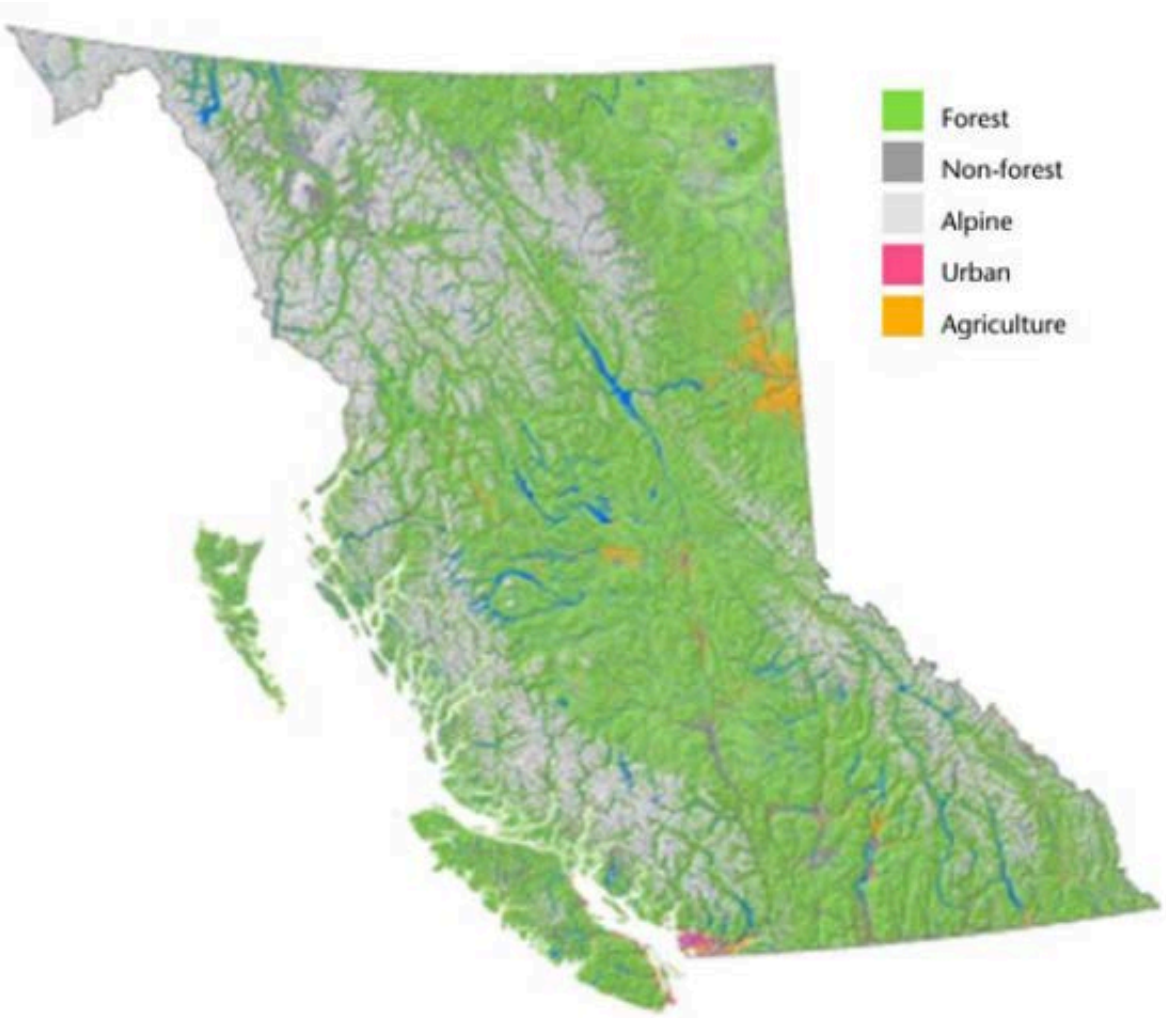
British Columbia Forest Inventory Review Panel Summary Report

December 2018



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Summary of Key Messages from the Review and Recommendations

The British Columbia (BC) Forests, Lands, Natural Resources Operations and Rural Development (FLNR) Minister Doug Donaldson announced in February 2018 that a Panel would review the BC Forest Inventory Program. Panel members are Dr. Bill Bourgeois (Panel chair), RPF (Ret); Dr. Clark Binkley; Dr. Valerie LeMay, RPF; Dr. Ian Moss, RPF; and Nick Reynolds, RPF.

The Panel reviewed the Forest Analysis and Inventory Branch's (FAIB) Inventory Program between April and September 2018. This included reviewing the existing program, requesting and evaluating written submissions, interviewing key users and developers, and assessing programs in other jurisdictions. This Summary Report highlights the Panel's key findings and provides recommendations on possible improvements to the Inventory Program. A separate Technical Background Report prepared by the Panel provides further details on findings and recommendations. The Panel acknowledges and thanks the numerous individuals and organizations listed in Appendix 1 of the Technical Background Report.

Key Messages from the Review

Government asserts BC is a world leader in sustainable forest management with leading-edge environmental practices. Fundamental to this claim is the ability to demonstrate the forest inventory is appropriate for supporting this statement. The review of the current BC Forest Inventory Program concluded:

- **FAIB staff should be commended** for their efforts in meeting the needs of forest inventory users and working toward having an inventory program that will support well-managed forests. Their efforts are particularly commendable in light of the declining and now very low levels of financial and other support they receive.
- The ministry needs to move toward each component and project demonstrating how it contributes to the integrated **"forest inventory system."**
- The **forest inventory is widely used in decision-making**, not only within the FLNR but by other resource ministries, Crown corporations, non-governmental organizations, First Nations, and the forest industry.
- Based on the Panel's criteria for assessing the current Forest Inventory Program from the perspective of supporting well-managed forests, **having the lowest funding allocation per cubic metre logged among the provinces** (i.e., $\$0.16/m^3$) **is the major limiting factor** in:
  - Moving away from FAIB having to adopt a crisis management approach in responding to user needs, including those of government,
  - Providing the foundation for establishing effective forest management policies, guidelines, and practices which support the claim of being a world leader in forest management,
  - Meeting user needs for economic, environmental and social values decision-making,
  - Maintaining the forest inventory asset,
  - Being able to predict and respond to current and future conditions affecting the forest, and
  - Capitalizing on innovation and new technologies.
- The Panel is **confident FAIB will be able to generate the innovation to overcome the deficiencies** in an efficient and cost-effective manner to support well-managed forests, if provided with adequate resourcing and direction.

- The analysis supporting AAC determinations in BC is essentially the same, if not more complex, than that used to develop long-term forest management plans for industrial and institutional timberland owners in North America. BC's expenditure on inventory is less than one tenth of that of these other organizations yet the cost of poor decisions is likely to be much greater.

Panel Recommendations

Resourcing

1. Provide adequate and sustainable funding to move toward a robust forest inventory system with the data and analysis to support decision-making for well-managed forests.

2. Maintain and increase qualified workforce in terms of both the number of people and their skill levels.

3. Establish an innovation fund within the FAIB annual budget.

4. Establish a Growth and Yield Partnership to build financial and collaborative support for a long-term and sustainable Growth and Yield program.

5. Provide independent IT resourcing to increase efficiency and expansion of data storage and analytical capacity.

Administration

6. Restore the Chief Forester's legislated responsibility for the forest inventory.

7. Establish a ministry policy to view all inventory project and program decisions from the perspective of contributing to the BC forest inventory system as a whole, not as separate projects.

8. Expand the mandate of the Forest Practices Board to include providing independent advice regarding delivery of the Forest Inventory Program.

9. Establish a Forest Inventory Technical Advisory Group.

Communications

10. Develop a robust inventory system communications program to support an informed base of professional users and public audience.

Inventory

11. Obtain full LiDAR coverage for BC.

12. Achieve an up-to-date VRI layer 1 (or LVI) available wall-to-wall across BC.

13. Utilize advanced forest inventory information, tools and processes to achieve additional information important for forest management planning and practices in prioritized areas of the province, particularly to support AAC determinations in areas where timber supply is constrained and/or contentious.

14. Investigate and implement methodologies to estimate inventory uncertainty.

Innovation

15. Establish three (or more) inventory system research, development, and implementation test sites within the province.

Growth and Yield

16. Develop Growth and Yield models that cover the main stand types and management regimes in BC.

Acknowledgments

The Panel acknowledges the openness and availability of Forest Analysis and Inventory Branch (FAIB) staff and other staff in the BC government in providing the needed information and for responding to Panel questions concerning details of the BC Forest Inventory Program. The Panel also sends great thanks to all those in other jurisdictions who took the time to respond to requests for feedback on their Forest Inventory Programs. Finally, the Panel is extremely grateful to all those who provided honest and open feedback on both the successes of the BC Forest Inventory Program and the concerns they have. The numerous individuals and organizations who kindly provided feedback and ideas are listed in Appendix 1 in the Technical Background Report.

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1.0 Introduction

Preface

Forests, Lands, Natural Resources and Rural Development Minister Doug Donaldson announced in February 2018 that a Panel would review British Columbia's (BC's) Forest Inventory Program. The announcement stated that the Panel members are Bill Bourgeois, Clark Binkley, Valerie LeMay, Ian Moss and Nick Reynolds.

The Panel undertook its review of the Forest Inventory Program between April and September 2018. The Panel's work included reviewing the existing program, evaluating written submissions, interviewing key users, and assessing programs in other jurisdictions and ownerships. This Summary Report highlights the Panel's findings and provides recommendations on how BC's Forest Inventory Program can be improved. A separate Technical Background Report further describes the Panel's findings and recommendations.

The Panel heard from numerous organizations or individuals through submissions and/or interviews, and acknowledges those who provided input in Appendix 1 of the Technical Background Report.

Purpose of the Panel Review

The purpose of the review was to determine:

- If the Forest Inventory Program is meeting the current and future needs of users.
- And, if not, what recommended changes can be made to optimize the program to meet those needs.

The inventory supports a variety of users including decision-makers. The users often utilize other information to support the tasks or decisions they make. The Panel was not asked to review the methods applied by users of the inventory (e.g., AAC determinations), but did assess the adequacy of the inventory in supporting user needs.

Motivation for the Review

With the mountain pine beetle epidemic, other emerging bark beetle and pest infestations, and extensive recent 2017 (and now also 2018) wildfires, concerns have been raised about the ability of the inventory to assess the existing and future mid-term timber supply. Many foresters are now asking – where is the wood that AAC determinations say is available? Are our projections on the performance of young stands accurate? Having an accurate and up-to-date forest inventory, including growth and yield models, has never been as critical as it is now for many parts of the province.

In addition to the importance of the inventory to assess timber supply, there are many other users who depend on a reliable forest inventory to make a variety of important decisions including forest stewardship, investment assessments, resource management, and modernized land-use planning.

There are growing concerns now about:

- Cumulative effects;
- Species at risk;
- Impacts on aboriginal rights and titles; and the

- Effects of climate change on increasing catastrophic events such as wildfires, floods, droughts, and the ability of future forests to adapt to a changing climate.

This list is indicative rather than exhaustive.

Rapid technological advancements in the use of LiDAR, remote sensing, and other tools may better inform the inventory. Resource practitioners have generally wanted an inventory that supports strategic decisions and is also useful for operational applications (at least for some critical areas). Practitioners and the public have raised concerns that a strategic level inventory is out of step with operational realities, which put us at risk of doing things on the ground that are inconsistent with desired strategic level outcomes. With advancements using new technologies, having a scalable inventory that provides reliable information to support operational applications may be possible and affordable.

It is within this rapidly changing environment that this review of the Forest Inventory Program was conducted.

2.0 Process Used by the Panel

The Panel began its review by meeting with ministry staff to discuss various facets of the Forest Inventory Program so the Panel had an understanding of the current program. The Panel then reviewed the key users and main decisions that rely on the forest inventory. From this review, the Panel identified and contacted organizations and individuals and provided an opportunity for them to prepare written and confidential submissions.

This included provincial government (operations and headquarters), federal government, major forest licensees, woodlot licensees and community forest agreement holders, academia, consultants, other non-governmental organizations, and First Nations.

The Panel also held interviews with organizations and individuals to get feedback on how the Forest Inventory Program could be improved.

The results of the Panel's outreach efforts included:

- Contacting 181 organizations and individuals and asking for submissions;
- Evaluating 58 submissions that were sent in confidence to the Panel; and
- Undertaking 25 interviews with organizations and individuals who use the inventory.

The Panel also:

- Examined the inventory programs in other jurisdictions and ownerships, particularly other provinces, in terms of their level of effort and approach;
- Reviewed applicable literature; and
- Utilized the within Panel expertise about the forest inventory to help evaluate the inventory program.

3.0 BC Forest Inventory System: Background

What is a 'Forest Inventory System'?

The term "forest inventory system" refers to a quantitative description of forest conditions on a specified land base at a fixed point in time. In traditional forest inventory, "forest conditions" referred to the quantity of merchantable timber available to harvest from a forest stand or management unit. As societal concerns related to other forest values—e.g., wildlife

and biodiversity, water, carbon stocks—have grown and broadened, the definition of "forest conditions" has evolved as well.

A forest inventory described this way generally requires two separate activities: i) measuring the forest conditions of interest, and ii) projecting them forward conditional on specified management activities. These two steps are required to know forest conditions at the present moment and also to project them into the future under various conditions.

BC faces one of the most daunting forest inventory challenges that exist anywhere:

- The forested area is large with much of it remote from convenient access;
- The forests are quite diverse with many species, age classes, and ecological conditions;
- The ministry is responsible not only for monitoring the forests conditions, but also for making long-term management decisions such as Allowable Annual Cut (AAC) determinations.

While these unique challenges have existed for years, changes in the forest and societal expectations have broadened and sharpened the need for good information. Industrial capacity has steadily grown just as insect attacks, fires and withdrawals of the timber-harvesting land base for other uses have reduced available timber supply. Slack in the system no longer exists, particularly in some areas (e.g., the Cariboo-Chilcotin). The people of BC expect ecological outcomes as well as economic ones. These changes mean that the costs of decision errors associated with poor information have grown. As a result, it is logical that the value of good information has increased and, with it, a requirement for improved inventory data and information.

Why Should BC Invest in a Forest Inventory System?

As a general matter, information is valuable only insofar as it affects decisions. The value of information can be measured by the losses avoided by poor decisions. The losses in turn depend on the *scale* and *importance* of the decisions. In BC, both the scale and importance of the decisions are quite large.

The most immediate and obvious use of forest inventory information relates to management of the province's forests. Key decisions include:

- Determining land use—boundaries, restrictions, regulations, permits
- Setting harvest levels and management direction including insect and wildfire outbreaks
- Monitoring sustainability.

The forest inventory supports decisions that go far beyond those of the forest industry or within the ministry's realm (which include AAC determinations by the Chief Forester) – several other provincial and federal agencies and Crown Corporations also rely on BC's inventory.

Based on the economic, ecological and social importance of BC forests, it would make sense to support a forest inventory system equivalent to, if not better than, the best in the world for well-managed forests.

Key pieces of legislation that underwrite the need for a reliable forest inventory include the:

- *Ministry of Forest and Range Act*
- *Forest Act*
- *Forest and Range Practices Act.*

How Much Should BC Invest in a Forest Inventory System?

The forest inventory is a provincial asset used by many organizations. As with any asset, it needs to be maintained, updated and improved to realize a continued stream of benefits. Failure to do so results in deterioration of the asset and loss of value in its use. In the case of the BC inventory it supports decisions for a wide range of economic, environmental and social values the greatest is associated with the forest sector. This sector is responsible for 32% of BC exports amounting to $17 Billion and government revenue of $1 Billion. The Forest Inventory Program is fundamental to decisions that generate provincial revenue both within the forest sector and the many others who use the data and information. This revenue is fundamental to support of societal values such as education, health, etc. Adequate and long-term sustainable funding for the Program is an investment in maintaining these financial benefits both now and into the future.

The BC forest inventory has been repeatedly highlighted as a critical need for all aspects of resources management in BC. In spite of this, resources allocated to inventory have been limited, and for the most part have also declined, as shown in Figure 1. The real budget has fallen just over 5% per year on average since 1990. This raises the question: Is the asset being maintained at a level sufficient to underwrite reasonable reliable decision-making?

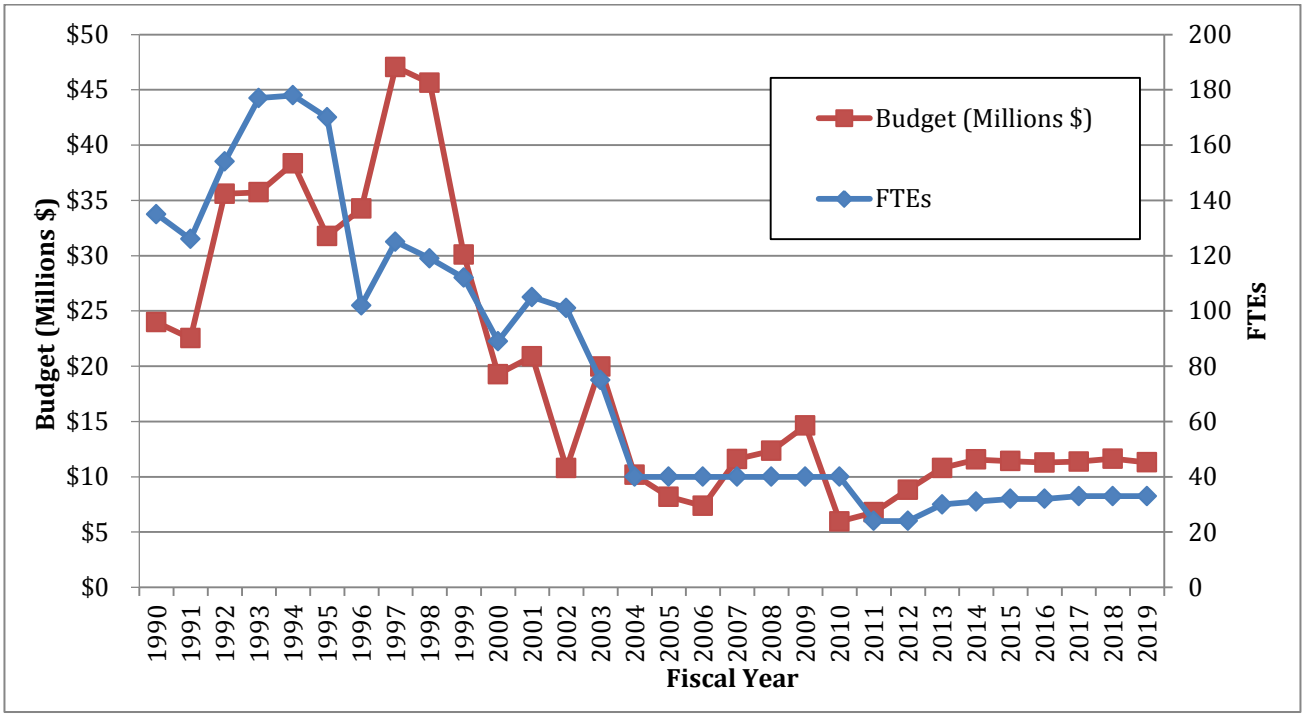

Figure 1. BC forest inventory budget and Full Time Equivalent (FTE) personnel over time (real, inflation-adjusted dollars, base year 2018)

The objective of an investment in forest inventory is to create value over time that exceeds the cost of the investment. The costs include one-time capital investments along with ongoing maintenance costs to sustain the system. The benefits are far harder to define as they mostly derive from avoiding poor decisions.

The Panel recognizes that government must have a means to determine the allocation of resources adequate to meet the current and future needs of the forest inventory system. The focus of such an allocation decision should be on meeting the criteria for a forest inventory system to achieve the goal of supporting well-managed forests (See Section 5). There are two measures presented regarding how well BC achieves this objective. The first is to compare what BC does in relation to other jurisdictions facing similar decisions (also See Section 5). The second is to consult users and other interested parties (Section 6).

4.0 BC Forest Inventory: History, Current Inventory, and Innovations

History of Forest Inventory in BC

The BC forest inventory has had an enduring role in supporting the development of forest management policies and in managing BC's forests. The forest inventory resides within a broader framework of information needs including topography, land cover, biogeoclimatic ecosystem classification (BEC), hydrological systems, road systems, and land survey and ownership, as well as human demographics and societal demands for various land uses, products, and ecosystem services (e.g., agriculture, timber, water, recreation, and cultural values). Collectively, this forest information provides a critical link between strategic, tactical, and operational decision-making, and is a foundation for establishing effective forest management policies, guidelines, and practices. An overview of the changes in the BC forest inventory over time is described in the Panel's Technical Background Report.

The Vegetation Resource Inventory (VRI) standard, introduced in mid-1990's, was intended to include:

- Phase I: Forest cover mapping using aerial photographs,
- Phase II: Ground sampling to adjust photo-interpreted attributes in forest cover maps
- Phase III: Destructive sampling of trees to estimate merchantable volumes.

Current BC Forest Inventory Program

The BC forest inventory currently provides data that is necessary for strategic decisions, and depending on circumstances, may or may not be useful for operational decisions at the management unit level e.g., Timber Supply Area (TSA) and Tree Farm License (TFL). The inventory uses a mixture of primary data from aerial photographs, Landsat and other remotely sensed data, ground plots, and destructive sampling.

Collectively, this information is used to provide the main products of the inventory: i) forest cover maps; ii) forest attributes for each stand in the forest cover maps; and iii) growth and yield models to forecast the future forest under different management scenarios.

The BC forest inventory system has changed over time, with introductions of improved and innovative methods. The current forest inventory consists of a number of products, some generated using current methodologies and models and others using historic methods. Together they provide the forest inventory data and information currently used in decision-making.

<u>Forest cover maps</u>
There are three main types of forest cover maps in BC:

- VRI Phase I

- Landscape Vegetation Inventory (LVI)
- Forest Inventory Polygons (FIP).

The VRI Phase I forest cover maps currently cover about 50% of BC forests. All Phase I projects are subjected to quality control by independent parties. Based on two recent projects, Phase I forest cover maps (spatial and attribute data) costs are about $1.50/ha.

LVI uses Landsat satellite imagery along with a systematic sample of digital aerial photos (DAPs) in a model-based approach to obtain forest cover maps. LVI is a much lower cost, at about $0.35/ha, but does not provide the same forest cover details as VRI Phase I. However, this level of forest cover information is sufficient for some areas of BC. For example, LVI is underway for the Cassiar TSA.

Older FIP coverage pre-dates VRI, and are the only available forest cover maps for some areas primarily in the northwest parts of BC. The area under FIP has been decreasing given that one of the goals of the 2013 Forest Inventory Strategic Plan was to have: "All forest cover inventory data is less than 30 years old" by 2023.

The inventory program is testing a LiDAR-Enhanced Forest Inventory (LEFI) in some areas.

Inventory updates

The dates when forest cover maps were prepared vary across the province. All maps are regularly updated for natural and human disturbances, as well as grown to the current date using a variety of information sources. The Vegetation Resource Inventory Management System (VRIMS) is used to update the forest cover maps for growth changes. Landsat is used to map large natural disturbances. New air photos, overview flights, and field visits are used to obtain higher resolution details about other natural disturbances. Harvest information provided by forest licensees and government in the Reporting Silviculture Updates and Land Status Tracking System (RESULTS) is another data source for updating the inventory. Although the intent is to provide these various updates annually, under the current inventory budget, there is a backlog of updates that have not been added to the inventory.

Re-inventory

Even though forest cover information is regularly updated, re-inventory is eventually needed. The timing of this re-inventory varies, since the need depends on the levels of natural and human disturbances, and impacts to timber supply and other forest values.

Ground plots

VRI Phase II ground plots were intended to be used to adjust VRI Phase I attributes. However, currently VRI Phase II ground plot information has not been commonly collected in recent years. VRI Phase III, also termed Net Volume Adjustment Factor sampling, is no longer supported.

The current ground sampling program is primarily a combination of National Forest Inventory (NFI) plots, along with BC's Change Monitoring Inventory (CMI), Young Stand Monitoring (YSM), VRI audit ground plots and Permanent Sample Plots (PSPs). All of these projects, except PSPs, use a widely spaced grid with a subset of these selected for ground sampling.

Growth and yield (GY)

The Variable Density Yield Projection (VDYP) model is a stand-level model for natural (unmanaged) stands that use attributes of existing stands to forecast future stands assuming no

human nor epidemic natural disturbances. The current version of the model, VDYP7, was developed using a combination of temporary and permanent sample plots (TSPs and PSPs).

Key inputs for each stand are average height, average age, site productivity, species combination, and basal area per ha available in forest cover map information (e.g., VRI Phase I). Of note, VDPY7 uses basal area per ha for density instead of percent forest cover that was previously used in VDYP6. As a density measure, basal area per ha is critical for yield forecasts, but is very difficult to photo-interpret; consequently, field visits and ground plot data are needed to support these estimates.

The Tree and Stand Simulator (TASS) and Table Interpolation Program for Stand Yields (TIPSY) are used to forecast the growth of managed stands. TASS was originally designed to simulate single-species planted forests. Since TASS II and TASS III include only a limited number of mixed-species stands, assumptions must be made in using TASS to simulate most types of mixed-species managed stands of BC. TIPSY uses stand-level variables for post-harvest stands to forecast future yields in timber supply and other analysis.

New Technologies and Innovation

The recent availability of a large variety of remotely sensed data has increased the interest in using more of these data sources to obtain forest inventory information. The main drivers are:

- Traditional forest inventories are expensive, and remotely sensed data have been shown to reduce costs based on prior successes and recent projects (e.g., LVI).
- LiDAR (remote sensing technology) is particularly promising for obtaining higher spatial resolution data. Since the primary use of LiDAR is for accurate Digital Elevation Models (DEM) which vastly improves harvest and road engineering, the cost of LiDAR for forest inventory use is often considered "free" as it can be considered an added-on benefit of acquisition for other purposes.
- Digital aerial photos (DAPs) viewed in 3D have seen a resurgence in literature for providing within-stand details.
- Experience using new technologies suggests that reasonably accurate operational-level forest inventories at finer spatial scales can be achieved at lower costs using model-based approaches and a mixture of remotely sensed data.

There are also increasing pressures for improved GY models. The main driver is the need for more detailed within-stand information forecasted in time, including:

- Stand and stock tables showing tree and species distributions of stems and volume per ha, for product analyses, value analyses, species diversity, and habitat analyses.
- Dead trees and coarse woody debris needed for habitat analyses, fire risk analyses near communities, and carbon accounting, as well as for valuing stands for products that may utilize these materials including biofuels.
- Growth and yield under different climate scenarios.
- Growth and yield responses to disturbance agents (e.g., rusts, insects, etc.).
- Growth and yield responses to a wide variety of harvest/silvicultural regimes, such as variable retention harvests, patch cuts, single-tree harvests, improved genetic stocks, species mixtures, fertilization, etc.

New innovations provide a significant opportunity to integrate forest, landscape, and tree level forecasting with inventory data. Such integration could improve impact assessments

related to disturbance agents (e.g., bark beetles, wildfire, harvesting, climate change, etc.) on timber supply, water resources, wildlife habitat, and socio-economic conditions. If this integration were to be coupled with more reliable inventory at a polygon scale (i.e., stand-level) and more detailed data at a higher resolution, there would be an opportunity to better guide silviculture, harvesting, and forest protection activities to achieve desired outcomes at the forest and landscape-level scales.

Related Programs and Other Data Sources

Data from FLNR and other ministry programs support the BC forest inventory and/or analysis activities including:

- Silvicultural and harvest information from the RESULTS database.
- Operational cruise data on areas scheduled for upcoming harvest.
- Base Mapping Information including topography (e.g., TRIM) and administrative layers such as land ownership and forest tenures.
- BEC GIS layers including Predictive and Terrestrial Ecosystem Mapping (PEM/TEM).
- Remotely sensed data collected by a variety of agencies including Landsat, and digital/analog aerial photographs.
- Conservation Data Centre information regarding species and ecosystems at risk.
- Research data collected by government and non-government organizations.
- LiDAR data, when available, to help build models of forest attributes.
- Other GIS data including Google Earth.

Collectively, these data critically support: i) forest cover mapping; ii) inventory updates for harvests and regeneration; iii) updates for major natural disturbances; and iv) analyses by government and non-governmental groups for a wide variety of applications.

Data from other agencies are critical for forest inventory and analysis. Efforts have been made to increase data sharing and to investigate opportunities to decrease costs incurred by a single program (e.g., cost-sharing LiDAR acquisition given its many applications and uses).

5.0 Supporting Well Managed Forest Decisions

How well does the current forest inventory system serve BC needs? Answering this question requires criteria to address adequacy. Data from other provincial, national and international inventory programs assist in the evaluation.

Criteria for Evaluating Forest Inventory and Forest Inventory Practices

The criteria developed for the assessment of effective and efficient forest inventory administration includes:

- Clear lines of responsibility
- Stable and adequate funding
- Effective quality assurance system
- Accessibility of data and products
- Reporting
- Innovation and research.

The criteria for evaluating the status of the forest inventory includes:

- Currency

- Coverage and sufficiency
- Forecasting and linking historical and spatial data
- Resolution, scalability, reliability, and level of detail.

Comparisons with Forest Inventories in Other Jurisdictions

The Panel interviewed and solicited submissions from Forest Inventory Programs of Alberta, Saskatchewan, Ontario, Quebec and New Brunswick. Table 1 summarizes ownership, size and relative forestry activity for these provinces. Table 2 provides summary statistics on government resourcing of Forest Inventory Programs.

Table 1. Percent of ownership, size and harvest activities on forestland in Canada

Province	Provincial (%)	Federal (%)	Private (%)	Forested land (millions ha)	Crown Timber Harvesting Land Base (millions ha)	Annual Harvest (m^3)[2]
British Columbia	95	1	4	60	25	67,970,000
Alberta	87	8	5	35.2	23.3	23,031,000
Saskatchewan	90	4	6	34	11.7	3,712,000
Ontario	91	1	7	71	27	15,829,000
Quebec	89	0	11	76	28.2	28,559,000
New Brunswick	48	2	50	6	3.3	9,363,000

Table 2. Summary of relative government resourcing of Forest Inventory Programs
(arrows indicate BC as being above ↑ or below ↓ or consistent = with the Canadian average)

	Above/ Below Average	BC	Alta	Sask	Ont	Que	NB
Domestic Economic Impact of Forestry as percent of GDP	↑	8%	2%	1%	2%	5%	13%
Government revenue ($) per m^3 logged	↑	12	7	3	6	11	9
Inventory budget ($) per m^3 logged	↓	0.16	0.37	0.27	0.59	0.70	0.25
% Inventory budget of Crown revenue from forestry	↓	1%	5%	10%	9%	7%	3%
Inventory budget ($) per km^2 of THLB	=	44	37	9	34	71	71
Staff per km^2 (000) of THLB	↑	0.13	0.04	0.06	0.1	0.27	0.39
Km^2 of THLB per ground plot	↓	63	259	138	37	24	2

BC spends approximately $44 per km2 of timber harvesting land base (THLB) on its Forest Inventory Program, which is 30% less then Quebec and New Brunswick. Despite this relatively lower BC budget, FAIB maintains a comparably higher ratio of staff within its program. Every jurisdiction in Canada surveyed (except BC) has a strategic target for a complete re-inventory of 10 years. BC has instead set a target that by 2023 all inventories will be younger than 30 years old.

The Panel's Technical Background Report also describes inventory programs in the US and in the Nordic countries (Denmark, Finland, Sweden and Norway). The forest management situation in the US differs markedly from that in Canada. While the vast majority of the timber harvesting land base is in private ownership in the US, long-term forest management planning on large industrial and institutional lands in those regions face essentially the same challenges as AAC determinations in BC. However, those ownerships support forest inventories with a ground plot for each one to 10 ha. The sampling intensity for BC's forest inventory is hundreds to thousands times less.

6.0 What the Panel Heard

Context of Input

The information received by the Panel needs to be put into context. The Panel views the Forest Inventory Program as a system. This was perhaps not considered by many, if not all, the people providing input. The input tended to be focused on the expertise of the individual or their role in the organization in utilizing BC forest inventory information. Seldom was the comment made in consideration of the resources available to FAIB in suggesting user needs. Consequently, the input may not consider the requirements of a system or a reflection of what FAIB may or may not be doing or the constraints to which they are confronted

User Needs Summary

Based on the feedback, uses of the BC forest inventory (from most to least common) include:

- Strategic scale timber supply decisions. The inventory is the underpinnings that help inform a sustainable rate of cut.
- Operational applications, including the use of the inventory to target harvest profiles, support operational planning, and estimate current stand level conditions.
- Land use planning decisions, most commonly wildlife habitat supply, hydrologic recovery and biodiversity modeling.
- Fire abatement planning and implementation.
- Forest carbon modeling.

What is Working Well

Throughout the user feedback process, commendation was expressed for the work undertaken by FAIB. Much of this praise came for the ongoing efforts of staff to deliver complex products, maintain programs on time and budget, and provide technical support despite limited resources. Many comments extolled the Forest Inventory Programs ability to support strategic level decision-making, and providing objective and methodical means to maintain a complex inventory with notable improvements in currency and completeness. In addition there was common praise for the program's ability to provide free and open access to data.

Many users were supportive of the programs development of new growth and yield models (TASS III), and exploration toward integrating new technologies to enhance the inventory.

What Needs Improving

There was ***major agreement*** based on the feedback on the following themes:

Increase program linkages to improve program inter-compatibility. There are multiple programs with data collection overlaps that might be linked to leverage efficiencies e.g.,

- To improve weak links between cruise, silviculture, forest health and the inventory programs, and
- To optimize efforts for field sampling.

Address Growth and Yield model issues. Model parameters or the scope associated with TASS, TIPSY or VDYP need review or improvement e.g.,

- Models provide inadequate projections for complex stands.
- There are too many unsubstantiated assumptions and extrapolated data use.
- Models do not sufficiently account for forest dynamics.

Improve communications and data access. Dissemination of information e.g., need for:

- More documentation and/or extension of inventory products,
- Increased training for product use, particularly for GY platforms.
- More peer-reviewed, accessible documentation for transparent accountability.
- Inventory-based spatialized timber supply products to increase confidence.
- Forest summaries including information on VRI updates at regional level.
- Public access to ground plot information.

Address attribution issues. Inventory attributes need to be improved, including issues related to the integrity of data inputs into the inventory e.g.,

- Attribution does not account for the heterogeneity of stands.
- Interest in non-timber information.
- Concern regarding age class breaks and definitions.
- Concern over quality assurance.
- Too many attributes.

Enhanced forest inventory (EFI) methods. The province should broaden the use of proven technology and methods to enhance forest inventories e.g.,

- Integrate remote sensing into inventory (e.g., LiDAR).
- Share or distribute the baseline acquisition standards for LiDAR.
- Less subjective, automatable attributes can provide the ability to quantify uncertainty.

There was ***moderate agreement*** based on the feedback regarding:
Resourcing. Constraints (human/financial) impede delivery of the inventory program e.g.,

- There is not enough capacity for core business areas due to limited base funding.
- Not enough targeted (additional) funding for focal program areas e.g., use of LiDAR in enhanced forest inventories).
- Increased data demands have stressed corporate data infrastructure to their limits.

Update issues. There were problems with the annual inventory updates e.g.,

- Generalization of silviculture records (RESULTS) when brought into the inventory.

- Currency – harvest and natural disturbance not always updated in timely manner.

Incomplete inventory. Inadequate inventories not up to VRI standards (e.g., FIP) e.g.,

- Currency of inventory inadequate even in some areas with significant forest activity.
- Frustration by inconsistency of data standards e.g., VRI forest cover information does not exist across BC.

Develop partnerships. Between the inventory program and its users e.g.,

- Initiate a collaborative platform between users to centralize the acquisition and access to LiDAR and other remote sensing products.
- Support greater academic involvement in growth and yield development.
- Develop a growth and yield (GY) cooperative among forest professionals.

There was ***minor agreement*** based on this feedback regarding:

- Disparity between data. There are increasing differences between inventory standards between forest tenure holders and the provincial inventory.
- Uncertainties in innovation. Uncertainty in advancements impedes the forest inventory.
- Training. There are issues with training, attrition/succession in the workforce.

Many of the above noted themes are interdependent e.g., increased program linkages for ground sampling may improve GY models, improve attribution quality, or contribute to enhanced forest inventory.

There is a general conflict in expectations between the BC forest inventory as a strategic program, but users wanting a tactical or operational scale of inventory.

As forest licensees complement the BC forest inventory with refined operational data, there is a growing divide between public access to the best available information for forest management.

Another important undercurrent of user feedback was the need to better quantify/qualify uncertainties, the lack thereof impacting confidence or subverting decisions.

7.0 Panel Assessment of the BC Forest Inventory Program

Importance of the BC Forest Inventory and the Panel Review Process

Forest inventories provide the essential information needed to develop forest management policies and management plans. A key use is assessing the long-term sustainability of forest benefits including economical, such as timber values; environmental, including carbon sequestration, animal and bird habitats; and social benefits including high water quality, recreation opportunities, and human health. This is particularly relevant for BC where forests are largely publically owned and managed and cover approximately 60% of BC land base.

Given the large amount of information received by the Panel, focus and refinement was needed. To that end, the Panel used the criteria for supporting well-managed BC forests as the framework for the assessment; the information in Sections 4, 5, and 6 as evidence; and the expertise within the Panel. An evaluation summary using the criteria is presented below.

Effective and Efficient Forest Inventory Administration

Clear Lines of Responsibility

Generally, there are clear lines of responsibility for the BC Forest Inventory Program e.g.,

- Program responsibility rests with one Branch of the ministry.
- Inventory users expressed praise about Branch staff efforts despite limited resources.

However, there are overlaps with other government programs that have contributed to difficulties in delivering inventory products e.g.,

- Concern about multiple entries (e.g., inventory, cruise and silviculture survey plots) to the same land area as evidence that collaboration and coordination could be improved leading to budget and data collection and management efficiencies.
- GY programs are not cohesively organized e.g., VDYP and TASS/TIPSY are separated into two task groups with different user interfaces; and different Branches manage the PSP vs EP plots.
- The inventory program requires extensive IT resources to store and analyze data but it is under-resourced and IT support resides elsewhere in government.

Stable and Adequate Funding

The budget for the BC forest inventory has been sparse relative to the information needs and the challenges in obtaining these data given: i) the vast area of forest land; ii) extensive ecological diversity of the forests; iii) limited access; and iv) limited tax base to fund inventories (i.e., since human population is low in BC relative to forests in other countries). As shown in Figure 1, resources for the BC forest inventory declined significantly between 1990 and 2012.

The FAIB should be complemented on their performance to address user needs within such a limited budget. However, this has decreased the opportunity to improve the BC Forest Inventory Program to meet the requirements to support well-managed forests.

Challenges in providing inventory products within budget have been recently exacerbated by:

- Large scale changes to the forests from wildfires and the mountain pine beetle.
- Increasing needs for detailed high-resolution spatial information (e.g., to assess fire risks near communities, to address critical habitat for species at risk).
- Increased scrutiny by members of the public in how forest inventory information is used to support resource decisions.
- Increasing pressure to test and make use of new and emerging technologies to improve the inventory.
- Increasing needs to address forest survival, growth, and species shifts given changing climates.

What are the budget shortfalls? If we consider a 10-year cycle (as is the stated target in other provinces) to cover the entire 60 million ha of forest land in BC (i.e., complete 1/10 of BC each year), the current program budget does not even cover the task of forest cover mapping.

As shown earlier in Table 2, the BC inventory program is underfunded relative to most other programs in Canada. Given this limited budget, the program has focused on delivering necessary base products while diverting funds to other urgent needs, including the need to assess 2017 and 2018 wildfire timber supply impacts. This has resulted in the requirement of adopting a crisis management approach. The status of program funding is even less adequate

if compared with that of comparable industry and institutional lands in North America with similar forest management planning challenges.

Effective Quality Assurance System

The BC inventory program has a number of processes in place for quality assurance:

- The program maintains and regularly updates standards for VRI and ground plots.
- Data dictionaries are generally available within the BC Geographic Warehouse (BCGW).
- Certification programs are in place for photo-interpretation and ground plot personnel.
- The program conducts audits of VRI Phase I forest cover information using ground plots.

There are concerns, however:

- Although standards for deriving VRI Phase I spatial and attribute data include use of ground plots and doing fly-overs, budgetary constraints limit the ability to obtain this information.
- Given the complexity of forest inventory data systems, there is concern about data integrity (e.g., generalized RESULTS information used to update the inventory).
- Low program budget and staffing contribute to the perception of data integrity issues.
- Although quality control systems are in place, accuracy reporting could be improved.
- GY models are the result of research using PSPs and EPs yet much of this research has not been peer-reviewed.

Accessibility of Data and Products

BC forest inventory products have been made available for public use, and the Panel received program praise about how openly the program shares inventory products. However, there are concerns, particularly:

- An assessment of data accuracy is often not included with the data.
- Forest cover maps are easily accessible via web sites for the upper canopy level only. For other information, staff must be directly contacted (e.g., other canopy levels, ground plot data, data nuances) which takes time and other resources away from their production of Inventory products.
- GY models are only available on separate platforms since they were developed independently; as a result, platform updates for new technologies and training of new users is difficult and more costly.
- While aerial photos are available, other spatial datasets (e.g., LiDAR) should be made available for users.

Reporting

Standards for ground plots and VRI Phase I data are well-documented and publically available. The Panel heard that program staff are very approachable with regards to questions on the inventory.

However, based on the Panel review:

- Some reports made available to the Panel were internal to government only.
- Current reports on the status of BC forests (existing report is from 2010) and for areas of interest (e.g., regions) within the province are not available.
- Information on the forest inventory that was available on prior websites is no longer supported (e.g., a GY overview).

Innovation and Research

The program has supported innovation and research including:

- Collaborative research with academia, and collaborative work with industry on a LiDAR Enhanced Forest Inventory or LEFI (i.e., 2.5 million ha completed to date).
- Investigations of tree growth under different management regimes, and site productivity research including some collaboration with academia.

However, innovation and research should be expanded based on Panel feedback given:

- Pressures to assess and implement new technologies to improve the inventory.
- GY concerns related to insects and disease impacts, reliability of forecasts for mixed species complex stands, and need to assess impacts of harvest/silviculture practices.
- The need to obtain other attributes for uses such as habitat assessments.
- The need for explicit assessment of the uncertainties in the inventory projection systems, the cost of decision errors and the value of additional information.

The main barrier to expanding BC Forest Inventory Program's activities in innovation and research is limited resources (budget and staff). Increasing program resources for innovation and research should help leverage collaboration with academia, federal government, industry and other partners.

Status of Forest Inventory

Currency

The program has been delivering as much as 4 million hectares of new inventory annually. Within the last year alone the program has added:

- Over 1.5 million hectares of proprietary Tree Farm License forest inventory was added to the BC forest inventory.
- Over 900,000 hectares of updates for wildfires.
- 24,000 depletion record updates for timber harvests.
- 8,000 silviculture record updates.

As well, 600 new or re-measured ground plots were completed across the province.

As stated, while these data are continuously updated for major natural and human disturbances, other changes, including changes in species compositions, along with small-scale mortality and regeneration, require periodic re-inventories. The program goal is to have 100% of BC forest cover information that is less than 30 years old, but this is unlikely to be reached given the current budget. Further, there was concern by users that updates for natural and human disturbances need to be more timely to support effectual planning to address those disturbances.

Coverage and Sufficiency

Overall, the forest cover maps include most of BC (about 95%) – with the program goal to have 100% coverage by 2023. As noted, the vintages and sources of these data vary over BC. The main existing 'holes' in coverage are older provincial and national parks, and private lands.

In terms of sufficiency, with available budgets, the program defines the BC forest inventory as providing information for large-scale analysis at the management unit level (e.g., TSAs and TFLs) for analysis such as Timber Supply Review. The inventory was never designed or

intended for tactical or operational applications. However, a mismatch between the strategic-level inventory and operational realities could result in localized management activities that are inconsistent with desired strategic-level outcomes.

Since the BC forest inventory data are often the only available data, the Panel received feedback that users use these data at operational levels resulting in:

- Professionals having to field-check all forest cover information before use.
- Reliability concerns when only LVI or FIP forest cover information was available (i.e., VRI Phase I forest cover information was not available).
- For some applications, including assessing fire risk and habitat suitability, some attributes are not available in VRI forest cover information; however, some efforts have already been made to partially address these concerns with the addition of new protocols for information on dead materials to forest cover data.

While there are general pressures to have reliable forest inventory data for tactical and operational applications in BC, these pressures are higher in some locations. Efforts have been made to meet these information needs when possible as special projects (e.g., LEFI projects). However, this pressure is very likely to grow. The question that remains is: Where will communities, tenure holders, and forest practitioners get the information they need to manage public forests?

Forecasting and Linking Historical and Spatial Data

There have been program successes in GY and site productivity:

- VDYP and TASS/TIPSY have been developed and are used for timber supply analysis.
- GY and SiteTools software are available for public use.
- Further development of TASS has occurred with release of TASS III.
- Efforts have been made to model insect and disease impacts, and to address improved genetic stocks.
- Program GY and site productivity staff and consultants are highly regarded.
- Excellent collaboration with Experimental Plots (EPs) managed by another Branch.
- Quality GY research including collaboration with academia and federal government.

However, there are some concerns:

- GY models need to be improved particularly for multi-species and complex stands.
- Uncertainty regarding the reliability of GY forecasts.
- GY models need PSP re-measurements but this has been curtailed due to budget issues.
- Neither VDYP nor TIPSY accounts for future climates.

Resolution, Scalability, Reliability, and Level of Detail

The BC Forest Inventory Program currently supports strategic analysis, but there is increased demand, at least in some areas, for an inventory that supports operational applications and provides more forest attributes. Two GY models are supported by the program but these were not designed to cover all needs for forecasting stands.

Questions include:

- How can demands for forest information and future forest forecasts be suitably met?
- Given budget levels, how reliable is the inventory at various scales of spatial resolution?
- Can new and emerging technologies provide solutions?
- What research is needed, and by whom, to address forest disturbances and growth?

The overall perception is that since BC forest lands are primarily publicly owned, that public funding, in partnership with others, should be used to answer these questions.

8.0 Recommendations

The forest inventory needs to focus on meeting the needs of the users from the perspective of supporting well-managed forest decisions. The Panel believes the forest inventory has to be constructed and implemented as a system using a number of criteria to measure adequacy. In this regard, it is the Panel's view FAIB has done an admirable job in implementing an inventory program to work toward meeting this requirement within the resources government has allocated. However, there are areas needing improvement that the following recommendations - many of which require additional resources - are directed.

The following 16 recommendations are listed under the following headings:

- Resourcing (Recommendations #1-5)
- Administration (Recommendations #6-9)
- Communications (Recommendation #10)
- Inventory (Recommendations #11-14)
- Innovation (Recommendation #15)
- Growth and Yield (Recommendations #16).

The Technical Background Report provides additional supporting information including process, essential resources, innovations, and additional rationale.

Resourcing

Recommendation #1: Provide adequate and sustainable funding to move toward a robust forest inventory system with the data and analysis to support decision-making for well-managed forests.

Rationale:

- The Chief Forester identified the need for an inventory that provides:
  - Data and information to address the current and expected timber and non-timber related issues associated with its use; and
  - Reliability, accuracy, with an appropriate level of detail at the desired levels of resolution necessary for confidence in its use on major issues raised by users and critics.
- The ABCFP (2012) reported the government had not achieved the "stable and adequate funding" of $15 million annually to "…maintain a reasonably current inventory required to underwrite the mandate of the Chief Forester.".
- The forest sector is responsible for 32% of BC exports amounting to $17 billion and government revenue of $1 billion.
- The Forest Inventory Program is fundamental to decisions that generate the provincial revenue that support societal values such as education, health, etc. Increasing funding for the program is an investment in maintaining these financial benefits now and into the future. Many ministries, Crown corporations and forest sector companies depend on the forest inventory in their decision-making.

- The 2017-2018 FAIB budget is $11.3 M. If this was doubled to $22 M the cost per cubic metre of harvest volume would increase from $0.21/$m^3$ of the provincial TSA cut level to $0.42/$m^3$. Relative to the importance of the information to decision-making and government revenue this is a small investment in the asset.
- The recent Professional Reliance Commission (*The Challenges of Using a Professional Reliance Model in Environmental Protection – British Columbia's Riparian Areas Regulation*) report recommendation (R28) highlighted the importance of resource information being available to the public.
- The Professional Reliance Commission report also identified the need to identify opportunities to improve the quality of natural resource information to help improve professional reliance outcomes (R33). The review noted that a number of disputes concerning the quality of resource information presented in professional work products.
- Achieving the needs of the Chief Forester, forest professionals and public requires a sustained well-resourced forest inventory system that has a sustained level of adequate funding for staff and operations.

Recommendation #2: Maintain and increase qualified workforce in terms of both number of people and their skill levels.

Rationale:

- While BC has some of the most highly trained forest inventory staff in Canada, current staffing levels are not sufficient to meet certain core business needs.
- Sustainable forest management, and public trust, requires that products (e.g., re-inventories, forest change mapping, AAC analyses) are continually and promptly delivered.
- The inventory program is often strained by high analytical demands in answering pressing socio-economic questions, as well as demands to refine the spatial resolutions and shorten the delivery time for decision-support products.
- This often leads to triaging staffing resources, at best diverting or postponing certain key business deliverables, and at worst diluting key program areas.
- There are 46% less staff in the BC Forest Inventory Program between the 2000-2009 period and 2010-2017 period; however, the rate of harvest only dropped 8% over the same periods.
- In an era of skilled labour decline, it is important to identify current skills, anticipate future skills required, and pro-actively engage post-secondary institutions and the contractor community to find mutually beneficial solutions.

Recommendation #3: Establish an innovation fund within the FAIB annual budget.

Rationale:

- Some of the methods for developing forest inventories in BC and the tools to maintain those inventories are becoming antiquated.
- While the Forest Inventory Program successfully pursues projects in collaboration with research leaders, many projects are piece-meal rather than part of a focussed plan for integrating technological advancements.
- The business demands of the program have limited the province's capacity to conduct

research, and develop and implement methodological changes to its inventory system.

- Since 2011, most of the program's operational budget has gone towards meeting core business activities and deliverables, with only 4% of the budget going to research in other spatial inventories.
- While the contribution from forestry to the provincial economy is one of the highest in Canada, BC spends the lowest amount on forest inventory relative to crown revenues directly sourced from the sector.
- Innovation is fueling change in forest inventories across Canada and around the world. An innovation fund could harness that knowledge base and find efficiencies through initiatives that can be practically applied.
    - For example, research and limited trials using new technologies have shown that reasonably accurate operational-level forest inventories at finer spatial scales can be achieved at lower costs using model-based approaches and a mixture of remotely sensed data.
- Higher levels of accuracy, efficiencies through automatable products and short-term returns on investments are a few benefits that align directly with the programs strategic plan.
- A formalized fund with a spending strategy guided by a committee of experts will tangibly link technological advancements with the program's core business needs.

Recommendation #4: Establish a Growth and Yield (GY) Partnership to build financial and collaborative support for a long-term and sustainable Growth and Yield program.

Rationale:

- The inventory system is dependent upon a GY program that projects forest growth through computer models supported by on-the-ground plot data and verification procedures.
- A BC GY program is a critical component in realizing the full benefits of the forest asset to the government, communities and industry over the long-term.
- The Chief Forester advises government and informs the public on sustainable forest management. GY data and projections are integral to providing advice on this matter.
- GY programs are long-term and need sustainability to reflect the growth of the forest under historical conditions and environmental changes such as insect attack and climate change.
    - This can be best achieved if the key parties (i.e. government and forest companies) are committed and actively involved in the GY program and resourcing mechanisms that can withstand economic and environmental changes.
- It takes leadership by both key parties who benefit greatest from sound data and projections generated through a GY program. The parties must work as a team and be committed to the GY program if the full benefits are to be realized.

Recommendation #5: Provide independent IT resourcing to increase efficiency and expansion of data storage and analytical capacity.

Rationale:

- FLNR is confronted with changes in technology that are placing increasing demands on

processing and data storage capabilities, particularly as it relates to the processing and storage of LiDAR, and LiDAR related datasets.

- There is also a tendency to move data processing into cloud-based services as means of accessing increasing computing capacity, and as a means of controlling software development without dependencies on multiple platforms.
- Finally, there is an opportunity to better coordinate and harmonize internal software development and updating as a means of converting tacit knowledge into explicit institutional knowledge that can be accessed by multiple parties without having to refer to the originator.

Administration

Recommendation #6: Restore the Chief Forester's legislated responsibility for the forest inventory

Rationale:

- The forest inventory provides fundamental information necessary to make decisions for forest planning and practices.
- Prior to 2002, Section 2 of the *Forest Act* stated that: *The chief forester must develop and maintain an inventory of the land and forests in British Columbia.*
- When the responsibility for the forest inventory was moved to another ministry, Section 2 of the *Forest Act* was repealed.
- When government returned responsibility for the BC Forest Inventory Program to the ministry, government did not restore the Chief Forester's legislated responsibility for the inventory.
- Currently there is no legislative mandate to develop and maintain a forest inventory.
- Without a legislative mandate, the forest inventory annual budget plummeted from $15.0 million with 75 staff in 2002/2003 to $5.9 million with 40 staff in 2005/2006.
- Without a legislative mandate, future governments will likely make budget decisions in the absence of consideration of legislative responsibilities.

Recommendation #7: Establish a ministry policy to view all inventory project and program decisions from the perspective of contributing to the BC forest inventory system as a whole, not as separate projects.

Rationale:

- The shared understanding of inventory as a system, both in terms of production and the variety of applications, is a necessary prerequisite ensuring effective allocation of resources for maintaining, updating, and advancing the system as a whole.
- Large-scale forest inventory systems are both complex and demanding in terms of the breadth of knowledge required given the multi-source data, advanced methods (i.e., a mixture of design-based, model-assisted, and model-based methods), decisions made using these data, and requirements for accurate information within budget constraints.
- One of the greatest limitations is the tendency to focus on fulfilling our immediate responsibilities and needs without sufficient consideration or understanding of impacts elsewhere in the process; this is particularly the case where resources are limited and timelines for completion of work activities are demanding.

- Viewing the forest inventory as a system, as well as adding an inventory specialist, will reduce these barriers among separate inventory tasks, and advance the system as a whole.
- Overall, considering the forest inventory as a system, rather than separate tasks, will reduce redundancies within the system, facilitate communication to users inside and outside of government, facilitate identifying opportunities to utilize new technologies, and refine the production process. This will, in turn, increase the quality of the information and reduce delivery times, which will improve the timeliness and quality of decisions made.

Recommendation #8: Expand the mandate of the Forest Practices Board to include providing independent advice regarding delivery of the Forest Inventory Program

Rationale:

- The Chief Forester advises government and informs the public on sustainable forest management.
- The Panel heard concerns regarding the status of data within the forest inventory system.
- A review by an independent body would provide a higher degree of confidence in delivery of components of the system.
- The inventory program would benefit from the external advice the Board can provide.
- The model would capitalize on the Forest Practices Board's positive public reputation of an independent voice and their audit experience.

Recommendation #9: Establish a Forest Inventory Technical Advisory Group.

Rationale:

- Users identified a desire to have more of a say in the forest inventory to meet their needs
- Although government has the responsibility for establishing standards, guidance from a Forest Inventory Technical Advisory Group would assist in meeting user needs
- An Advisory Group can provide guidance on an on-going basis and identify the resources needed for the BC Forest Inventory Program to support decisions necessary to achieve well-managed forests.
- An Advisory Group can help build inventory program support; facilitate improved communication; foster innovation; encourage collaboration; and help the program be more responsive to user needs.
- An Advisory Group can:
  - Help build inventory program support
  - Facilitate improved communication (which is a two-way interest)
  - Foster innovation
  - Encourage collaboration
  - Help the program be more responsive to user needs.

Communications

Recommendation #10: Develop a robust inventory system communications program to support an informed base of professional users and public audience.

Rationale:

- Improvement in communications and data access was the third most agreed upon premise by users surveyed by the Panel.
- Transparency in how the products are made and applied is tantamount to building trust within the public and professionals.
- This is even more important when much of the responsibility of sustainably managed forests relies on forest professionals.
- Understanding the needs and application of Forest Inventory Program and products by the user base will be essential to a successful communications strategy.
- Increased extension will also build government decision-makers awareness of the importance of the inventory as part of many decisions across government, industry and Crown corporations and the associated economic, environmental and social benefits.

Inventory

Recommendation #11: Obtain full LIDAR coverage for BC.

Rationale:

- LiDAR is viewed as a critical technology to increase efficiency and the quality of the Inventory system.
- LiDAR is proven valuable as an inventory tool, with most large tenure holders having already invested with costs recovered through forest-engineering savings alone.
- BC Timber Sales has acquired as much as 5.2 million hectares of forest with LiDAR with costs of approximately $1.20 per hectare.
- LiDAR is not only a valuable contribution to operational forestry (e.g., engineering, stream mapping), it is foundational for developing point-cloud enhanced inventories (canopy height models), but the LiDAR derived- DEM or DTM also crucial for exploring other (possibly less expensive) remotely sensed methods for deriving model-based attribution (e.g., digital aerial photogrammetry).
- Aside from investments by BC forest licensees, this technology has been widely invested by governments in Canada (e.g., Quebec and New Brunswick) and the world (e.g., Sweden, Norway, Washington State).
- The multiplicity of LiDAR use is testified through a variety of BC agencies who list its acquisition within annual budgets leading to collective distribution rights for up to 9.5 million hectares of LiDAR through the Coordinated Free and Open LiDAR Program Initiative. Collaboration between users is therefore key.
- BC's Forest Inventory Program will be a key beneficiary to a clear multi-year funding strategy thereby creating opportunities for high-resolution forest inventory.

Recommendation #12: Achieve an up-to-date VRI layer 1 (or LVI) available wall-to-wall across BC.

Rationale:

- Forest cover maps are the basis for all land-based assessments including timber supply analyses, habitat analyses, impacts of fires, pests, prioritizing silvicultural investments, assessing fire risks, etc.
- Professionals and public lose confidence in all analyses when data are not accurate in time

and space. This was very frequently a concern expressed in interviews and other feedback, since this affects all forest management in BC.

Recommendation #13: Utilize advanced forest inventory information, tools and processes to achieve additional information important for forest management planning and practices in prioritized areas of the province, particularly to support AAC determinations in areas where timber supply is constrained and/or contentious.

Rationale:

- This recommendation is designed to recognize that there are certain landscape areas and/or forest management units within the province that may require additional information as a means of better ensuring sustainable forest management plans and practices (e.g., areas where AACs are determined).
- It recognizes that there are situations where additional resources are needed to characterize the current state of the forest and its expected changes with time relative to the information that is available in the province-wide VRI Phase I inventory.
- It also recognizes that if there is additional or improved information, then the VRI Phase I inventory information should be consistent with the improvements (and vice versa).
- The decision as to where additional information may be required and how best to develop that information is at the discretion of FLNR.
- An example may be where there are high demands for various goods and services (e.g., old growth, habitat, water supply, fire risk reduction, wood supplies, pest management, etc.) and there is considerable uncertainty as to whether forests are, in reality, in a state to fulfill any or all demands, where and to what extent, either now and/or in the future.
- Professionals and the public lose confidence in analyses when inventory, growth and yield data are lacking in necessary and sufficient detail or sufficient accuracy across time and space. This was a very frequently expressed concern in the Panel review, with potential application to all forest management plans and practices in BC.
- If long-term strategic forest management plans are not based on activities that can be operationally implemented on the ground, it is unlikely that the desired strategic outcomes will be obtained.

Recommendation #14: Investigate and implement methodologies to estimate inventory uncertainty.

Rationale:

- Uncertainty in inventory estimates and projections based on them is likely to deter investment and create social and economic costs to the people of BC.
- BC's forest inventory system should be capable of quantifying at the current point in time and forecasting into the future the volume of harvestable (merchantable) timber within an estimation or prediction interval suitable for the decisions to be made on the basis of such information.
- At present, there are few formal measures (VRI Q/A and audits) within the FAIB Program to identify inventory uncertainty.
- Source of errors include such factors as: sampling error, measurement errors, and modeling accuracy for such key parameters as diameter, basal area, height and tree

volume; and uncertainty in growth and yield models.

- Recent research has demonstrated the methods for and the value of such formal assessments of inventory accuracies.
- Routine comparisons of actual harvest volumes with volumes carried in the BC inventory system for the same stands is a component of well-managed forests in other jurisdictions. Such comparisons not only provide the basis for improving forecasting, but are also critical to monitoring the sustainability of actual forest management activities.
- The Panel acknowledges the difficulty of making such comparisons with the extant inventory system where inventory polygons may not conform to harvest-unit boundaries. This disparity highlights the need for an inventory system on the THLB that reflects operational realities.
- Inventory information is costly to collect and maintain. There is a clear economic basis for justifying expenditures on this activity. It is likely the province is spending too little in some areas where complex, complicated forest management decisions are being made against the backdrop of rapid forest and market dynamics. It is also possible the province is spending too much in other places.

Recommendation #15: Establish three (or more) inventory system research, development, and implementation test sites within the province.

Rationale:

- One of the main barriers to adopting new inventory techniques is the difficulty in introducing the resultant information into practice within a broader inventory framework.
- The inventory system test-sites would be designed in a way that made it easier to do so, with one of the main barriers, lack of ground plot data, built into the process.
- The systems can be periodically reviewed and used as a basis for advancing inventory systems used both by private and public agencies.

Growth and Yield

Recommendation #16: Develop Growth and Yield models that cover the main stand types and management regimes in BC.

Rationale:

- GY forecasts are critical to any forest analysis, including determining AACs under current and possible future climates.
- While the current state of the BC forest inventory provides the base for the future forecasts, the GY models forecast these stands forward 100 years or more.
- The currently supported GY models do not cover all stand types or management regimes well, resulting in uncertainties that could be reduced given improved GY models.
- Further, the documentation of the supported GY models is insufficient to promote confidence by forest professionals.
    - Of note, many changes have been made to TASS in the 40 years of development, but there is a great paucity of documentation on the changes, as well as the current TASS versions (i.e., TASS II and III).
    - Contributing to these gaps is the very low level of support attributed to this task within the forest inventory system.