of accounts "… to monitor additions and deletions throughout a year of both physical attributes, such as wildlife forage production, recreational use, and other market-valued activities, such as timber harvesting and silviculture activities." They believed that this approach would "… generate a high level of confidence in the adequacy of management effort and expenditures for non-market values, as well as the long term sustainability of all values."

They clearly stated their belief that it was "… important that the inventory process apply to all lands, including parks, wilderness areas, ecological reserves, etc. Only with a complete picture of resource values in all lands can the best land use decisions be made."

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). The Resources Inventory Committee struck a Timber Inventory Task Force to make recommendations on how to improve forest vegetation inventories in the province (Resources Inventory Committee,1992). By February of 1992, a report was completed summarizing the long BC history involving the use of various inventory sampling designs in the province (J.S. Thrower and Associates Ltd. 1992). In April of 1992, the 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 Peel 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 Vegetation Resources Inventory (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. 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 (Ministry of Forests and Range, 2005b). "The current inventory section has fewer resources now than in 2001, but has responded by streamlining the business process, staff consolidation, reliance on third party data collection and dropping some activities that were not sustainable." The Ministry of Forests and Range (2005b) stated the purpose of the resource inventory program as:

- 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.

The Ministry of Forests and Range (2005c) recently initiated a Forest Inventory Program Review, co-sponsored by Jim Snetsinger, Chief Forester and Tim Sheldan, Assistant Deputy Minister, Operations Division. 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.

Forest Inventory Evaluation

As noted in the vision statement, an ideal forest inventory provides information to a wide variety of users, for a wide range of applications, at an appropriate level of detail and accuracy, in a timely way, and at a reasonable cost. A particular inventory can be assessed against the ideal by determining how well a number of evaluation criteria are met. The uses (and users) of the inventory data need to be identified in order to direct the assessment.

A number of criteria were identified and expressed as questions that could be used to assess an existing forest inventory. For each criterion we give a short rationale for the question being asked. Where necessary, questions relating to the establishment of these criteria have also been identified. The evaluation criteria are subdivided into two parts:

- attributes of a good inventory; and,
- attributes of effective inventory administration.

In addition to considering desired attributes of a good inventory and its effective administration, it was felt important to identify common uses and users of the inventory. Lists of general uses and more specific forest management and stand management uses were used to help ensure that the criteria for assessment were complete.

Various kinds of users were also identified, each of which need access to the forest inventory. It is useful to recognize who these people are as the first step toward ensuring that their needs are being met. The lists of uses and users are also included in this section.

Attributes of a Good Inventory

1. **Is the inventory current?**

   Currency of data is paramount for most uses (e.g. timber supply analysis, selection of sites for experiments, etc.).

2. **Is there a process in place for re-inventory?**

   A re-inventory process is necessary to insure currency of the inventory.

3. Has the updating process been explicitly addressed?

- If the inventory is not current, has the inventory been updated to the current date?
- Is there a process in place to update the inventory annually for:

  a) human inventions;

  b) natural disturbances; and,

  c) stand dynamics (e.g. growth, yield, increment, mortality, changes in species composition).

Since forest land changes occur frequently, even with a re-inventory process in place, the inventory must be updated for disturbance events. The process should be clearly documented and updates should occur at least annually.

4. Is the inventory complete?

- Does the inventory provide complete spatial coverage?
- Does the inventory provide all of the information anticipated as being necessary for a variety of uses (see section on uses)?
- Is the inventory transparent across administrative boundaries?

An inventory is complete, only insofar as it contains a set of polygon attributes, assessed to a common standard for the province, across all forest lands within the province. For a variety of reasons, inventory of all forest lands may be the responsibility of a number of agencies (e.g. provincial and federal government, industry). Transparency across boundaries facilitates a number of inventory uses.

5. Is the inventory capable of providing information through time?

- Are there processes in place to accurately project future inventory?
- Are there prior records of the inventory (historical) that allow for change analyses?

The current inventory provides the starting point for decisions on how best to make use of forest resources and what kinds of interventions might be used to create desired future forest conditions. Forecasts of future inventory conditions are important for identifying desired future forest conditions and for determining the associated management interventions that may be required in order to realize these conditions. Historical inventory conditions are used to inform prognostications of how the forest is likely to develop into the future. This information is also used to determine the degree to which past policies produced the then desired future forest conditions. Well-documented

observations of change in forest conditions can be used to improve predictions of future forest conditions and to improve understanding of what might have caused those changes.

6. **Is the information provided sufficiently reliable?**

   - Is it representative / accurate?
   - Is it appropriately precise?
   - Is documentation of all data collection and analyses procedures readily available?

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

7. **Can a variety of users access/query the inventory database?**

   - Are the inventory data easily obtained (time and cost)?
   - Are the inventory data easy to use?
   - Are meta data (documentation) provided and easy to understand?

   Since forest inventory data are used by a wide variety of users, documentation and ease of use is a critical characteristic of the inventory. Data that are hard to obtain, analyze or understand will result in many complaints and delays in obtaining results.

8. **Is the inventory scalable?**

   - Does the inventory design allow for data collection at the small, medium, and/or large spatial scales?
   - Are the data logically consistent across scales?

   An inventory design that allows for data collection at a variety of scales allows for flexibility in response to needs and cost (time, money) constraints. Consistency of data across scales both in collection and analysis allows for reporting that is specific locally while remaining applicable at higher levels of abstraction (i.e. local vs. regional representation).

9. **Is the inventory sufficient for addressing the forest management issues of today?**

   The inventory data should be sufficient and easy to use in answering information needs for current management issues.

10. **Can the inventory be easily adapted for new variables to address new management issues?**

    As well as being sufficient for the current issues, the data should be sufficient for providing needed information on emerging management issues.

11. **Does the inventory make the best use of appropriate technologies?**

    The inventory design, including data collection, storage, presentation and analysis, should utilize the best appropriate technologies to reduce the cost and time to collect and interpret/analyze the forest inventory information.

12. **Does the inventory have the ability to provide routine reports on a variety of data at a variety of scales?**

    Standard reports such as the State of the BC Forests, should be routinely provided as part of the inventory system.

13. **Is there a quality assurance system in place?**

    - Are measurement standards clearly stated?
    - Are all inventory models validated (e.g. growth and yield predictions, volume functions)?
    - Are data checked for correctness, including coding and transcription errors, consistency of measures across variables etc.?

    A quality assurance system reduces the time spent in analysis of inventory data and ensures that decisions are made using the best possible inventory with a minimum of errors.

14. **Are there provisions for cross-linkages of various types of inventories?**

    - Are the inventories connected to the best possible base map?
    - Is registration of the forest inventory information with other inventories (e.g. topography, ecosystem mapping, soil maps) straightforward (e.g. no need for complex registration using ground control points)?

    Registration of a variety of data sources can be very time consuming and will result in longer lags in providing data for decisions.

Attributes Of Effective Inventory Administration

As part of a good forest inventory, management practices should:

1. **Provide clear lines of responsibility for the inventory.**

   - have a clearly defined mandate
   - inter-agency interfacing / capability

   Difficulties can readily arise if the inventory is fragmented and not well connected across various agencies with some responsibility for inventory function, use and maintenance.

2. **Provide stable and adequate funding for implementation and maintenance of the inventory.**

   An update and re-inventory process for currency of the information and storage of archival data is not possible without a secure funding base.

3. **Implement an effective quality assurance system.**

   Timely responses to information needs are greatly facilitated through the assurance of quality data.

4. **Produce routine reports on components of the inventory.**

   As part of a mandate of public land stewardship, a schedule of routine reports should be part of the inventory design.

5. **Support innovation for on-going research including uses of new technologies and methods.**

   To reduce costs and increase accuracies of the information, innovation including the use of new technologies should be supported as part of the inventory system. This should include all aspects of the inventory system (e.g., data collection, storage, display, analysis across scales, forecasting).

Inventory Uses and Users

General Uses

There are many potential uses of a forest inventory depending on the kinds of data that are used to describe it. Some of those uses are common to all jurisdictions, suggesting that there is a certain subset of data that is core to all inventories on a province-wide basis. At the same time, an inventory must be sufficiently flexible to include new data to support the management of other issues on a more local scale (e.g. TSA), or the same issues, but with greater intensity than is required on a province-wide basis.

1. **Base information for all planning and management activities at all spatial scales.**
2. **Strategic planning**
   - Longer term (e.g. 150 + years), broad scale forest management
   - Provincial/Timber Supply Area/Tree Farm Licence
3. **Tactical/operational planning**
   - Short-term (≤ 20 years), localized management
   - Operating area/unit scale
4. **Reporting**
   - State of the forest reports
   - Special issues.
5. **Research**

Forest Management Uses

Assessment, management, administration, verification and reporting of:

- Biodiversity (natural disturbance regimes; coarse filter)
- Species' habitats (including fisheries; fine filter).
- Water supplies (quality/quantity)
- Timber
- Property rights
  - tenures, licenses, permits
  - native land claims

- Forest health and protection
- Sustainability of forest management practices
- Climate change/CO_2 sequestration

Stand Management and Other Regular Uses

These activities generally involve using the inventory, including a map, to locate specific kinds of stands. A few of these activities are listed here as examples.

Although this type of use could be considered 'incidental', the number and variety of users is very high and may exceed other uses of the data. The uses are as follows:

- Sustainability of forest management practices
- Climate change / CO_2 sequestration
- Silviculture and harvesting prescriptions
- Road and cutblock layout
- Plot establishment – cruising, research, growth and yield
- Location of sites for experiments and research data collection
- Local habitat assessment for particular species, including changes over time

Users

There are a very large variety of users of forest inventory data, including:

- NGOs and ENGOs (e.g. corporations, societies, forestry consultants, advocacy groups)
- Government (provincial, regional, municipal, tribal: boards, councils, advisory groups, employees)
- Consultants
- Resource licensees and permit holders
- Research institutions
- Education institutions

Forest Inventory Evaluation Responses

In order to evaluate the current state of the BC forest inventory, a number of people from government, industry, consulting and academia were asked to comment on how well the inventory meets the listed criteria. The Chief Forester was also consulted on this topic. The comments obtained are summarized and paraphrased in this section.

General Comments

- In general, I see three key issues impeding the design and implementation of a successful inventory program:
    * Trying to define programs and processes without having first clearly documented the business needs.
    * Lack of technical expertise to implement programs after they are designed. We have enough expertise to design the programs, just not enough to get them implemented on the ground.
    * Lack of stable funding (resulting in part from the lack of government priority for inventory programs, which in part is a result of the government folks not having clearly defined their business needs).

Some argue that while the VRI was well designed, it wasn't designed to meet the right objectives. (I would define business needs and then from these formulate specific objectives.) Furthermore, whether or not you agree with the design of the VRI, the subsequent problem has not been the design; it has been the lack of funding and technical expertise to implement the program.

- Inventory is fundamental to the implementation of the sustainable forest management framework.
- Given the lack of technical expertise, it is critical there is more professional reliance on those that have the expertise. The implementation process is bogged down when folks assigned to audit the process do not have the expertise to do so.
- Inventories are used for a variety of land-based decisions that affect communities, the provincial budget, and conservation of world ecological systems.
- There are always budgetary constraints to obtaining any inventory information.
- In my opinion, one of the key issues in designing a good inventory is to obtain a balance between collecting general inventory information and collecting information on growth rates and estimating changes to forest resources. We have not performed well in the area of collecting growth and

change information. Although the *Forest Act* states that the Chief Forester should consider the rate at which forests are growing to make the AAC decision, we assume that the existing photo-based data and yield models developed from empirical data have accurate growth information. Growth information from randomly located sample plots is totally lacking. So the question is: How do we know that harvest levels are lower than (or equal to) growth rates – a condition necessary for sustainable forest management?

- I think you should try to address the issue of measuring real growth rates in your review.
- Had the questions that sparked this review been asked two or three years ago many of the answers below would have been very different. Significant strides ahead have occurred in the maturity of the systems that were being developed then to address the needs for data storage and distribution. Critical user information such as meta data and a simple data dictionary were only then being developed. GIS analysts were using a number of different systems to access the data and there was not one authorative source for analysis information. Standards, funding models, and the need for inventory plans were in a continual state of evolution.

Comments on the Vision

- Too long.
- Too idealistic, ambitious, motherhood statement.
- Needs to be more focused: "The uses (and users) of the inventory data need to be identified in order to direct the assessment." AND "Should narrow the focus by including references to clearly defined business needs and placing emphasis on the necessity of having those business needs defined and agreed to before any programs are designed" AND "A wide variety of users is another area where we need to get specific. If we are not specific on users, it is difficult to define inventory objectives."
- Inventories need to be flexible – not purpose specific.
- Too Broad: This is a very encompassing vision that reflects a broader vision than just our forest inventory mandate. The number of natural resources in our forests is infinite. At our current level of knowledge, we are aware of information needs for a handful of resources that are of public interest, or may be at risk. Is it possible to catalogue these resources, group them, and assign accountability for data collection accordingly?
- Reasonable cost depends on the level at which accuracy objectives are set. If accuracy is set at the landscape unit level as opposed to, say, TSA level, higher cost will be incurred. But that does not mean that setting accuracy expectations at the landscape level is unreasonable.

- My point is that an opportunity to change the status quo might be lost if we continue to stick with generalities when we are defining the purpose of the inventory. More specific definitions of what we want might be helpful.
- Good: contains a number of key words such as detail, accuracy, timely, reasonable cost, currency, standardized, consistent, adaptable as well as themes of information on a wide array of natural resources to a wide variety of users and uses.
- Scalability: "I think the statement should be changed to recognize scalability over time. I know some users won't be happy with this but I believe it be more preferable to have reconnaissance-level inventories over the province (that can be intelligently augmented in a second re-inventory) than the current situation where very detailed information is collected in only a few areas at a time." AND "The current inventory is used to make decisions at a landscape-unit level. They do this because there is no other suitable data. How accurate is the current inventory at a landscape unit level? Should we be investing more money to improve accuracy at a landscape unit level? Most decisions which are based on forest inventory, use the polygon as the starting point. The polygons are aggregated by strata of interest to compute averages. How can polygon level accuracy be improved?"
- Suggested vision statements:
    1. A better example of a vision statement that springs to mind is the concise MoFR Road Ahead vision statement; "Diverse and sustainable forest and range values for BC"
    2. "The natural resources inventory system provides information on an array of natural resources, to a wide variety of uses, at an appropriate level of detail and accuracy, in a timely manner, at a reasonable cost. The inventory recognizes that natural resources are dynamic. The inventory is kept current, via standardized updating procedures applied annually. Processes and information are consistent across scales and through time, but allow incorporation of new variables and new technologies, when appropriate. The inventory system is widely recognized as a valuable asset, which is key to good natural resources management in the province."
    3. "To provide current, accurate, consistent and cost effective delivery of resource inventory to meet the business needs of resource managers."
    4. "The ideal natural resource inventory system will provide the necessary information to meet the documented business needs of all users in a cost efficient manner."

Evaluation Criteria

1. Is the inventory current?

- No – dates of last inventory vary and some areas (e.g. Cassier) are quite old, other areas (e.g. provincial parks, federal parks, private lands) are out of date and/or non-existent.
- The inventory can never be current; there will always be harvesting, natural disturbances and growth at a stand level that is not accounted for.
- We manage currency of the inventory through disturbance update, growth projection and re-inventory (new inventories).
- Currency is not equally important in all units.
    * Relatively current for 'active' areas
    * In areas where harvest activity is small relative to the land base (i.e. Cassiar, Nass) maybe currency is not paramount.
    * In general the update for human activities has been improving (inventories current for depletions to 2004) and hopefully the RESULTS experiment will lead to further improvements.
    * Not as current areas of large natural disturbance events are taking place (e.g. mountain pine beetle).
- Status of VRI (current program):
    * Re-inventory has been conducted to replace inventories based on priorities. Tend to have older information in areas where timber management is not the main objectives for land use.
    * 40-50% of the province has been interpreted to VRI standards.
    * Where VRI (standards-based) inventories have been completed (phase one), they are generally current enough to be acceptable.

2. Is there a process in place for re-inventory?

- You can only update for so long -- new data are needed to reflect real change.
    * Updating often results in sub-divisions of polygons and this leads to too much complexity because of the increasing number of polygons over time.
- Must support and finance an ongoing inventory process.
- Preference is for a continuous inventory, rather than a 'new' inventory. Re-inventory with a new process can sometimes result in more problems as the old inventory does not 'connect' with the new one. A continuous process of collecting new information in a well-designed program would be advantageous over an entirely new inventory with a new process.

- Inventory is a cost of forest management in the province of BC.
- There is a process in place for new inventories with well defined standards, funding, audit and quality assurance. New inventories are done by licensees with approval by government.
    * What is missing from this is a clearly defined governance model identifying the roles played by government, industry and consultants. Also missing is a consistent decision process for determining where new inventories are needed.
    * There also needs to be a strategic mechanism to prioritize provincial re-inventory work so that scarce resources are used most efficiently. Letting licensees make a re-inventory decision in isolation from provincial priorities only leads to re-inventory when it meets licensees needs (one user).
- An inventory design usually identifies a cycle for an inventory. This is not the case in BC, so there is no formal process for re-inventory.

3. Has the updating process been explicitly addressed?

- The funding is not continuous resulting in an irregular program of updates to some areas and for some changes only.
- Updating via projections:
    * Inventory projected annually for changes in age, height and volume at the stand level.
    * Updating does not account for changes in stand structural attributes, which is particularly important in complex stands (mixed species and ages). These attributes are important for stand projection, habitat assessment and projection, fire, insect and disease risk, watershed dynamics, etc.
    * Crown closure specifically is not projected as the stand ages yet crown closure is an attribute used in the derivation of stand volume.
    * Successional changes and species conversions are not modelled in the projection process. This will become more significant with the increased emphasis on partial harvest and variable retention harvest.
    * When an inventory is no longer credible due to changes in stand dynamics it is replaced via a re-inventory.
- Updating via change detection:
    * No updating program for insects/disease is in place.
    * Update program for opening (harvests) from RESULTS, with confirmation using satellite imagery (in testing).

    * Other human-caused disturbances are regularly updated.
    * Some research on using remote sensing for updating for natural disturbances and for checking updates for openings.
- Recent changes to updating were added to the Vegetation Inventory Management System (VIMS), are in the final stages of user testing prior to implementation.
- Non-traditional attributes (e.g. non-timber attributes) are not updated for change.

4. Is the inventory complete?

- Missing spatial coverage (due to changes in responsibility for inventory), even using multiple vintages of data, in:
    * TFLs, may be available, but accessible only by the company;
    * Federal lands;
    * Provincial parks; and
    * Private lands.
- Coverage of variables and details (including resolution) varies depending upon when the inventory was completed (not consistent).
- Cannot have full provincial coverage at a high level of detail for every land area but should have a minimum of set of inventory information everywhere at a minimum accuracy level.
- The inventory is not complete with respect to the most current inventory standards (VRI).
    * Over half the province is information collected to the Forest Inventory Planning File (FIP) format (prior to most current vegetation resources inventory standards).
    * Additionally silviculture information supplied by licensees to RESULTS is not to the VRI standard.

5. Is the inventory capable of providing information through time?

Projection

- There is a process in place to project the future inventory but how accurate these projections are is a question as growth and yield models do not reflect stand dynamics well.
    * VDYP is used at the stand level for update and VDYP and TIPSY are used to project for timber supply analysis.
    * VDYP is not very suitable for complex stands with multiple species, particularly where stand attributes over time are of interest (e.g. habitat modelling).

    * Efforts should be concentrated in second-growth stands, mixed species stands, uneven-aged stands and managed stands.
    * It may be possible to integrate more precise Ecological Classification into the re-inventory process, making it available for future projections. As a temporary measure, map estimates of ecological units can be used either as an adjunct to plot measures or as a separate sample system.
    * Temporary plots are often later used in ways not anticipated. They should be set up so they can be relocated and remeasured in the future.
    * Second-growth stands are important for any inventory, particularly for productivity measurements that so strongly affect long-term growth projections.
    * Site index questions vs. ecological approaches may require some major splits in procedures between even and uneven-aged forests.
- No projection models for non-timber attributes.

Historical Data

- No, NO, NOOO!
- No archiving system is in place for inventory for the entire province.
- Again, if the inventory process is radically changed, it is difficult to reconstruct historically pathways. Comparing two inventories for different standards does not constitute real change.
- The BC vegetation resources inventory file is available on the LRDW (Land Resource Data Warehouse). The LRDW contains copies of the inventory updated for each year beginning with 2002.

6. Is the information provided sufficiently reliable?

- Yes, for stand-level timber 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.
- Measurements standards and inventory protocol are well documented for VRI.
- No statements of accuracy are published for most inventories in BC.
- Could consider fixed 'polygons' rather than variable – e.g. the polygons of the US FIA system.

- Accuracy of the inventory is often confused with confidence in the inventory. Ideally it would seem that if the inventory is accurate that one would have confidence in it. There remains the question of how the accuracy is measured and how the confidence in instilled. While it is not often possible to provide a simple accuracy statement for a forest inventory because of the number of variables and the complex network of analyses and models, documentation of the collection and analysis of inventory data helps users to determine the quality of inventory data. Confidence comes from the knowledge in the strengths and weaknesses of the measurements and their application to resource planning.
- Precision or reliability is an issue of balancing resources. There may not be the resources (people, funding) in place to obtain the desired reliability (e.g. not enough qualified interpreters to quickly update for MPB-damage).
- This is a tough question to answer - it is dependent on the application. For strategic analysis, the inventory might be precise enough but not for operational planning. What is needed is a careful assessment of the inventories principal uses and what reliability is needed to make decisions based on that inventory.
- Documentation of data collection and analyses procedures are readily available.

7. Can a variety of users access/query the inventory database?

- The vegetation inventory is much easier to access and use than the previous FIP inventory:
    * It is stored and distributed as a seamless spatial coverage with associated information tables.
    * Users can access it in a number of different ways.
        * It can be viewed directly over the Internet using a number in internet mapping framework (IMF) applications such as Mapview or IMAP. IMAP is available to the general public.
        * The data can also be downloaded through the LRDW data distribution service. Land and Resource Data Warehouse (LRDW) has been designed to increase user accessibility.
        * It can also be accessed directly using GIS applications.
    * Information is freely used between all provincial government agencies, is shared with the Federal government for their National Forest Inventory reporting, and is distributed to others under digital data sales or data exchange agreements.
    * Meta data are available now to a limited extent.

    * The standards and procedures for VRI data collection, storage and the VRI data dictionary have been available on the internet since 2003.

- Since inventory is a complex process, there are concerns about how these data will be used, and that users will understand the constraints of forest inventory.
    * The data are not easy to use. It is a complex representation of the forest stands in the province.
    * Understanding some of its aspects is challenging. It helps to know how the data has been collected and what has happened to some of the data through time. Unfortunately this is not well documented.
    * Most of the data was collected before the concept of meta data was created.
    * Many of the data migrations or transformations such as the conversion to the metric system are not documented in the data file.
    * The VRI is just one of many layers the analyst is expected to know and most do not take the time to memorize the data dictionary.
- There is also an additional concern about the cost of provided data to users.
- A program to increase the public knowledge of forest inventory would help dispel the concern about misuse of these data.
- Some information (e.g. private land data, if this is included in future) may be removed from general public access.

8. Is the inventory scalable?

- Dissatisfaction with the inventory also can occur when the information has been used for purposes other than which the sampling plan was designed to provide. This has lead to dissatisfaction with previous inventories because the information was expected to provide answers that were not considered when the sampling system was designed or the questions had not been asked. This is an endemic problem with inventory practice and is not a new problem with the VRI. Strata averages from the 1951-1957 inventory were sometimes used to estimate volumes of individual timer sales. It was not the objective of the inventory to estimate the volumes of individual stands, but the inventory information was used for this purpose and it created a perception that it did not adequately represent the forest.
- VRI and TEM/PEM were designed for a variety of spatial scales.
    * The VRI is scalable and can be consistent across scales. The costs of collecting the data at smaller scales are, however, very high on a per hectare basis.

* The inventory has been implemented at a provincial level to satisfy the National Forest Inventory. It has also been implemented at a woodlot level. Where the inventory fails to meet its perceived accuracy is usually when insufficient calibration and or sampling is undertaken.
* However, the implementation is generally for the MU scale.
* This can be scaled up from the MU to higher scales.
* The inventory protocols are not designed for the very small scale (e.g. a woodlot, stand level) (one comment on this).
* For individual areas, supplemental information at the very small scale can be used along with available VRI/PEM/TEM data to obtain within stand details.

9. Is the inventory sufficient for addressing today's forest management issues?

- For TSR analysis, the inventory is adequate, unless there is a demand for increasing polygonal accuracy for spatial models.
- The VRI/PEM/TEM seems to be sufficient for MU level analyses for timber management issues.
- Inventories need to be clever – perhaps the inventory should be issues independent since the issues of tomorrow may not be answered by the inventory of today. (e.g. can we assess climate change impact?)
- The current inventory is varied as to date, variables and cannot be used to address all issues, without additional supplemental data. For example, we are not updating fast enough for bark beetle damage. Information for habitat modelling may not be available.
- There is little or no data on stand structure over time, even though we are moving toward more complex stands.
- The information is the best we have and it continues to evolve almost as quickly as the forest management issues of today evolve. This is really a question of what is an acceptable level of risk.

10. Can the inventory be easily adapted for new variables to address new management issues?

- Data analysts will continue to use information from the next inventory for purposes other than it is designed.
- It is impossible to know exactly what information will be required of the next inventory into the future. However, trends in timber utilization, public opinion, use of the forest and forest management can be used to help identify the type of information that might be needed in the future.

- Any VRI probably does not allow the flexibility needed to adapt to new variables needed to address emerging forest management issues. While allowing this flexibility is necessary, it must be weighed against the need to maintain some consistency across the units to allow multi-unit analysis.
- Additional information can be obtained and used along with VRI/PEM/TEM data for special projects.
- Imputation methods to estimate other variables for non-sampled polygons have been developed and tested and could be used for other variables. However, it would be difficult to add these to the LRDW (due to needs for consistency for multi-unit analyses.

11. Does the inventory make the best use of appropriate technologies?

- New technologies, such as LIDAR and other remotely sensed data are being explored. For example, there are projects on inventory update for openings, change detection for MPB and obtaining within stand structure elements. These projects are currently at the research level rather than the development and implementation stage.
- 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 variability.
- The BC vegetation inventories have always been an early adopter of new technologies.
- It is not hard to imagine that the LIDAR could be the next technology to be oversold as a fix all for the inventory.
- I think the inventory could be more innovative with regard to making use of appropriate technologies.

12. Does the inventory have the ability to provide routine reports on a variety of data at a variety of scales?

- Inventory reports at the MU level are no longer being produced.
- Routine reporting is no longer an inventory function. Data to support routine reports on the state of the forest can be provided at a variety of scales.
- Reports can be generated from the inventory. However, statements of accuracy for the reports cannot be made except at a broad provincial level.

13. Is there a quality assurance system in place?

- The inventory is BMGS (Base Mapping and Geomatic Services) consistent and certified under ISO 9001:2000.
- Standards for VRI/PEM/TEM are clearly reported on the Internet.

- There has been a movement toward 3rd party measurements, and quality checking is particularly important.
- LDRW is checked for completeness, consistency among variables, etc. However, meta data sometimes gets lost when transferred among many parties.
- All inventory models are validated using existing data sources.
- In some cases, models continue to be tested and there may be unnecessary delays in model implantation.

14. Are there provisions for cross-linkages of various types of inventories?

- There are provisions for geo-registration of various data sources via GPS locations and other mechanisms.
- Base maps and associated GIS data are of high quality; TRIM is the provincial standard for all publicly funded work.
- VRI/TEM/PEM are all connected to the base map.
- A feedback system to use data from silviculture stand-level surveys is not currently in place (e.g. free-to-grow surveys).
- Other data sources (e.g. cruise plots), may be useful for error checking of polygon information, imputation for habitat and stand structure projections, etc.
- Spatial and temporal registration of a variety of data sources can be very time consuming and will result in longer lags in providing data for decisions.
- The inventory design (most current VRI) always intended that other inventories could be added to it in order to provide more specific information.

Inventory Administration

As part of a good forest inventory, management practices should:

1. **Provide clear lines of responsibility for the inventory.**
    - Historically, responsibility has waffled and shifted … disastrous. Clear lines of responsibility should exist.
    - Difficulties can readily arise if the inventory is fragmented and not well connected across various agencies with some responsibility for inventory function, use, and maintenance. This is the root of our present problems – bouncing responsibility from ministry to ministry and the abysmal attitude in line staff has crippled government's ability to respond to this challenge effectively.
    - A lack of clear responsibility that has hampered the inventory program the past five years.
    - Recommend:
        * Responsibility should be with the agencies that have the responsibility and expertise in the subject area of the inventory (i.e. not a generic survey or information agency) BUT there must be strong interconnections, commonality and compatibility among the inventories and cooperation among responsible agencies. Difficulties can readily arise if the inventory is fragmented and not well connected across various agencies with some responsibility for inventory function, use, and maintenance.
        * Government must be responsible. Ontario has recently had to repatriate the inventory after transferring responsibility to industry which did a poor job. Various provinces have been held ransom by companies (in FMAs) who have responsibility for inventory but no legal requirement to provide them to governments, etc.
        * The responsibility for forest inventory must be put back into the *Forest Act*. The inventory is not currently a statutory requirement even though it is a foundational element in resource management and development.
2. **Provide stable and adequate funding for implementation and maintenance of the inventory.**
    - The notion of secure funding is somewhat idealistic. Need recognition of the cyclical nature of an inventory and need for variable funding.

- However:
    * The development and maintenance of a provincial resource inventory requires but does not receive consistent long term funding. Most of the current funding is dependent upon forest licensee support through an annual management unit based FIA allocation. This is not consistent across the province or over time. Other resource inventory users do not have the funding to do the entire resource inventory but are dependent upon licensee support.
    * Each management unit should be assessed on its own issues and there could be a different priority in terms of what is funded first. The current FIA schema of 'directed funding' for VRI only doesn't allow for movement of funds in this type of situation. Some flexibility should be built into the system.
    * An update and re-inventory process for currency of the information, and storage of archival data is not possible without a secure funding base.
    * Inventory must be clear it is an ongoing / continual process, not a campaign (inventory then hiatus and then new inventory). This latter approach means the main inventory is conducted based on special/ additional funding, which is dangerous, not guaranteed and subject to many problems. Stable sufficient funding with occasional influxes of more money is needed.
- To obtain more security of funding:
    * A champion is needed.
    * A clear definition of need is required. For example, there is a connection between forest inventories and the future prospects of babies. The shorter your connection between the two, the more likely your success in convincing almost everybody that there is a pressing need regarding forest inventories.

3. Implement an effective quality assurance system.

- This appears to be in place, with the current VRI/PEM/TEM/TRIM vegetation resources inventory system.

4. Produce routine reports on components of the inventory.

- Not everyone agreed that this is needed any more since reports can be created for any area using available data relatively quickly. Maybe there is a need for a "State of the Forests" report, however.

5. **Support innovation for ongoing research including uses of new technologies and methods.**

   - To reduce costs and increase accuracies of the information, innovation including the use of new technologies should be supported as part of the inventory system. This should include all aspects of the inventory system (e.g. data collection, storage, display, analysis across scales and forecasting).
   - Current funding agencies (e.g. NSERC, federal and provincial governments) do not readily support inventory research.

Recommendations

In general, the most current protocols for acquisition and analysis of vegetation inventory data, including VRI, PEM/TEM and TRIM could be implemented to meet most of the criteria of a good vegetation resources inventory. However, there are issues in the implementation of these protocols and improvements are possible. A list of challenges is given here, along with recommendations to begin to address these challenges. It should be noted that the BC government has recently undertaken a review of the BC forest inventory. Some of these recommendations have been identified in this review process and efforts are being made to implement them.

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

   Inventory is a cost of good stewardship of forest lands. Although the acquisition of direct government funding may be an ambitious endeavour, the Ontario government recently approved an annual budget of $10 million for forest inventory. As forests are the most important resource in BC, a similar program should be adopted. Forestry professionals, and other professionals, simply cannot operate without inventory information to support their decisions.

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

   Changes should be made to the necessary act(s) to return this responsibility to the Chief Forester. Clear lines of responsibility are required in order to: 1) prioritize funding to areas where greater detail is needed; 2) facilitate long-term consistency in protocol; 3) provide for long-term data storage; and, 4) provide for access to information. The vegetation inventory program should be managed by personnel of the Ministry of Forests and Range, with collaborations with other ministries for other inventory components (e.g. base maps).

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.**

   Detailed information for every hectare of forest in BC is simply not economically feasible. However, information within the last five years at a lower level of resolution, including updates for major disturbances, is feasible. As most land is provincially owned, the responsibility for this should be born by the government of BC. The spatial coverage for this basic vegetation inventory information should include areas currently allocated to Tree Farm

Licences, Provincial and Federal Parks and private lands. In order to ameliorate issues of privacy and ownership, this information should be at a low level of resolution only.

The basic level of inventory information should be sufficient to obtain information such as:

- The distribution of vegetation types sufficient to assess vegetation biodiversity at a coarse filter of resolution.
- Location and ranges of habitats suitable for targeted wildlife species (e.g. keystone species).
- Vegetation information critical to the analysis of water quality and quantity at a high level of resolution.
- Provincial level information to the Federal government regarding the state of the forests in BC.

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

   The level of inventory information for areas currently under development (e.g. TFLs, TSAs, community forests, etc.) should be sufficient to obtain information for planning and resource allocation, for setting policy and for evaluating sustainability at a management unit level. This information should be higher resolution in that it is very current (within the last two years) and provides more detail at a stand level.

   For example, this information should include:

   - The specific locations of stand types, defined by species, stand structure, age, height, density, etc. (e.g. stand-level timber information at a minimum).
   - Forecast models and connections of these models to inventory data to forecast future outcomes based on alternative management pathways. Ground data for sampled stands will be needed to make these connections to forecast models.
   - Geo-spatial references that allow vegetation data to be linked to other data sources to assess a variety of renewable resources simultaneously (e.g. water bodies, wildlife resources, fisheries information, recreation facilities, etc.).

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.**

For cost feasibility, very detailed inventory information for local areas cannot be included with the base funding for the inventory program. Funding for these projects should be external to the central inventory program and funded on a case-by-case basis only.

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

   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 should also have a major role to play in strategic planning associated with the development and implementation of the forest inventory.

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.**

   For any use of the vegetation inventory, forecasts to predict future outcomes are needed. A system of forecast models that tie to the inventory is needed and should be considered part of the vegetation inventory, rather than a separate excluded program. This would include growth and yield models at the tree, stand or aggregate stand level, and models to forecast other attributes. Many of these models have already been developed, although there are gaps such as 1) connecting forecast models to inventory data is not seamless; 2) some forest types are not well represented in the suite of models currently available; and, 3) there very few models to project resources other than timber.

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.**

   To support this system of models, the system of repeated measures of permanent sample plots must be re-measured, maintained, and augmented. Forecast models cannot be developed without obtained information changes over time. For example, mortality can only be assessed through repeated measurements. This recommendation supports the permanent sample plot and experimental plots program of the Ministry of Forests and Range.

9. **Public access to summarized inventory products should be supported.**

   Inventory products, particularly map products, should be available to the public for this public land base. To avoid issues with privacy on private lands, and for Tree Farm Licences, and because of the complexity of analysis of inventory data components, this information should be generally available as map products and associated data tables only. Access to more detailed data should be made available for particular case under request. This recommendation supports the current trends for data availability supported by the Ministry of Forests and Range.

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

    In order to address information needs for issues such as sustainability, climate changes and management based on natural disturbance, historical records of vegetation inventory are essential. Records should be archived yearly. This recommendation supports a current change in vegetation inventory by the Ministry of Forests and Range.

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.**

    The Ministry of Forests and Range has been testing a number of innovative approaches to improve data storage and availability, and data acquisition (e.g. RESULTS; remote sensing for inventory update of large disturbances). Other innovative approaches should be tested. Examples of potential improvements are: 1) the use of multiple sources of data to provide the basic information for the entire province; and 2) the use of imputation methods to provide details for a variety of variables at lower costs and facilitate the connections of forecast models to inventory data. Models to forecast variables other than timber should also be developed through innovative research projects. Where possible, research into innovative methods should be supported by any available research funds or via collaboration among granting agencies to reduce costs. However, development costs to implement any promising results should be borne by the Provincial Government as part of the ongoing inventory program. This recommendation supports recent trends by the Ministry of Forests and Range to encourage and implement innovative research methods.

Other recommendations include:

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.
13. The accuracy of inventory updates needs 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.
14. A commitment to moving towards higher resolution of inventory information should be included in the mandate of the inventory program.
15. The existing inventory update program should be supported and used throughout the forested lands of BC.
16. Explicit mechanisms for linking inventory data with other sources of data relevant to a particular area and time are needed.
17. Regular periodic reviews of forest information needs in light of present inventory standards, procedures and expected future changes should be conducted.
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 meta data should be documented for possible future use by practitioners.
19. The quality assurance system needs to be monitored for effectiveness, and modified when necessary, as the inventory system evolves.

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Appendix 1

List of Respondents

The following individuals participated in the survey or were interviewed.
Rick Baker, Ministry of Forests and Range
Ken Day, Alex Fraser Research Forest, UBC
Dave Gilbert, retired
Mark Gillis, Canadian Forest Service
Kim Iles, consultant
Don Leckie, Canadian Forest Service and Adjunct Professor at UBC
Bob MacDonald, Ministry of Forests and Range
Tom Niemann. Ministry of Forests and Range
Albert Nussbaum, Ministry of Forests and Range
Sam Otukol, Ministry of Forests and Range
Tim Salkeld, Ministry of Forests and Range
Jim Snetzinger, Ministry of Forests and Range
Gerry Sommers, International Forest Products Ltd.
Jon Vivian, Ministry of Forests and Range

One additional person participated in the survey, but wished to remain anonymous. A number of other individuals indicated their desire to participate in the survey, but were unable to complete the survey as a result of outstanding obligations in the workplace. The survey was conducted in September 2006.

We greatly appreciate the insights provided by these individuals.

Appendix 2

Summary of Inventory Types

Table A2.1. Summary of inventories identified by the Forest Resources Commission (1991; Pp 84 - 85)

Inventory	Description	Agency Responsible
Sub-surface	Minerals, petroleum, natural gas and geothermal resources	Ministry of Energy and Mines
Timber	Crown lands - also focusing on wilderness	Ministry of Forest
Range potential Recreation potential	Values at the time	
Crown Land Registry		Ministry of Crown Lands
Lakes, rivers and streams Wildlife population Critical habitat (fish, wildlife) Water quality sampling Biophysical habitat Snow surveys Streamflow surveys Soils Climate monitoring Vegetation Flood plain mapping	The level of detail and information has depended on how critical the management need is. For example, wildlife inventory has been concentrated on ungulates as they are important game species	Ministry of Environment
Wildlife populations Vegetation mapping		Provincial Parks
Tourism resources	Tourism values will be inventoried in areas where land use conflicts occur	Ministry of Tourism
Archeological Sites	No inventory of cultural values on forestlands exists	Ministry of Municipal Affairs, Recreation and Culture
Animals Plants	Areas throughout the province including potential parks, ecological reserves and areas of biological significance	Royal BC Museum
Timber Soils	Information pertaining to private forest lands and property assessments	BC Assessment Authority
Reservoirs Transmission line corridors		BC Hydro
Rail routes		BC Rail
Marine Fish	Coastal biophysical inventory for marine finfish for the South Coast	Ministry of Agriculture and Fisheries
Soil type Cover Land Use	Agriculture Land Reserves	Agriculture land Commission
Anadromous fish resource and habitat		Federal Department of Fisheries and Oceans
Stream flow		Water Survey of Canada manages jointly funded federal-provincial stream flow network program
Native Reserves Native Land Claims		Federal Department of Indian and Northern Affairs

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