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

Growth and Yield Monitoring: An Investment Analysis for the Southern Interior Region

(with relevance to the province)

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1. BACKGROUND

Since incorporating in 1999, the Southern Interior Growth and Yield (SIGY) Co-operative has focused on strategic and educational projects to help support the growth and yield (G&Y) investments of its individual member organizations, both licensees and government. To date, proposals for the Co-op to engage in operational G&Y projects have not received sufficient licensee support (FIA-LBIP) to be strategically or economically viable. For example, in 2003-04, a regional Permanent Sample Plot (PSP) re-measurement proposal was turning down by large margin.

In February 2004, Co-op members met in Kamloops to discuss G&Y monitoring. Input was incorporated in a Long-term G&Y Data Strategy (SIGY, 2004). The report concluded that BC's prevailing climate of policy and investment incentives is not supportive of co-operative investments in long-term G&Y data, despite potential economies of scale. However, should government take steps to improve the investment climate for long-term G&Y data, monitoring would become a more attractive long-term G&Y data investment opportunity from the licensee perspective. Furthermore, SIGY's licensee members appear to favour the investment potential for G&Y monitoring over PSPs and Experimental Plots (EPs).

At member request, this strategy further examines investment rationales for G&Y monitoring. Technical detail is discussed only as it relates to an investment decision. This strategy is intended to provide licensees and government with a tactical investment analysis, rather than an operational (implementation) plan.

2. G&Y MONITORING DEFINITION

This strategy adopts a working definition of G&Y monitoring that coincides with that used in existing operational G&Y monitoring projects within BC. For example:

> **"G&Y monitoring is the process of comparing the actual G&Y of a forest or stand to the predicted or expected G&Y for that forest or stand."** (McWilliams and Thrower, 1994)

This form of G&Y monitoring is designed to provide extensive (forest-level) periodic feedback on predictions and expectations within the adaptive management framework. G&Y monitoring produces unbiased estimates of current state and historic change similar to a continuous forest inventory. However, it normally cannot provide explanations for any differences it detects between predicted and actual growth. Questions of cause and effect (e.g., treatment response) require more intensive, rigorous experimental designs such as silviculture field experiments. Hence, G&Y monitoring represents just one aspect of the larger suite of G&Y data that support sustainable forest management (SFM).

3. BUSINESS CASE RATIONALE

3.1 Reaffirming business needs for G&Y in general

Public and private sector 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 regime."*** *(or natural disturbance regime, to better reflect recent beetle and fire issues).*

G&Y models play a major role in these predictions including the ones used in timber supply analyses supporting the Chief Forester's determinations of Allowable Annual Cut (AAC). G&Y models are also used extensively in many other areas of SFM planning (FSPs, etc), silviculture investment analysis, and inventory projection. As decision support tools, G&Y models provide forest managers with a functional synthesis of current knowledge regarding forest dynamics and silvicultural treatment response.

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

G&Y's traditional focus on timber has been expanded to include other forest values such as wildlife habitat, biodiversity, visual quality and watershed protection. Predictive models for these and many other non-timber values rely on the forest structure predictions provided by G&Y models. The increasing complexity of forest management constantly places new demands on model predictions. G&Y models must continually incorporate new information and data to keep pace with new research and growing SFM demands.

Current BC forest management issues relying on G&Y model predictions include:

1. Maintaining or enhancing timber supply under increasing pressures
2. Improving future yield expectations through G&Y investment and silviculture
3. Timber supply impacts of large-scale natural disturbances (e.g., beetles, fire)
4. Enhancing information systems supporting a results-based policy environment
5. Managing for more complex stand structures to address non-timber values
6. Predicting and managing the future supply of non-timber values
7. Improving mill supply forecasting: log profiles and wood quality
8. Assuring market access through enhanced public trust (e.g., Kyoto, certification)
9. Assessing carbon sequestration opportunities and climate change impacts

From a business perspective, G&Y predictions support the regulatory license-to-cut through their central role in AAC determinations. They also support social license-to-cut and world market access through land-use planning and sustainability initiatives including certification and global environmental accords. Government and licensees both benefit from maximized harvest levels supported by defensible, scientifically sound models and data.

Past experience has shown investments in G&Y models and data often result in higher yield expectations replacing previous, more conservative, estimates. Even when model refinements have a negative effect (e.g., forest health), the net result is a more balanced, realistic prediction for business planning purposes. In addition, investments in better G&Y information tend to be cheaper and present a lower risk profile than investments in more intensive silviculture, which are exposed to natural disturbance losses, etc. Making intensive silviculture investments based on fuzzy G&Y expectations further compounds the risk.

3.2 Emerging interest in G&Y monitoring

BC continues to benefit from its much-envied investment legacy in G&Y models and supporting data. Two prominent and extensive government G&Y data programs, now commonly referred to as the PSPs and EPs, began in the early 1920's. Over the years, these programs have produced a massive amount of data and knowledge that continue to spawn world-class G&Y models for BC.

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 cannot, by design, provide a check on the operational predictions generated by these models. Our claims to sustainability rely on predictions from these models. Yet 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 largely responsible for the emerging interest in G&Y monitoring.

3.3 Regulatory drivers (hard law)

There is no explicit mention of G&Y monitoring in BC's current forest legislation and regulation. However, there are at least two notable references to general monitoring which have implications for G&Y monitoring. First, the only tenure with a hard law mandate for generalized monitoring is the Innovative Forest Practices Agreement (IFPA). The boilerplate IFPA agreement specifies the licensee(s) must develop a forestry plan which includes ***"a monitoring plan specifying what will be monitored, how it will be monitored and schedule for inspections".*** Tree Farm Licenses (TFLs) have no equivalent monitoring mandate within their forestry plan content requirements (Forest Act), nor do any other licenses. Because IFPA forestry plans are linked closely to AAC uplifts, a broad monitoring mandate would logically encompass G&Y – but it is not explicit.

Three IFPA uplift determinations have been released, to date. So far, only the Merritt IFPA was given an explicit uplift condition for G&Y monitoring (MoF, 2004). There is no way to anticipate conditions of an administrative AAC determination. The delegated decision maker may conclude proposed G&Y assumptions do not warrant an explicit G&Y monitoring condition. This may include applying sufficient G&Y "discounts" (e.g., accept half a proposed site index increase) to reduce perceived risk and uncertainty below his/her G&Y monitoring threshold. Consequently, most IFPAs appear to be postponing G&Y monitoring investments unless it is received as an explicit uplift condition.

The second hard law driver relates to government's self-imposed legislated responsibility to implement a Forest Resource Evaluation Program (FREP) to conduct on-going effectiveness evaluations of the Forest and Range Practices Act (FRPA). This represents a broad policy-focused adaptive management and monitoring initiative that includes aspects of G&Y. Current plans for the timber resource component focus mainly on statistics such as disturbance, reforestation and free growing, which can be mined from existing information systems, principally RESULTS. Limited government resources and the comparative lack of post-free growing G&Y monitoring data will make evaluation of long-term G&Y implications more problematic. Given these constraints, FREP is likely to rely heavily on model predictions (G&Y, TSR, etc) to infer long-term sustainability (post-free growing), similar to many certification plans.

3.4 Alberta hard law contrasts

In contrast to BC, key differences in crown forest stewardship have lead to broader implementation of hard law mandates for G&Y monitoring in Alberta. Area-based Forest Management Agreements (FMAs) represent Alberta's most extensive form of forest tenure. Like TFLs, FMA's must maintain an inventory and prepare forest management plans that

include timber supply analysis. However, unlike BC, downsizing of the Alberta Forest Service and creation of widespread FMAs both occurred before managed stand G&Y models had been introduced and widely implemented in timber supply analysis. At the time, Alberta AACs were based solely on natural stand G&Y – there was no allowable cut effect (ACE) for even basic silviculture. Subsequent development and implementation of managed stand G&Y fell to the FMAs. Having little direct involvement in the process, the Alberta Forest Service perceived greater risk and uncertainty around ACE expectations in FMA management plans. Consequently, Alberta has legislated rigorous approval standards for managed stand G&Y that include G&Y monitoring.

In contrast, volume-based tenures continue to dominant in BC. Since the early 1990's, the BC Forest Service (MoF) has led development and implementation of managed stand G&Y tools in TSR. Consequently, basic ACE effects (via TIPSY) became an integral part of every AAC in BC. Given its long-standing central roles in both G&Y and TSR, MoF likely feels (relative to Alberta) less risk and uncertainty around the basic managed stand G&Y predictions used in TSR. BC history and the current commitment to industry cost reduction continue to minimize this government's motivation for creating broader hard law incentives for G&Y monitoring.

3.5 Certification drivers (soft law)

SFM certification standards and international environmental accords (e.g., Kyoto) voluntarily adopted by licensees and governments generally all contain some general commitment to monitoring (Hickey, 2004). The nature of this monitoring commitment depends on the individual standard and its interpretation. However, in all cases, it is not specific enough to definitively imply G&Y monitoring as defined here. See Appendix for a comparison of G&Y monitoring-related requirements among the various certification standards.

The Canadian Council of Forest Ministers (CCFM) has developed high-level SFM Criteria and Indicators (C&I) which the Canadian Standards Association (CSA) has also adopted (CCFM, 2003). Some aspects of G&Y are addressed in Criterion 2:

> **CCFM Criterion 2: Ecosystem Condition and Productivity**
> **2.1** Total growing stock of both merchantable and non-merchantable tree species on forest land.
> **2.2** Additions and deletions of forest area, by cause.
> **2.3** Area of forest disturbed by fire, insects, disease and timber harvest.
> **2.4** Area of forest with impaired function due to ozone and acid rain.
> **2.5** Proportion of timber harvest area successfully regenerated.

Canada's National Forest Inventory (NFI) is intended to address some of these monitoring needs at international, national and provincial scales. However, the number of NFI ground plots in BC (268) is too small to provide management unit resolution. The NFI ground protocol is discussed later in more detail, since it currently represents BC's *defacto* standard for G&Y monitoring at the management unit level.

The Forest Stewardship Council (BC) appears to have the strongest implicit reference to G&Y monitoring. Although, like other certification standards, it is not specific about the technical details (FSC-BC, 2003).

> **FSC-BC Principle 8: Monitoring and Assessment:**
> 8.2.3 Data are collected and maintained in the monitoring database concerning growth rates, regeneration, forest health, productivity, condition of the forest, and disturbances resulting from forest operations or other causes.

The Sustainable Forestry Initiative (SFI) standards emphasize monitoring adherence to best management practices (BMPs) including the use of periodic inventories and G&Y models to support harvest level determinations (SFI, undated).

> **SFI Objective 1.** To broaden the implementation of sustainable forestry by ensuring long-term harvest levels based on the use of the best scientific information available.
> **Performance Measure 1.1.** Program Participants shall ensure that long-term harvest levels are sustainable and consistent with appropriate growth-and-yield models and written plans.
> **Indicators: (bold emphasis added)**
> 1. A long-term resource analysis to guide forest management planning at a level appropriate to the size and scale of the operation, including
>   a. **a periodic or ongoing forest inventory**;
>   b. a land classification system;
>   c. soils inventory and maps, where available;
>   **d. access to growth-and-yield modeling capabilities;**
>   e. up-to-date maps or a geographic information system (GIS);
>   f. recommended sustainable harvest levels; and
>   g. a review of non-timber issues (e.g., pilot projects and economic incentive programs to promote water protection, carbon storage, or biological diversity conservation).
> 2. Documentation of annual harvest trends in relation to the sustainable forest management plan.
> **3. A forest inventory system and a method to calculate growth.**
> 4. **Periodic updates of inventory** and recalculation of planned harvests.
> 5. Documentation of forest practices (e.g., planting, fertilization, and thinning) consistent with assumptions in harvest plans.

At this time, only a few BC licensees have implemented G&Y monitoring programs in response to certification needs. Most SMFPs (e.g., Canfor, 2002) appear to be relying on existing data sources (VRI, RESULTS, GENUS, etc) and model predictions (TSR, G&Y), similar to FRPA-FREP. In the absence of G&Y monitoring, periodic re-inventory is the most common indicator cited for checking long-term predictions and outcomes. This implies a planned re-inventory schedule, an experience that eludes BC so far.

3.6 TSR drivers (nonbinding)

The Chief Forester regularly incorporates nonbinding suggestions in AAC determinations, which are normally summarized in the Implementation section of a determination report. Common suggestions focus on improving information or practices where the Chief Forester perceives greatest risk and uncertainty. Unlike IFPA uplifts, these suggestions are not made as conditions to the determination at hand and do not have the force of law. Implementation is ultimately governed by available funding, organizational priorities, etc. If implementation (or non-implementation) has AAC implications, they would occur in a subsequent round of TSR.

Nonbinding suggestions also occur outside of the official determination report. Suggestions can also come through ministry staff (e.g., Forest Analysis Branch) interactions during the TSR data package and analysis phases. The AAC implications are similar to suggestions made in a determination itself, but the documentation is less formal.

To date, only a few licenses (mainly TFLs) have voluntarily implemented G&Y monitoring in response to concerns expressed by the Chief Forester or his staff. These concerns have

mainly related to licensee-supplied, upwards adjustments to managed-stand yields, such as site index and OAFs.

3.7 Ancillary uses in inventory and modelling

One of the main reasons SIGY's licensee members tend to rank investment potential for G&Y monitoring above PSPs and EPs relates to the potential of monitoring to address multiple business needs. Besides TSR and certification issues, G&Y monitoring also has the potential (in theory) to address other business issues, most notably inventory and G&Y model development (calibration). However, since G&Y monitoring is so new in BC, potential applications in these areas have yet to be tested operationally. While there are no definitive reasons to discount application in either inventory or model development, there are reasons to be somewhat cautious with assumptions in this regard.

Inventory linkage is entirely possible given sufficient planning and statistical consideration. Change Monitoring/National Forest Inventory (CMI/NFI) plots should be able to supplement and or substitute for Vegetation Resources Inventory (VRI) ground-plots. Close kinship between CMI/NFI and VRI ground-plot standards facilitate this linkage, which the Ministry of Sustainable Resource Management (MSRM) is keen on exploring operationally (JST, 2001). Differences in plot configuration and sampling designs represent larger hurdles for existing VRIs. In new VRI's, sampling strata could be aligned (e.g., PHR) to facilitate more efficient integration.

Although checking G&Y model predictions is a central objective of G&Y monitoring, use of the data in the model development phase could be problematic for a number of reasons. Historically, model developers in BC have rejected data (non-EP) containing treatment and other confounding growth affects (excl. density control). Such conditions will likely be more prevalent in PHR monitoring data than in natural stand PSPs (e.g., improved seed, fertilization, etc). Monitoring plot size (0.04ha) is also half the generalized optimum for modelling (e.g., PSPs). However, modellers are chronically data-starved and may not reject data on this basis alone. For modelling purposes, small plots provide less information on stand dynamics (e.g., mortality) and spatially diverse stand structures, such as those created by partial cutting, variable retention and natural disturbances (e.g., insects, disease and fire). There are also statistical conflicts inherent in using the same data to both develop (calibrate) and check (validate) the same model. This should presumably be less of an issue if monitoring data constitute only a small portion of a modelling dataset, as should be the case if PSPs and EPs continue to be maintained.

For now, it seems safest to assume G&Y monitoring data will only supplement inventory (VRI) and model development (PSPs & EPs) datasets.

3.8 Incomplete and ineffective incentives

The current policy and fiscal climate in BC has left many investment incentives for inventory and G&Y (incl. monitoring) in an incomplete and/or ineffective state. Early public service downsizing, budget cuts and policy revisions associated with government's New Era agenda anticipated significant shifting of forest management responsibilities to licensees, including many aspects of inventory and G&Y. As a result, government G&Y investments (staff and budgets) were cut by approximately 50%. However, implementation of compensating policy and fiscal incentives has remained incomplete through this first term. Consequently, licensees and government have been caught in an inventory and G&Y

investment stalemate for the past five years. Government has yet to implement clear, workable incentives around these stewardship responsibilities.

The original vision for the Defined-Area Forest Management (DFAM) initiative was something akin to a co-operative TFL. However, policy and fiscal incentives that were initially inadequate continue to erode. For example, DFAM (TSAs) licensees still lack the AAC-growth capture incentive that TFLs enjoy. Some TSAs have embraced the co-operative model more readily than others. Funding incentives largely focus on FIA allocations, which are not sufficient to meet broader SFM goals for DFAM. Current incentives do not adequately address inventory and G&Y needs associated with TSR, DFAM or SFM in general.

Future funding is crucial to the success of long-term data programs such as monitoring. BC's experiments with different funding models have produced mixed results in this regard. The cyclical nature of government forestry programs (FRDA, FRBC, FIA) has not stayed in sync with recurring stewardship expenses for inventories and G&Y. A more direct linkage between resource revenues and stewardship expenses seems to be logical. Yet, inventory and G&Y are currently not being considered for stumpage adjustments.

The mountain pine beetle and wildfire crises recently brought the inventory stalemate into the spotlight, and presumably G&Y by association. SIGY is currently participating in a related strategic planning exercise sponsored by MoF and MSRM.

4. Technical standards (CMI/NFI)

4.1 Sample location

G&Y monitoring seeks to characterize the existing landbase (or strata thereof) similar to an inventory. This is fundamentally different from most PSPs and EPs which are subjectively located to target specific stand conditions for modelling purposes without regard to their relative occurrence on the landbase. While PSPs and EPs are installed to understand and predict generalized G&Y behaviour, G&Y monitoring (like inventory) provides repeated snapshots in time, of cumulative G&Y behaviour on a specific landbase. Different objectives require different sampling protocols. To achieve statistical validity and reliability, sampling for G&Y monitoring and inventories must be random in nature. There are several acceptable methods for obtaining randomness including grid-based (systematic) sampling.

The CMI/NFI standard was developed for NFI, which uses a national sampling grid. A similar grid approach has been used in five of the existing seven G&Y monitoring projects to date. TFLs 30 & 37 used stratified random (SR) sample location similar to VRI. The two approaches have unique advantages and disadvantages. SR approaches are generally more cost effective, particularly when sampling multiple strata. SR by definition is tied to pre-defined strata, while grid-based sampling is more adaptable to the inevitable post-stratification exercises stemming from future what-if questions, or inventory line-work changes. However, this flexibility comes at a cost, since grid designs tend to carry more plots than SR approaches. But, for just one strata (~30 plots), initial cost differences are likely negligible. Grid designs are also easier for field staff to implement and adjust over time, and they are easier for the public to comprehend.

To maintain statistical sampling rigour, a plot cannot be moved from its pre-selected location to reduce travel costs, etc. Unlike PSPs and EPs, monitoring plots must <u>not</u> be given special management consideration (i.e., they can be cut, etc). To be valid monitoring, plots must reflect all changes and disturbances on the landbase. Consequently, monitoring

plot monumentation (signage/tagging) is generally kept low-key to avoid attracting undue attention.

4.2 Plot characteristics

The CMI/NFI standard is based largely on VRI-ground standards with the main difference being the use of single fixed-area plots rather than a cluster of variable radius (prism) plots. A CMI/NFI installation consists of one (1) fixed-area, 0.04ha (11.28m radius), circular plot. Two smaller, nested, concentric circular plots capture data on small trees down to 30cm in height. Tree attributes recorded include measured heights and net-factoring/call-grading for all trees. Age is taken on selected site (index) trees.

Use of multiple-plot clusters in VRI is intended to reduce sampling variance and reduce sample sizes. VRI plots are also intended to be temporary and only provide one snapshot in time. Fixed-area plots (i.e., CMI/NFI) are commonly preferred when sampling change with repeated measurements over time. The use of single, small, fixed-area plots in monitoring is a common cost compromise (e.g., NFI).

In addition to tree measurements, the full CMI/NFI standard also includes data capture for stumps, snags, coarse woody debris (CWD), eco-classification, range attributes, plus plant, soil and succession information. Many of these data are specific to NFI (national) reporting criteria and may have less utility at an operational MU level. When fully implemented, plot measurement requires nearly two days.

4.3 Common modifications

Existing projects have generally eliminated most of the non-tree measurements to reduce plot measurement to a more cost-efficient one day. Visual eco-classification has been the most common addition to tree measures, followed by CWD. The other measures can always be added later should the need arise for certification, etc. Custom measurements can also be added for special uses (e.g., branch size, etc). One attempt was made to test measuring a subset of heights and ratio-adjusting visual estimates on the remainder. However, the cost-accuracy trade-off is already being strained by the small plot compromise. Use of time-saving electronic height devices will likely provide a better return on investment in the long run. MSRM-RIB is likely to take more interest in proposed additions or modifications to implemented standards, as opposed to complete omission of any non-tree measures.

Occasionally, unique needs for a specific attribute may motivate plot design adjustments (e.g., Merritt IFPA and potential site index). However, measurement standards for the attribute(s) should still be followed, when they exist. Measurement standards only define minimum requirements; enhancements are possible.

4.4 Data management

MSRM-RIB is the Provincial custodian of the CMI/NFI standard and associated data. MSRM-RIB ensures the data conform to VRI-based data entry and compilation standards and are submitted to MSRM-RIB for provincial warehousing. MSRM-RIB also makes standard data management programs (routines) available to licensees and consultants for application within corporate information systems.

4.5 Other monitoring protocols

Beginning in 1994, MoF-RIB (pre-MSRM) undertook a 7-year strategic analysis of G&Y monitoring (McWilliams & Thrower, 1994, etc). The same G&Y monitoring definition adopted in this SIGY strategy became the yardstick by which existing "monitoring" programs were evaluated, beginning with MoF-RIB's own PSPs, Intensive Forestry, and Silviculturally Treated Programs. None of these designs supported the G&Y monitoring definition; in part due to different interpretations of the general term "monitoring". The essence of the G&Y monitoring definition implies a sampling design that generates statistically valid estimates in the true inventory sense. Sampling designs for these other data programs do not produce representative (unbiased) samples of meaningful populations in the inventory sense. The subjective (or opportunistic) sample location procedures used in some of these programs may support other objectives (e.g., modelling), but not inventory or G&Y monitoring, as defined.

TRENDS (NIVMA) and PROBE (MoF) are two other commonly referenced "monitoring" programs in BC; both are focused on young-stand performance and vegetation management. PROBE is a research protocol that was not designed to be an operational G&Y monitoring or inventory program. The TRENDS sample location procedures would appear to be more inventory-like, if they are consistently applied. Like the initial PROBE design, TRENDS would need to undergo plot modifications to produce useful long-term G&Y data. NIVMA activities have been suspended in BC as of January 2005.

5. Operational G&Y monitoring experience in BC

5.1 Players involved

Currently, eight management units in BC are actively engaged in G&Y monitoring: five TFLs (5, 30, 35, 37, 52), two IFPAs (Hope, Merritt), and one TSA (Ft St John). The Merritt IFPA is just beginning to install plots in response to an explicit condition placed on their AAC uplift. A few other management units (e.g., Adam's Lake IFPA, Prince George TSA, TFL 18) have prepared G&Y strategies that include G&Y monitoring but are postponing implementation. Most projects received public funding through FRBC or FIA and reports are deemed public through those funding agreements.

Most all the G&Y monitoring projects referenced above were designed by JS Thrower & Associates (JST). Field work was sometimes shared with other contractors, thereby increasing the experience pool. JST was instrumental in the early development of G&Y monitoring strategies for MoF-RIB (pre-MSRM) (McWilliams & Thrower, 1994). JST also helped develop modifications to VRI to create the CMI protocol, which became the template for the NFI ground sampling protocol. With much of the developmental work in place now, other qualified inventory and analytical consultants can bid on future contracts using the CMI/NFI standard.

MSRM-RIB maintains the CMI/NFI standard and serves as contact for G&Y (inventory) monitoring projects under the "Information Gathering and Management" component of the FIA Landbase Program Investment Program (LBIP). Projects proposing standards deviations may be required to submit project plans through the FIA-LBIP "Innovative Project" track. Licensees considering G&Y monitoring are encouraged to begin coordinating plans with MSRM-RIB at an early stage.

5.2 Objectives drive design

Initial planning starts with a clear understanding of business needs and objectives. Clear objectives and priorities help accommodate cost considerations without compromising key expectations. The most common licensee objectives relate to TSR (incl. IFPA uplift conditions) and certification. The ministry perspective also includes FRPA-FREP. The do-nothing option generally entails continued reliance on existing regulatory monitoring for harvesting and reforestation data (e.g., RESULTS, GENUS) with long-term sustainability supported notionally by modelling (TSR, G&Y). IFPA uplift conditions aside, there are currently no explicit mandates in legislation or certification for G&Y monitoring, as defined here. Most licensees continue to function without it at the moment. However, a few have elected to voluntarily initiate G&Y monitoring to provide a defensible framework for checking the long-term G&Y predictions underlying claims to sustainability within TSR and certification.

With the exception of TFL 37, the existing projects restrict sampling to second-growth managed stands, i.e., post-harvest regenerated (PHR) stands. TFL 37 installed CMI/NFI plots alongside all VRI plots. The emphasis on PHR G&Y recognizes that PHR yields largely determine long-term sustainability in TSR, and therefore will continue to be a major focus of risk and uncertainty debates. The interior projects initially targeted PHR stands from 15-20 years to 30-45 years of age depending on the unit's management history and TSR assumptions. Stands less than 15-20 years-old generally do not have enough merchantable volume to monitor. Regulatory monitoring programs (regen and free growing surveys) can also be referenced below this age range. On the coast, Hope IFPA targeted PHR from 21-80 years of age.

In response to the specific G&Y concerns raised in their uplift determination, Merritt IFPA sampling targets volume yields and potential site index (PSI) using two different plot types. Volume yields are being monitored in both low and high elevation PHR stands with CMI/NFI plots. A non-standard 9-plot cluster is being used to monitor PSI in high elevation and smallwood stands. Using a 2km grid, Merritt initially expects to install 46 CMI/NFI plots and 20-45 PSI plots, depending on the availability of site trees.

In the other projects, sampling intensities ranged from 30 and 75 plots per management unit. In most cases, this provided useful information to help corroborate expected yield increases. However, in the case of TFL 30, variability in the PHR strata was so high that it masked potential difference. More plots will likely be needed in this case. Projects with higher sampling intensities (>30) were able to examine at a few sub-strata differences (e.g., species, etc).

Every sampling scheme represents a trade-off between sampling intensity and cost. Greater sampling intensity provides finer resolution (i.e., stratification capability). Twenty to thirty (20-30) plots are generally considered a minimum statistical sample for any one stratum. Consequently, a 30 plot sample makes further stratification by species, ecology or silviculture regime a tenuous exercise. In essence, 30 plots provide a single average G&Y estimate for all PHR stands combined.

Most projects utilized a grid-based sampling scheme; TFL 30 and 37 used stratified random designs. Grid designs utilized UTM coordinates to facilitated GIS and GPS implementation. Grid plot spacing was 1-2km for TFLs, and 3km for Ft St John TSA, reflecting a larger geographic scale. Plans call for new plot establishments and/or retirements as more PHR is created and comes of age. The inherent flexibility of the design accommodates future adjustments in plot numbers (up or down) based on subsequent feedback. This also

allows an initially tentative investment to be expanded later. Extending sampling to natural stands was often cited as a future option.

Installation costs for the existing projects generally ranged from $1.8-3.0K/plot, of which 60-85% represented field work with the remainder for design and analysis activities. Future re-measurement costs will include data management and analysis costs. Provisions for quality control/assurance (e.g., check cruising, etc) are essential.

Design for long-term data collection must consider future funding. Recurring costs are guaranteed to come under recurring scrutiny. Justification will need to meet higher standards when budgets are tight. Anticipate future investment justification by documenting rationales and evidence of return on investment (e.g., AAC and/or certification maintained). Built-in design flexibility will also help address future budget pressures. Options include adjustments to re-measurement intervals and/or plot numbers for some or all strata.

5.3 Early results

None of the existing projects have completed their first scheduled 5-yr re-measurement. However, installation measurements have been summarized and analyzed to varying degrees as inventory audits. Inventory comparisons were made at high levels of aggregation (e.g., all pine PHR polygons) due to small sample sizes, yet most were generally supportive of the elevated PHR G&Y expectations being incorporated in TSR. Some anomalies were also detected that will help to focus further investigation (e.g., balsam ingress). The high degree of variability encountered on TFL 30 was unique among the existing projects, and indicates some management units may need more than a bare minimum of 30 plots. It remains to be seen what long-term impacts G&Y monitoring will have on the business issues it is designed to address (certification & AAC support). Yet, G&Y monitoring has already enhanced certification plans (SFMPs) and provided valuable initial feedback on G&Y and TSR that has not been available before.

6. Conclusions and Recommendations

6.1 Investment rationales & incentives

G&Y monitoring represents an increasingly important gap in BC's historic suite of long-term G&Y data. G&Y predictions play a central role in TSR and many other SFM decisions which rely on predictions of the future forest. Adaptive management and monitoring are now cornerstones of SFM, certification and FRPA-FREP programs. Current regulatory-based monitoring systems focus mainly on harvesting and regeneration up to the point of free growing. G&Y monitoring extends this horizon by continuing to check long-term G&Y predictions used to support claims of sustainability within TSR and certification.

SIGY licensee members generally rank the investment potential of G&Y monitoring above other forms of long-term G&Y data (e.g., PSPs and EPs). However, actual licensee investments in all forms of long-term G&Y data continue to be restrained by a climate of incomplete and ineffective policy and financial investment incentives. To date, only eight managements units in BC have implemented G&Y monitoring. Seven have restricted sampling to managed (PHR) stands for economic and strategic reasons. Use of the provincial CMI/NFI standard continues to provide the common framework that helps ensure defensibility and acceptability of results.

TSR and certification are the primary investment drivers for G&Y monitoring from a licensee perspective. Currently, only IFPAs have a forestry plan content requirement for general

monitoring, but it is not explicit regarding G&Y monitoring. So far, G&Y monitoring has been made an explicit IFPA uplift condition in only one in three determinations. G&Y monitoring is also being used to proactively address non-binding ministry suggestions (concerns) in TSR related to G&Y.

All certification standards include monitoring and allude to G&Y in varying degrees. However, most interpretations have yet to imply G&Y monitoring, as defined here. Instead, G&Y-related monitoring plans for FRPA-FREP and most licensee certification plans (SFMPs) generally rely on data from existing regulatory monitoring programs up to free growing, and then infer long-term sustainability through G&Y predictions and TSR.

Most licensees are currently postponing long-term G&Y investments and assuming a wait-and-see stance. The on-going government-industry stalemate regarding inventory and G&Y investments is affecting G&Y monitoring by association. Actions to address this stalemate are likely to involve at least some of the following: clearer policy definition of joint stewardship responsibilities related to inventory, G&Y and monitoring; FIA and/or ministry budget increases; and implementation of stumpage adjustments.

6.2 Investment opportunities

Given a favourable climate of policy and fiscal incentives, G&Y monitoring makes a particularly attractive G&Y investment because it has the ability to address multiple business needs and objectives. G&Y monitoring has the potential of addressing both short- and long-term issues related to: TSR, certification, FRPA-FREP, inventory and G&Y model development.

With the exception of TFL 37, existing G&Y monitoring programs in BC are independent of VRI. Greater investment efficiencies should be possible with closer integration (JST, 2001). This should be considered in all new inventory implementations, including those arising from the current MPB and wildfire crises. These large-scale destructive disturbances greatly enhance the need to monitor G&Y predictions for the surviving growing stock, which determines mid-term timber supply and socio-economic consequences. There are signs these crises may help drive resolution of the current inventory/monitoring investment stalemate.

There are additional opportunities to examine G&Y monitoring at different scales for different business needs. For instance, Alberta has proposed a three-tiered system that monitors unmanaged stands at a broader scale than managed stands (Huang, Yang and Heidt, 2004). Certain aspects of this approach may have merit in BC since G&Y assumptions and predictions for natural stands are generally much more consistent between MU's. A regional approach to monitoring natural stands could be shared through a co-op structure, possibly in conjunction with NFI and PSPs. In addition, MUs (mainly TSAs) continuing to use MoF's standard suite of G&Y assumptions for PHR in TSR may also benefit from sharing PHR monitoring, at least for the time being. Design flexibility is paramount, since change is the only constant.

Leveraging national and provincial standards increases opportunities for multiple-use and joint funding. Multi-stakeholder co-operation produces economies of scale through sharing of common procedures, information and experience. Co-operation also facilitates better communication, which enhances acceptance and adoption of new information. Forestry co-operatives, such as SIGY, may become even more functional depending on how government and licensees continue to refine the jointly-shared crown-forest stewardship model.

6.3 Delivery models

Some combination of government funding and licensee delivery is likely to dominant through the life of this government administration. However, government will need to create more incentives if G&Y monitoring is to be implemented any further in BC. Government's own FRPA-FREP mandate along with mountain pine beetle and wildfire issues should provide additional incentives for the needed policy and budget changes. Stumpage adjustments may represent the best long-term funding solution for both inventory and monitoring. Licensees want to maintain the option of contributing to co-operative efforts or fund their own custom projects. However, SIGY experience has repeatedly demonstrated the current FIA-LBIP funding model does not support large-scale co-operative G&Y investments at a regional scale.

SIGY has yet to garner broad licensee support for large regional FIA-LBIP projects (e.g., PSPs) partly because it requires so many individual funding decisions, i.e., each individual licensee within each management unit. Partial subscription is to be expected under these circumstances. However, this frequently causes otherwise supportive licensees to drop out because they feel non-subscribers should not accrue benefits without sharing costs. In contrast, the Forest Genetics Council has been successful under FRBC and FIA because their program obtains off-the-top funding based on a business planning process that involves licensees. SIGY petitions for a similar model have yet to gain favour. Unless alternate funding mechanisms appear, the co-op delivery model for G&Y will continue to be ham-strung in this fiscal climate -- despite government's championing of public-private partnerships. In 2005-06, SIGY will explore provincial coverage of the G&Y co-op model as a potential way to increase the profile and funding success of regional G&Y issues.

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8. Appendix: Comparison of Certification Standards

Comparison of selected requirements related to G&Y monitoring across five soft-law standards applicable to BC. Adapted from Hickey (2004).	Montreal	ISO14001	CSA	SFI	FSC-BC
1. ADAPTIVE MGMT, PLANNING and INVENTORY					
a) Planning					
Adaptive Mgmt			X		X
Monitoring Plan			X	X	X
Elements to be monitored					X
Indicators and rationale					X
Consistent with mgmt plan					X
Consultation with persons affected					X
Resource Inventories	X		X	X	X
Rationale for harvest rate				X	X
Growth rates and yield calculations				X	X
b) Records					
Monitoring records			X		X
Document changes in monitoring					X
Monitoring database					X
Persons responsible					X
Quality assurance/quality control					X
c) Monitoring (general)					
Need for background/baseline monitoring specified	X		X	X	X
Scale and intensity		X		X	X
Evaluation		X	X	X	X
Forecasting			X		
Modelling			X		
Scenario based			X		
Periodic assessment		X	X	X	X
Discrepancies between outcomes and expectations					X
Data quality	X		X		X
Availability and extent	X		X		X
Scope, frequency and reliability	X		X		X
Methodologies			X		X
Consistency and reliability					X
Compatibility	X		X		
Correlation with observations					X
d) Research and Development					
Monitoring to promote understanding	X	X	X	X	X
Biodiversity			X	X	X
Forest health				X	
Yield of all forest products				X	X

Comparison of selected requirements related to G&Y monitoring across five soft-law standards applicable to BC. Adapted from Hickey (2004).	Montreal	ISO14001	CSA	SFI	FSC-BC
d) Research and Development (continued)					
Monitoring to promote understanding					
Growth rates, regeneration and condition				X	X
Flora and fauna				X	X
Prediction / forecasts		X	X	X	X
Sensitivity analysis					X
Precautionary principle					X
c) Forest inventory (basic)					
Forest area	X		X	X	X
Forest type	X			X	X
BEC					X
Crown closure					X
Growth rate				X	X
Forest structure				X	X
Fallen dead wood					X
Hollow trees / snags / standing dead				X	X
Total growing stock (all spp)	X			X	X
Total plantation stock	X				X
Total plantation area					X
Forest genetic stock			X		
Forest health	X		X	X	X
Abiotic damage to forests	X				X
Biotic damage to forests	X				X
Regen / stocking surveys				X	X
f) Management Systems					
Incorporate research and monitoring into management		X	X	X	X
Promote continual improvement		X	X	X	X
Monitor, measure, report performance		X	X	X	X
2. FOREST ENVIRONMENT AND ECOSYSTEM PROTECTION					
g) Forest Health					
Area affected by processes or agents			X	X	X
Insects			X	X	X
Disease			X	X	X
Overstocking				X	
Windthrow			X		
Plantation health					X
Mortality					X
Disease					X
Insect outbreak					X