Our claims to sustainability rest on our ability to predict the future forest.

Provincial PSP Remeasurement Priorities (BC's PSP Strategy Revisited)

March 2006

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Funded by Forest Investment Account (FIA-LBIP) allocation transfers from member licensees.
SIGY Website: http://www.for.gov.bc.ca/hre/sigy/index.htm

Table of Contents

Page

1. INTRODUCTION **3**

2. PROGRAM BACKGROUND **3**

2.1 GENERAL DESCRIPTION 3

2.2 HISTORICAL INTENT AND USAGE 4

2.3 GENERAL DESIGN 4

3. BUSINESS CASE **5**

3.1 G&Y IN GENERAL 5

3.2 PSPs SPECIFICALLY 6

3.3 RELATIVE TO MONITORING 6

3.4 IMPLICATIONS FOR A PSP DELIVERY MODEL 7

4. REVISED INVESTMENT PRIORITIES **7**

4.1 ASSUMPTIONS 7

4.2 PROVINCE-WIDE RE-MEASUREMENTS 8

4.3 MPB-RELATED RE-MEASUREMENTS 9

4.4 DATABASE STEWARDSHIP 9

4.5 NEW ESTABLISHMENTS 9

5. STANDARDS REVISITED **9**

5.1 REMEASUREMENT INTERVAL 9

5.2 TREE MEASUREMENTS 10

5.3 OTHER DATA 10

6. LITERATURE REFERENCES **11**

1. INTRODUCTION

Since incorporating in 1999, the Southern Interior Growth and Yield (SIGY) Co-operative has focused on strategic and educational projects to support the growth and yield (G&Y) investments of its individual member organizations, both licensees and government. SIGY strategies have included a long-term data strategy in 2003-04 and a monitoring strategy in 2004-05.

The Provincial Permanent Sample Plot (PSP) Program has been a major component of the provincial G&Y program for nearly 70 years. A number of recent developments have lead SIGY to revisit the provincial PSP strategy:

1. A large remeasurement backlog has been accumulating since direct provincial government funding for the Program ceased in the late 1990's.
2. Since then, most licensees have not perceived enough incentives to invest discretionary FIA-LBIP funds in PSPs. Where scattered local investments did occur, they were not strategic at a regional or provincial scale.
3. Questions continue to be raised about the continued relevance of PSPs, yet modellers continue to actively seek out this type of data.
4. There are also questions related to the continuing role for PSPs in light of the emerging emphasis on G&Y and inventory monitoring (e.g., permanent VRI Phase 2 plots).
5. The MPB epidemic has highlighted potential new uses for PSP data and the need to consider the long-term value of PSPs in MPB-effected stands.
6. After the Forest Productivity Council (FPC) was decommissioned in 2002, SIGY is the only remaining multi-stakeholder strategic G&Y organization in the province.
7. Finally, during 2005-06, the government inventory program was repatriated back into the Forest Service along with a renewed interest in direct government investment activity related to inventories and PSPs.

2. PROGRAM BACKGROUND

2.1 GENERAL DESCRIPTION

Today's Provincial PSP Program represents an amalgamation of plots established under various ministry and licensee programs, some dating back to the 1920's. New plot establishments and 10-yr re-measurements have been on-going, albeit intermittent, over the last 75 years depending on funding availability. In the 1980's, the Forest Productivity Council (FPC) created the Provincial PSP Program by combining the various datasets and establishing common data standards.

Today, there are approximately 10,500 plots in the database -- 9,400 are still considered active and 7,600 of these have been (re)measured in the last 15 years. Nearly all the plots are on crown land.

During its tenure, the FPC championed creation of a plot-level summary "header database" and an associated sampling "matrix" of stand conditions. This matrix approach continues to serve as the primary tool for strategic management of the Program including the targeting of new plot establishments, re-measurement priorities, and the selective release of existing plots for harvesting.

With some notable exceptions, the provincial government has always been the primary steward and custodian of the PSP Program. Active industry involvement has largely been a function of government funding programs, e.g., Section 88, FRBC, etc. Responsibility for PSPs established by licensees under these funding programs was generally transferred to government once these funding programs ended. Forest Analysis and Inventory Branch (FAIB), BC Ministry of Forest and Range (MoFR) is the current program steward and database custodian. Along with re-measurements, government investment in PSP data management has been minimal since the late 1990's.

2.2 HISTORICAL INTENT AND USAGE

The general (generic) notion of PSPs is fundamental to forestry (Anon., 2004; Irland and Camp, 2005). PSP Programs similar to BC's are common in many forest jurisdictions worldwide. Marshall, et al (2000) reviewed and compared PSP Programs outside BC in a report for the FPC. The report describes PSP programs in ten countries and eight Canadian provinces.

The greatest strength of PSPs also seems to be their greatest weakness – PSPs are essentially a speculative investment and therefore under continuous justification pressure. The data are collected with only a general notion of their future use. Although the primary intent has always been G&Y model development, it was never intended to be model-specific.

The objective has been to build and maintain a standardized G&Y database to promote on-going innovation in modelling. Empirical modellers generally prefer growth trajectory data from plots remeasured over time. This implies a long-term investment in data collection must precede modelling. Consequently, data cost and availability are recognized as significant impediments to innovation. PSP programs help facilitate the innovation process by maintaining a common long-term database. Moreover, large-scale (provincial/regional) PSP programs are able to capture economies of scale unattainable by individual modelling programs or management units.

History seems to support these intended benefits. The frequency of PSP use by modellers has increased over time, in part due to advances in computing that have increased the rate and diversity of modelling projects. Both of the G&Y models currently used in TSR (VDYP and TASS/TIPSY) have long relied on PSP data (in different ways) and continue to do so. A number of other recent modelling efforts have also benefited from, and in some cases existed only because of the availability of PSP data; the latter include Prognosis^{BC} and STIM. Recent development work on VDYP and Prognosis^{BC} exhausted existing PSP data such that continued enhancement of these particular models depends on additional PSP re-measurements. PSP use has also recently branched out to include, among other things, a stand structure classification system (ForesTree Dynamics Ltd., 2006; Farnden, et al, 2003) and pine site curves (Batho, *In progress*; Garcia and Batho, 2005). MPB issues are currently highlighting potential new uses, such as shelf-life and regeneration modelling.

2.3 GENERAL DESIGN

PSP is a generic term for plots designed to be remeasured over time. However, throughout this report the term PSP refers to the Provincial PSP Program unless otherwise noted. Generic PSP designs follow one of three sample location methods:

- Experimental – used in research to assess treatment response, isolate and study specific biological processes, etc. Plot location is normally purposive/subjective, but with more intensive sampling (multiple plots in a few stands) compared to either of the following more extensive sampling designs (single plots in many stands). Experimental plots (EPs) are outside the scope of the Provincial PSP Program and this strategy.
- Random/systematic – used mainly in inventory and/or monitoring to characterize current conditions on a specific landbase. Random designs may be unstratified, or stratified as in VRI applications. Systematic designs generally locate plots on a fixed grid, such as the Canadian National Forest Inventory (NFI) and several licensee-initiated monitoring programs in BC (SIGY Monitoring Strategy, 2005).
- Purposive/subjective – primarily intended for model development, e.g., predicting G&Y over a range of possible stand conditions both current and future. This design cannot function as an inventory, but it is an efficient method for sampling the underlying biological growth relationships. The Provincial PSP Program falls in this category.

Understanding the strengths, weaknesses and unique aspects of these three general sampling designs is the key to understanding PSPs in the larger context of G&Y and inventory in BC. All three forms of sampling have their place and contribute to a well-rounded, effective G&Y program.

With some exceptions, the current PSP Program is largely made up of single plots purposively/subjectively located in natural stands. Plots can be round or square and generally range from 0.04 to 0.10 ha with 0.08 ha being fairly common. Plot measurement standards have evolved over time. Reductions in lower diameter thresholds (tagging limits) over time have dramatically improved the utility of subsequent remeasurements. All trees down to 4cm dbh are currently tagged and measured on the main plot. A nested subplot captures data on smaller trees down to 2cm; trees under 2cm counted within two height classes. In addition, many plots have been stem-mapped and/or eco-classified.

3. BUSINESS CASE

3.1 G&Y IN GENERAL

G&Y investments support the broad vision established by the Forest Productivity Council (FPC) of BC:

"To be able to consistently and accurately predict the quality, quantity and dynamics of British Columbia's forests under any management *<or natural disturbance>* ***regime."***

As such, G&Y is essential to the practice of sustainable forest management (SFM) worldwide.

Our claims to sustainability rest on our ability to predict the future forest. (SIGY)

An active G&Y program is an explicit SFM criterion in at least one major SFM certification program (SFI) and implied in most others. In BC, the single most prominent SFM application of G&Y is the Timber Supply Review program supporting the Chief Forester's Allowable Annual Cut (AAC) determinations. G&Y is also used extensively in many other areas of SFM planning (FRPA FSPs, etc), silviculture investment analysis (FFT, etc), and inventory projection (VRI). BC's suite of G&Y decision support tools provide forest managers with a functional synthesis of current knowledge regarding forest dynamics and silvicultural treatment response.

Refer to the SIGY report entitled ***Components of a Provincial G&Y Strategy*** (SIGY, 2006) for a more comprehensive discussion of the business case for G&Y in general.

3.2 PSPs SPECIFICALLY

Justification of on-going PSP investments involves SFM, the larger G&Y program, and the stewardship responsibilities of the organizations involved. BC's results-based SFM policy environment (e.g., FRPA) along with the recent increase in major natural disturbance events (MPB, fire, and implications for climate change) all point to the need for better forecasting tools combined with an increased emphasis on monitoring actual outcomes.

The potential for economies of scale is evident in both data collection and modelling. Both investments are long-term with the magnitude of the investment largely independent of scale. That is, the investment required to maintain independent G&Y programs in 10 individual management units would be nearly 10 times that of a single regional program. In addition, larger areas provide a broader diversity of sampling opportunities, which produces more robust models. Recent Lignum IFPA experience further supports the notion that self-contained G&Y programs are unsustainable at a management unit level.

G&Y tools continue to evolve to address new SFM challenges and the associated risk and uncertainty in forecasting SFM outcomes. On-going improvement of empirical G&Y models (e.g., VDYP, Prognosis^{BC}, MGM, etc) depends on a large continuous supply of PSP-like data. More process-based "hybrid" models (e.g, TASS/TIPSY, FORCAST, SORTIE, etc) tend to be less dependent on PSP data, but share similar monitoring needs with empirical models.

SIGY's Long-term G&Y Data Strategy (2004) examined investment rationales for PSPs, EPs and monitoring under today's climate of policy and fiscal investment incentives. That strategy documents the continued need for PSPs and EPs to support on-going, much-needed G&Y model enhancements that address the increasing complexity of SFM. However, these historic data programs alone cannot provide a check on the operational predictions generated by these models. While our claims to sustainability rely on predictions from these models, investments continue to lag in monitoring the actual long-term outcome of G&Y predictions on the operational landbase. Accelerated transfer of traditional crown forest stewardship responsibilities to non-governmental licensees within a results-based legislative environment and the increasing societal emphasis on sustainability and certification are finally focusing attention on G&Y monitoring needs.

3.3 RELATIVE TO MONITORING

The emerging interest in monitoring adds a significant new dimension to the rationalization of G&Y investments, especially PSPs, given limited resources. SIGY's Monitoring Strategy (2005) examined the tradeoffs between investments in PSPs vs. monitoring. Monitoring data is similar in character to that of PSPs and can, in general, be used for model development and validation, as well. However, there are also differences that indicate some mix of the two would be optimum.

First, monitoring necessitates a random/systematic design, which will tend to overlook or under-sample less common stand conditions. These may include conditions expected to become more common over time and/or biological extremes (densities, etc) that help define a more robust predictive model.

Second, the modelling process seeks to isolate individual growth effects in order to predict the outcomes of various management and natural disturbance regimes, some as yet unknown. Consequently, modellers tend to be highly selective about data, rejecting data plot-by-plot that appears to be "confounded" by too many known and/or unknown "treatment" effects for a specific purpose. In this regard, monitoring plots can be expected to have a higher rejection rate for model development.

Finally, for economic reasons, monitoring designs commonly use plot sizes about half that of PSPs. Smaller plots generally provide less definitive information on complex stand dynamics (e.g., mortality, stand structure, succession, etc).

To the extent practical, data standards should be consistent among monitoring and PSP protocols in order to facilitate the use of both in modelling and to minimize confounding in comparative analyses.

3.4 IMPLICATIONS FOR A PSP DELIVERY MODEL

Experience with FRBC and FIA Landbase Programs since 1998 has shown the discretionary FIA investment priorities of individual licensees within management units rarely extend to long-term regional and provincial priorities such as PSPs. In 2003-04, SIGY tried unsuccessfully to sponsor a regional PSP remeasurement project through the FIA Landbase Program. Success, under this funding model, depended on the individual discretionary investment decisions of 50+ individual licensees at the management unit level. The disparity between local and regional priorities was further aggravated by misconceptions regarding the basic nature of PSPs. For instance, some licensees did not support sharing of regional project costs because they felt PSPs in other management units had no local relevance to them. There was also a strong undercurrent that government should reclaim responsibility for PSPs.

Other jurisdictions, such as Ontario and Alberta have also experienced similar strategic problems with discretionary, licensee-lead PSP investments at the management unit level. Strategic management of a large-scale PSP program is meant to capture economies of scale, but this is easily confounded by decentralized funding models. Government's current movement back toward centralized government PSP funding is a significant first step toward restoration of strategic program management. However, integration of data collection and modelling strategies into a unified G&Y Program is still restricted by the disparity in governance and funding models.

4. REVISED INVESTMENT PRIORITIES

4.1 ASSUMPTIONS

1) Evolving SFM demands will continue to increase expectations for G&Y predictions. Improving predictions for complex (multi-species and/or uneven-age) stand conditions will likely remain the top modelling priority for the foreseeable future. The associated G&Y models will continue to become more complex and data intensive.

2) Existing G&Y models that have used PSP data in the past will continue to seek out and use PSP data for the foreseeable future. This includes developers of managed stand G&Y models who continue to value and seek out long-term data from natural stands for calibration and validation.

3) Shelf-life and natural regeneration represent unique high-priority MPB-related modelling issues for which PSPs may provide important supplemental data. In all other aspects, general G&Y modelling of salvaged and unsalvaged MPB-affected stands will continue to leverage existing modelling efforts, many of which continue to rely on PSP data.

4) Emerging monitoring program(s) will supplement but not totally replace PSP data in G&Y modelling. New monitoring programs may not yield significant amounts of growth data for 10+ years.

5) All long-term datasets, including PSPs, will become increasingly valuable for climate change research (etc). Based on past experience world-wide, unanticipated uses for these long-term datasets will likely emerge as well.

4.2 PROVINCE-WIDE RE-MEASUREMENTS

1) The existing FPC matrix in combination with the FPC plot protection policy provide a good initial framework for prioritization given a few possible caveats:

    a) The current matrix only applies to plots with relatively simple stand conditions (single species, even-age), though this currently covers the majority of existing plots. Other classification/prioritization scheme(s) need to be devised for plots with more complex stand conditions, including plots acquiring more complex stand structures through the effects of natural disturbance agents such as MPB, etc.

    b) Proposed matrix surplus optimization techniques should be applied. I.e., re-measurement data from surplus plots in the matrix are assessed for populating additional (different) matrix cells.

    c) “Tier 2” (less common) species should no longer be assigned a lower priority. Continuing to do so will aggravate data shortages for economically important lesser species such as larch and yellow cedar. Lesser species may also become more important under the effects of climate change, etc.

    d) Untreated controls in planted and natural stands within the deactivated ST and IF programs should be considered for re-measurement where genetic improvement effects can be assumed minimal, which is likely the case for all older plantations.

2) Limited funds and a large, aging remeasurement backlog mean some plots will have to be abandon. Abandonment needs to be a strategic decision based on as much information as possible. Among other things, priorities should consider plot life expectancy without maintenance (loss of tags and monumentation) and plot disturbance (harvesting, MPB, etc). Pre-measurement reconnaissance is justified in most cases.

3) Recent installations that have not yet had a first re-measurement represent a high-priority opportunity to capture the installation investment and to further diversify the database.

4) Data needs of specific, current modelling projects should have priority over more general speculative long-term uses. This includes, but is not limited to, current TASS development focusing on boreal aspen and mixedwood, and MPB-related projects (next section).

4.3 MPB-RELATED RE-MEASUREMENTS

1) Data from MPB-affected plots have many potential uses including shelf-life, natural regen and long-term succession. Every effort should be made to coordinate re-measurement priorities with known high-priority, urgent data needs (e.g., shelf-life and regen). Data standards may need to be modified to accommodate some of these special data needs.

2) As noted earlier, a new stand matrix/sampling scheme is needed to prioritize MPB-affected plots and other complex stand conditions.

3) Sampling should focus on both pine and non-pine, as the latter represents an increasing proportion of the growing stock comprising the mid-term timber supply in MPB-affected units. Volume production from non-pine species will become increasingly important once salvage pine eventually declines.

4.4 DATABASE STEWARDSHIP

Stewardship of the existing database is just as important, if nor more so, than acquiring new data, based on the relative value of the existing data asset. The PSP database was undergoing significant upgrading when funding collapsed 5+ years ago. The existing data management plan needs to be revisited in light of interim experience, available resources and changing technology.

Over the last 5 years, the database custodian (now FAIB) has also lost significant corporate memory through downsizing and retirements; impact of the latter on PSPs is on-going and significant. A priority should be place on capturing the remaining corporate memory within the database before it is lost.

If PSP data are to realize new, expanded usage beyond the small, traditional G&Y modelling community within MoFR, a more proactive communication and outreach effort is needed. Potential users currently do not have easy (web) access to basic data characteristics and summaries. Opportunities are being lost because potential users are unaware of the database and its potential utility for them. Online access to the data itself should be the ultimate goal in order to fully realize its innovation potential (Zeide, 2002).

4.5 NEW ESTABLISHMENTS

New plot establishments should be postponed until:

1. A provincial G&Y monitoring strategy is established and PSP needs have been (re)rationalized with respect to the availability and utility of monitoring data for model development and validation, and/or

2. A PSP sampling framework (e.g., matrix) is developed for complex stand conditions including MPB-effected stands.

5. STANDARDS REVISITED

5.1 REMEASUREMENT INTERVAL

The existing remeasurement internal of 10 years is still adequate in general. However, some flexibility is required given the current backlog and special needs that may arise (e.g., MPB).

Whenever a plot gets re-measured off its established 10-yr cycle, the plot's remeasurement schedule should be re-initiated and revised from that point forward. This minimizes the number of non-standard remeasurement periods over the life of the plot, which minimizes the need for data interpolation by modellers.

For example, consider the following remeasurement schedules for one plot:

Past Remeasurement Schedule				Delayed Remeasurement	Future Remeasurement Schedule			
1973	1983	1993	~~2003~~	**2006**	2016	2026	2036	2046

5.2 TREE MEASUREMENTS

The current standards capture data across all size classes. The tagging limit on the main plot (4cm dbh) appears adequate for most purposes, given that data on smaller trees (>0.3m ht) are captured on the subplot. However, regeneration modellers should be consulted to determine if increasing the number of height classes under 2cm dbh would significantly improve regeneration modelling utility, particularly with regard to MPB.

The historic practice of sub-sampling heights introduces a confounding height estimation bias into all subsequent analyses of the data. Modern height measurement technologies (laser, etc) significantly reduce the effort required to capture quality height data in the field and bring into question this historic compromise. BC should follow the world-wide trend toward 100% height measurement in the field.

Forest health data (damage and disease codes) within most historic G&Y datasets, including PSPs, are generally not consistent and reliable enough to support forest health-specific analyses. Given the expected increase in forest health issues related to climate change, this particular data quality issue may deserve greater consideration and emphasis.

Enhancing measurements on dead trees would supplement scarce data on decay rates (shelf-life), one of the high-priority MPB issues. New non-destructive sampling standards should be developed in close collaboration with shelf-life researchers to ensure maximum utility of the data. There may also be opportunities to conduct destructive sampling well outside plot boundaries. Again, given expected increases in climate change-induced forest health issues, enhanced decay-rate data should be considered for other species across the province. Consideration should also be given to sampling coarse woody debris (incl. snag falls) from the shelf-life and bio-diversity modelling perspectives. Fixed line transects may be an option for this.

5.3 OTHER DATA

Plot documentation and monumentation is always a high priority. PSPs need to appear on the "special feature" GIS overlays used by operational planners to adequately support plot protection policies. Old plots need to be GPS'd when revisited and the documentation and GIS overlays updated as part of regular on-going database management practices.

BEC classification of every plot remains a priority and it should be done by qualified personnel. BEC classification should probably start being treated as a dynamic "derived"

variable. The BEC classification system is itself dynamic, as are the possible effects of climate change and large-scale natural disturbances. Consequently, consideration should be given to collecting the component data (plant community and edaphic data) at each remeasurement. This would be analogous to carrying height-age data in the database instead of just derived site index – it will provide flexibility should things change.

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