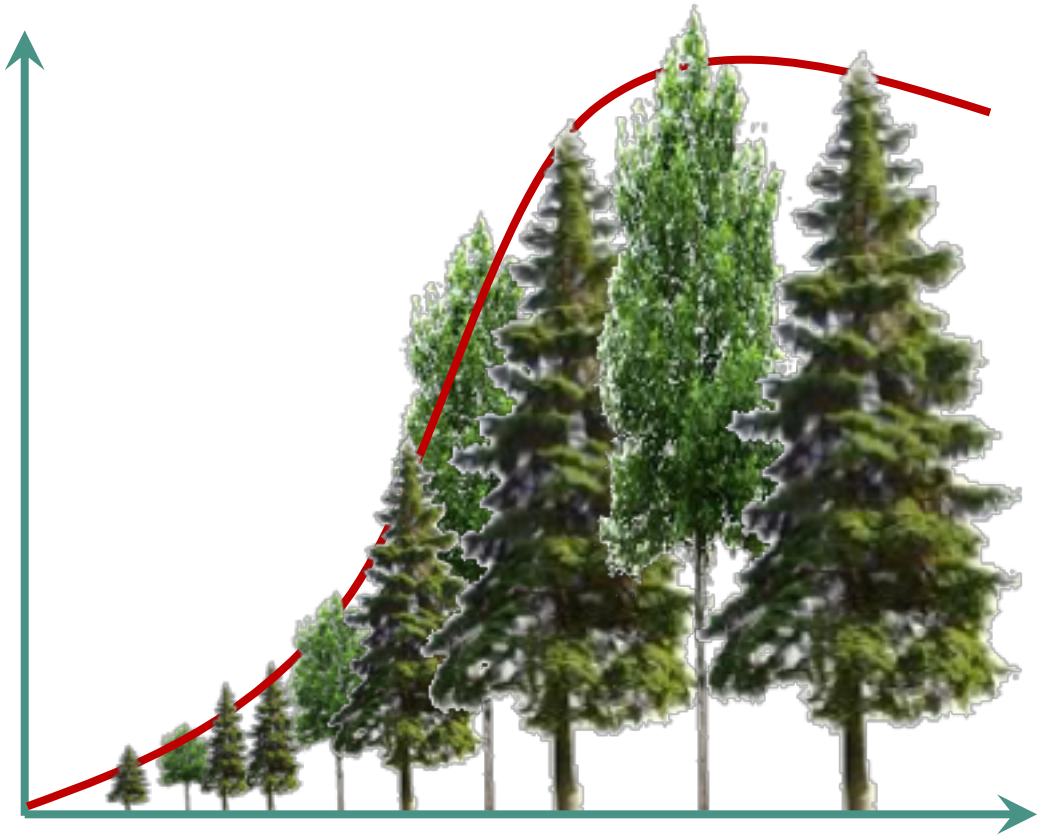

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The Ontario Growth and Yield Program Status and Needs - Report to the Forestry Futures Trust Committee

Margaret Penner and Doug Pitt

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Executive Summary

Ontario's rich Crown forests cover close to 90% of the province. Under the Crown Forest Sustainability Act (CFSA), the Ontario Ministry of Natural Resources and Forestry (MNRF) manages the Crown forest sustainably to meet social, economic and environmental needs of present and future generations. Sustainable forest management requires a knowledge of the resource (an inventory) and projections of how that resource will develop (growth and yield – G&Y).

G&Y products contribute to the production of an inventory. G&Y tools are used to project the current forest under different management scenarios and a changing climate, and monitor the achievement of objectives over time. G&Y products are used by forest managers, policy makers and planners to evaluate options, make decisions, compare outcomes and adapt management.

In 2017 forest industry requested funding from the Forest Futures Trust Committee (FFTC) to address G&Y data collection concerns – a request that was considered outside the scope of the FFTC. A short time previously, FFTC became aware that linkages between G&Y and the MNRF's Forest Resource Inventory (FRI) program were deemed by FRI to be inadequate. Through further informal discussions, it became apparent to the FFTC that Ontario's existing G&Y program was beset with a number of issues that frustrated both G&Y practitioners and clients, including industry, and that an assessment of the current status of the G&Y program and its possible future was in order. To this end, FFTC and MNRF's FRI section deemed that such an assessment could be accommodated through the FFTC-managed Knowledge Tool and Technology Development (KTTD) program.

Consequently, with support from the KTTD, four workshops were held across Ontario through the fall of 2018 to solicit input on Ontario's G&Y needs to support sustainable forest management for the next 20 years and beyond. More than 130 participants were heard from representing government, forest industry and academia. Three main themes emerged:

1. Growth and yield data and tools are critical to the sustainable management of Ontario's forests. The current program is designed to meet *strategic* planning needs. Few people know the data and science behind the tools, how to use the tools or how reliable they are. Better tools are needed for conditions such as mixedwoods and managed forests. Users would like tools for operational planning.
2. Better communication is needed at all levels. Developers and users of growth and yield need regular opportunities to meet and exchange ideas and concerns. Annual reports of current work plans and program accomplishments are needed.
3. Roles and responsibilities are not clear and, when an issue arises, it is not clear who to call. This leads to a lack of accountability.

These consultations revealed issues with the governance structure and resourcing of the G&Y program. Inventories are a joint product of the FRI and G&Y programs and the workshops confirmed links between the two programs are inadequate and roles and responsibilities in producing the inventory are not clear. The current G&Y program has limited capacity to reduce uncertainty in decision making and contribute to defining, defending and demonstrating the sustainability of forest management in Ontario.

Workshop participants shared a sense that Ontario's G&Y program has reached a point of crisis. The province is about to embark on a new round of forest inventory in 2019 that will demand new, high quality G&Y data and tools for its maintenance. Ontario's forests and forest management practices have evolved to

the point where new data and tools are imperative. A changing climate and associated disturbance factors add to these needs. As long as a sustainable wood supply is considered a valuable commodity in Ontario, data and tools that quantify and project this wood supply must be considered a high priority and wise investment. The authors of this report reflect on this participant feedback and their own personal experience to suggest a path to the revitalization and renewal of Ontario's G&Y program.

Acknowledgements

The authors thank the Forestry Futures Trust Committee for recognizing this project could be accommodated within the scope of KTTD and for funding. The idea to shed light on the G&Y program is both timely and much needed. The authors thank all who passionately contributed thoughts, ideas, comments and time to the conversation and this report.

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Project Objective

The objective of this project was to meet with government and forest industry to **identify the growth and yield (G&Y) needs to serve sustainable forest management in Ontario for the next twenty years and beyond**.

This report focuses on the G&Y program and its linkages to the current Forest Resource Inventory (FRI) and the forest management planning process. The goal is to summarize the G&Y short- and long-term needs identified by workshop participants, given anticipated changes to these programs and forests over the next 20 years. The ***Results*** section of this report reflects the written and verbal feedback received over the course of four workshops held across Ontario between November 13 and December 5, 2018, from more than 130 stakeholders including government, forest industry, and academia. The remainder of the report includes emphasis, recommendations and conclusions drawn by the authors, largely from the workshop sessions, but also from experience in G&Y and FRI within Ontario and elsewhere in Canada. The target audience for this report is the Ontario Ministry of Natural Resources and Forestry (MNRF), Forest Industry and the Forestry Futures Trust Committee (FFTC).

G&Y – a Primer and Some History

Why care about G&Y?

Ontario's forests cover approximately 71 million ha, approximately 90% of which are Crown forest. Forest management on Crown land in Ontario is regulated through the Crown Forest Sustainability Act (CFSA 1994). The purpose of the CFSA is to provide for the sustainability of Crown forests and, in accordance with that objective, to ensure that Crown forests are managed to meet social, economic and environmental needs of present and future generations.

Indeed, *sustainability* is a common thread through just about every document describing the MNRF's mission, mandate, and activities (e.g., OMNR 2000). In simple terms, sustainability means the forest resource, like a financial investment, will remain healthy, intact and, through growth, be able to yield a relatively constant stream of benefits long into the future. *G&Y* is used to support decisions aimed at balancing harvesting (withdrawals) against expected future growth and losses to ensure forest capital is protected over time (analogous to a financial advisor). The *FRI* is an assessment of the current state of the forest capital (analogous to an investment account statement). *Forest estate models* quantify potential options to achieve sustainability. G&Y and forest inventory provide the inputs and some of the rules for these estate models and provide the evaluation foundation for sustainability. Periodic forest inventories and permanent sample plots allow monitoring of the achievement of sustainability. Demonstrating sustainability therefore requires both G&Y and forest inventory.

G&Y is used to project or predict the forest resource into the future so that appropriate action may be taken today to protect the forest capital. Specifically, G&Y is used to estimate sustainable harvest levels, by species and product, given expected losses to agents such as fire, insects, disease and extreme weather, and projected changes in the forest from regeneration and growth.

The G&Y Program of the MNRF is primarily responsible for addressing Condition 49 of Declaration Order MNR-75[1] regarding the Forest Management Class EA. This condition states that "*MNRF shall continue to support and implement a provincially coordinated program, known as the Growth and Yield Program,*

[1] https://www.ontario.ca/page/declaration-order-mnr-75-environmental-assessment-requirements-forest-management-crown-lands-ontario

to obtain further information on forest growth and yield, as influenced by: climate change; site; forest structure; silvicultural treatments; and other natural events. The Forest Management Planning Manual shall include requirements to incorporate the results of the Growth and Yield Program for use in forest management planning." The G&Y Program addresses this obligation through a consistent and continuous cycle of data collection, analysis and interpretation, and reporting. An annual report to the Legislature is a legal requirement and the program also has to describe its accomplishments in the 5-year Forest Environmental Assessment Report submitted to the Ministry of the Environment, Conservation and Parks. G&Y is an explicit objective under the province's Wood Supply Strategy (OMNR 2004a).

What is G&Y?

The growth potential of a particular investment is often judged based on detailed records of past performance history, coupled with how markets are expected to behave in the future. Forest G&Y is similarly based on repeated observations of forests over time, along with the anthropogenic and environmental conditions associated with changes in the forests. These basic data are used to model expected changes in the forest capital and balance future growth and losses through management. The core of any G&Y program is, therefore, detailed, quality measurements of forests over time. These repeated observations are traditionally collected in field plots. G&Y also encompasses the prediction and projection tools that are developed from these data and used in forest management decision making.

Ontario's G&Y program is designed to: *define* how forests are growing and the products they are producing; *defend* the sustainability of decisions and activities undertaken through forest management planning; *demonstrate* sustainability over time; and *develop* new practices as adaptations to evolving climates (social, economic, and environmental). The current G&Y Program operates under a masterplan (OMNR 1993) that states: "*The purpose of the provincial growth and yield program is to improve resource management decision-making by helping managers better predict and understand the dynamics and productivity of Ontario's natural and managed stands.*"

G&Y includes both monitoring and modelling. Monitoring is generally aimed at quantifying the change of the resource over time. This is usually accomplished by remeasuring plots with known sampling probabilities. Canada's National Forest Inventory (NFI)[2] is an example of a monitoring plot network. The NFI network of plots (and the supplementary Provincial Forest Inventory Growth Plots) are located on a grid. Modelling is generally aimed at quantifying relationships between attributes. The data may come from a number of sources including intentionally located permanent plots. The Thunder Bay spacing trial (Homagain *et al.* 2011) is an example of plot network designed for G&Y modelling.

What is the current status of G&Y in Ontario?

Prior to the late 1980's, the G&Y plot network in Ontario was an ad hoc collection of forest industry, provincial government, and research plots. This network was a valuable resource, with some limitations. Plot placement often targeted mature, natural forest conditions and measurement standards and procedures were not consistent. In the 1950's, normal yield tables (published in metric as Plonski 1981) and cull tables (Morawski *et al.* 1958) were developed and are still in operational use by some managers in the province today. In the late 1980's, recognizing the need for more rigorous G&Y information and a shift from timber to forest management, the province went through a series of consensus-building meetings with stakeholders to draft a comprehensive G&Y strategy that was to become the province's masterplan for G&Y (OMNR 1993). The Forest Management Class Environmental Assessment of 1994 provided additional impetus for the implementation of this plan.

[2] https://nfi.nfis.org/en/general

The 1993 masterplan for G&Y called for an annual budget rising from $0.65 million to $4 million, outside of "A" salary staff during the initial 5 years (1991/92 – 1995/96) of the plan. For the first two years of implementation, the *Sustainable Forestry Initiative* (SFI) provided financial commitments of $1.74 million per year in above-salary funding. By 2009/10, $0.6 million in above-salary funding was allocated to G&Y (15% of proposed, OMNR 2010). This past year (2018/19), the program received $0.44 million in above-salary funding (11% of proposed). In addition, the number of "A" salary staff positions has been reduced. Notably, the 1993 masterplan is still in effect and neither the objectives nor budget have been revised.

The 1993 masterplan medium-term (1994-1997) deliverables called for the establishment of 4308 permanent sample plots (PSPs), each with three growth subplots. Commensurate with the funding received, and including plots established outside of the program (e.g., National Forest Inventory and industry-lead plots), approximately 1,200 PSPs and 2,700 permanent growth plots (PGPs – equivalent to a single subplot of the PSP) have been established. Plot establishment in mixedwoods and new areas of interest has suffered and, more important from a value perspective, plots have not been remeasured on the proposed 5 – 10-year interval. The current average measurement interval for a plot is approximately 25 years, based on the information in Table 1, but remeasurements have been inconsistent. Many plots have not been remeasured, some are unsalvageable or lost, and sufficient time has elapsed on others to discount the value of time-series. While the established plot-network is an important asset, the network needs to be evaluated and data gaps identified. The G&Y program at present does not have an adequate sample of long-term measurements to generate reliable growth curves for all forest conditions of interest. Yield curves such as Plonski (1981) and those in the Modelling and Inventory Support Tool (MIST) do not cover selection or shelterwood silvicultural systems. Yield curves are for clearcut silvicultural systems that lead to even-aged, single-species conditions. Growth models are required to support partial harvest systems and conditions with multiple species and age cohorts. Growth models require remeasurement data and the number and timing of the measurements is critical. Growth models are also required to project the inventory through time, used in calculating the allowable harvest.

Program staff have taken advantage of partnerships and produced many useful tools, primarily for boreal forest management. These include standard forest units for the northwest and northeast regions, benchmark yield curves (e.g., Penner *et al.* 2008), taper models (e.g., Zakrzewski 1999; Woods and Zakrzewski 2000; Sharma and Zhang 2004; Zakrzewski and Penner 2013), stand density effects on taper (e.g., Sharma and Parton 2009), site index models (e.g., Sharma *et al.* 2015; Sharma and Reid 2016, Sharma and Parton 2018a, 2018b, 2018c), diameter growth models (e.g., Subedi and Sharma 2011), climatic effects on site productivity (e.g., Sharma *et al.* 2013; Sharma and Parton 2018a, 2018b, 2018c), climatic effects on diameter growth (e.g., Subedi and Sharma 2013), height-diameter models (e.g., Newton and Amponsah 2007; Sharma and Parton 2007; Sharma 2016), total-age to breast-height-age models, diameter-distribution models (e.g., Newton *et al.* 2005), preliminary density management diagrams (e.g., Smith *et al.* 1997; Newton 1997, 2003, 2016; Sharma and Zhang 2007) and prototype forest succession models (Lennon 2016). In the southern region, dominated by the Great Lakes - St. Lawrence (GLSL) forest, the tree marking program (OMNR 2004b) is a critical component of selection and shelterwood management and uses G&Y data.

The periodic (5-year) program review called for in the 1993 masterplan for G&Y (OMNR 1993) has never been undertaken. An internal review of the program (OMNR 2010) raised concerns over underfunding but recommendations were never acted upon. Recently, Regional Operations Division (ROD) held a series of meetings related to G&Y, identifying ROD business needs (Feb. 3, 2017), the need for confidence in G&Y predictions (Apr. 3, 2018), a statement of the impact of inaccurate volume estimates on sustainability (Apr. 9, 2018), and a ROD message statement to the IMF program (Apr. 11, 2018). These meetings raised important communication issues that have not been addressed.

In 1993, the G&Y program was split into a forest growth and measurements group (responsible for field sampling) and a forest modelling and productivity group. The field sampling portion was distributed to the regional science groups and is now a part of the Biodiversity and Monitoring Section (BAMS). The forest modelling and productivity group, consisting of researchers, technicians, database professionals and management staff responsible for model development, were moved to or were a part of the Forest Research and Monitoring Section (FRMS).

Currently, BAMS is responsible for the field program. Natural Resources Information Section (NRIS) is responsible for information management. FRMS and the Centre for Northern Forest Ecosystem Research (CNFER) are responsible for research and modelling. The Forest Analysis Unit (FAU) is responsible for maintaining approved tools and planning. Regional Operations Division (ROD) is responsible for training and transfer.

A field program has been maintained, despite major cuts in funding (and recently returned 3 G&Y professionals - a very positive sign), but the research group has all but disappeared. At FRMS, Dr. Sharma has been very productive for the program (see the **Literature Cited** section), but the development needs were to be the responsibility of a larger team including researchers, and support staff, and interaction with the field.

The latest status of the *Summary of the Progress in Inventory and Monitoring Program* indicator was that "*The growth and yield, and enhanced forest resource inventory programs continue to be well below targets*" (State of Ontario's Natural Resources – Forests 2016, MNRF 2016). The reliability of the G&Y information depends on a long-term commitment of adequate resources. In its statement of environmental values, the MNRF states:

> *As our understanding of the way the natural world works and how our actions affect it is often incomplete, MNRF staff should exercise caution and special concern for natural values in the face of such uncertainty*.[3]

There are significant costs to *uncertainty*.

[3] https://www.ebr.gov.on.ca/ERS-WEB-External/content/sev.jsp?pageName=sevList&subPageName=10002

Project Methods

To hear from government and forest industry across the province, four workshops were held: one in the northwest region, one in the northeast region, and two in the southern region (**Figure 1**). Prior to the workshops, a background document was prepared (**Appendix 1**) in consultation with MNRF staff and circulated to participants. The background document included a description of the project and a summary of the G&Y program and its history. In addition, the three programs closely linked to G&Y – FRI, the Integrated Monitoring Framework (IMF) and forest policy/planning – were summarized in terms of their current state and future directions. The future directions were not intended to be definitive plans but rather an indication of the likely direction of these programs. A questionnaire (**Appendix 2**) was circulated to workshop participants to solicit input prior to the workshops.

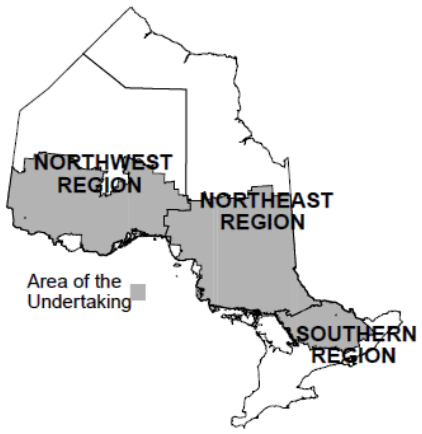

Figure 1. Ontario's regions are given (from OMNR 2004a).

In consultation with the FFTC, a list of workshop participants was developed. This list included the Sustainable Forest License (SFL) holders and other forest industry in Ontario as well as MNRF staff with ties to G&Y. Registration was free and not restricted to those receiving invitations. The project team handled workshop logistics and sent out the background material and questionnaire to all registrants. The participants are summarized by region and sector in **Appendix 3**.

Each workshop started with a presentation of the background material for G&Y, FRI, IMF and policy/planning. The following questions were then discussed by the group:

1. In the current G&Y program, what works and what doesn't work?
2. What are the emerging factors and what is needed to address them?
3. What are the barriers moving forward?
4. What are the next steps for G&Y?

Participants were given the opportunity at each workshop to provide both verbal and written comments. Participants were also given contact information for the project team for further comments. Additional input was solicited from people not able to attend the workshops.

Transcribed notes taken during the workshop discussions are provided in **Appendix 4**. A draft report was circulated to the FFTC, MNRF and forest industry for comment. This is the final report.

Results – summary of participant feedback

Three main themes emerged from the workshops:

1. Growth and yield data and tools are critical to the sustainable management of Ontario's forests. The current program is designed to meet *strategic* planning needs. At the management unit level, few people know the data and science behind the tools, how to use the tools or how reliable they are. Better tools are need for conditions such as mixedwoods and managed forests. Users would like tools for operational planning.
2. Better communication is needed at all levels. Developers and users of growth and yield need regular opportunities to meet and exchange ideas and concerns. Annual reports of current work plans and program accomplishments are needed.
3. Roles and responsibilities are not clear and, when an issue arises, it is not clear who to call. This leads to a lack of accountability.

The workshops provided a long-overdue opportunity for people to discuss their concerns, learn about the directions that the G&Y and other programs are taking, and to learn of the G&Y tools that are currently available and being developed.

Positive aspects of the current G&Y Program

The G&Y program has achieved some of the objectives established in the G&Y masterplan (OMNR 1993), particularly the short-term objectives with respect to the G&Y tools and initial PSP/PGP data collection. The workshop participants were largely unanimous in which aspects and elements of the G&Y Program they viewed positively.

Notably, the G&Y program has provided several tools that are widely being used:

1. Yield curves for the clearcut Standard Forest Units (SFUs) are available and used in forest management planning. Yield curves for the relatively pure SFUs in unmanaged conditions are working well.
2. A first draft of natural succession models (Lennon 2016) is working well in the northwest and northeast regions.
3. Site Index (SI) curves continue to be developed and are available for natural origin jack pine, black spruce and aspen. Climatic terms are included in the SI models for planted jack pine, black spruce, white spruce, white pine and red pine.
4. Height-Diameter at breast height (Ht-Dbh) curves and Volume/Basal Area Ratio (vbar) estimates are embedded in current tools.
5. The SFUs are designed to be the standard stratification scheme and are working in the boreal, increasing the efficiency of analysts.
6. The tree marking guide (OMNR 2004b) in the southern region draws, in part, from G&Y research.

The PSP/PGP program, while nowhere near the extent recommended in the 1993 masterplan, has many strengths:

- The data collection protocols are well-documented. The data quality is high.
- The plot network covers many (but not all) conditions.
- Many plots (but not all) have been remeasured, some more than once, providing estimates of growth and growth trends. This is a valuable dataset for developing G&Y tools.
- The boreal PSPs/PGPs are all in the PSP/PGP master database.

The PSP/PGP dataset reflects a commitment of time and funding. Nearly all participants emphasized that the value of long-term, repeated measurements over time cannot be overstated. For example, the wave of PSPs/PGPs established in the 1990s could not be used to estimate growth until the remeasurement cycle began, 5 – 10 years later.

The G&Y program professional staff include a coordinator, three forest productivity specialists and two data management personnel. Program staff have a history of being open to partnerships, both internally and externally.

Recent informal initiatives to bring together ROD and G&Y (Timmins 2018) and planning, G&Y and SFLs (Huntsville 2017) resulted in positive discussions and improved understanding of the tools and issues.

G&Y tools for aspatial, strategic-level planning for a mostly area-regulated allowable harvest level are working well.

Shortfalls in the current G&Y Program

The forests in Ontario are diverse and cover a wide range of ecological conditions. As a result, some of the strengths of the current program are also weaknesses because equivalent tools and assets are not available for all forest regions /conditions. Many of the weaknesses identified are data or tool gaps. Participants from the different regions generally did not disagree on the weaknesses and gaps identified, however there are regional differences in how these might be prioritized.

G&Y data and tools

The G&Y program has some notable gaps in the tools that are available, many of which would be filled if the masterplan was fully implemented. The following gaps were identified:

1. Yield curves for mixedwood conditions, managed stands including mixed species plantations, and the shelterwood and selection silvicultural systems are either weak or lacking. In general, yield curves are weak and poorly supported by data for the complex forests arising from extensive management. Stocking profiles are poorly estimated and crown closure may be a better alternative. Yield curves assume that species composition is constant over time, which is generally only appropriate for short (< 5-year) projections.
2. Documentation of the natural succession rules for the southern region is not available.
3. G&Y tools are weak for early stand development and not well-linked to early assessments and performance surveys. Guidelines for the development of post-renewal succession rules are needed (currently a Silviculture Enhancement Initiative (SEI) responsibility, but requiring links to G&Y).
4. Site Index curves are not available for minor boreal species such as white birch, cedar and tamarack. Site index curves that incorporate climate variables are limited to planted species. Site Index does not work in tolerant hardwoods since trees often remain suppressed in the understory for many years and the main canopy may be uneven-aged. There are no alternative site quality or productivity measures available in the FRI.
5. Ecosite, now part of the FRI, is not used in current G&Y models.
6. Current FRIs contain two-cohort stands. The Modelling and Inventory Support Tool (MIST) does not work for these and analyst have needed to develop work-arounds.
7. Cull factors are from the 1950's (Morawski *et al.* 1958) and limited to unmanaged stands. Cull stemming from today's harvesting practices, particularly in the south, is unknown.
8. Work on calibrating the Forest Vegetation Simulator (FVS) for Ontario has begun, but a working version of FVS is not available to users. Data for certain species and size classes are lacking; mortality and ingress models are weak.

9. *CROPLANNER* (a density management diagram developed by the Canadian Forest Service with data contributions from the MNRF) is not yet available. The release is pending empirical validation and incorporation of recently developed site index curves. The underlying models have been published (Newton 2016).
10. The southern region does not have SFUs and the forest units used by southern plans do not fit well in current planning tools (MIST and the Strategic Forest Management Model - SFMM). The current legacy of post-harvest assessment data in the southern region is linked to historic plan forest units.

There was plenty of discussion specifically about MIST, a software shell that incorporates many G&Y products including empirical yield curves, SI equations, taper models and cull estimates. MIST is used to assign volume per hectare to the current FRI and MIST yield curve outputs are used in SFMM to develop forest management plans. MIST does not work for all but the most informed users. There is a lack of confidence in its use. The training on MIST has been informal or non-existent. There is little available information on how MIST was developed; on the data behind the models; and the goodness of the predictions. Which models are reliable and which are not? Users have been asking for confidence intervals but, with discussion, it became apparent that users are really interested in seeing the source data superimposed on the prediction surfaces. Users are also interested in quantitative assessments of errors in the system used to predict the allowable harvest level. This would include errors in the FRI, yield curves, cull and uncertainty introduced by using broad strata. Not all conditions require the same level of confidence. The level of confidence should consider the user's need as well as the other sources of error in the systems (e.g., FRI error). As noted by Sobze *et al.* (2006), sensitivity analysis of wood supply predictions is complicated.

There was discussion at all four workshops about information management and access to data. Participants noted that it was difficult to access data and that not all the data from the southern region was in the master database.

PSP/PGP network

The PSP/PGP network does not cover the entire range of conditions being managed. There are large gaps or no data at all for post-harvest conditions, older plantations, mixedwoods, lowland hardwoods (including silver maple, white oak, bur oak and ash), mixtures of tolerant and mid-tolerant species (maple with oak, basswood and cherry) and shelterwood systems. Data for tolerant hardwood selection silviculture have limited geographic coverage (most plots are in Algonquin Park). There is a lack of data representing some northern forests within the AOU (e.g., Ogoki, Whitefeather). New plot establishments are rare.

Some trials and measurements, particularly in the southern region, have not been imported into the PSP/PGP master database. In the southern region, current efforts are directed at incorporating historic datasets including the Algonquin Region Growth Survey (ARGS) and the Algonquin Polar Plot (APP) networks. In the northeast region, the Hearst and Romeo Malette LiDAR calibration plots could be incorporated. *Information management* should be part of the planning, design, and execution of the G&Y program.

The extent and value of historic datasets outside the PSP/PGP master database is unknown. An imminent wave of retirements makes the loss of data a very real concern. The remeasurement schedule on existing plots (planned every 5 years) has not been maintained and many PSPs/PGPs are unrecoverable or costly to remeasure because of the maintenance required (tree tags are missing making relocating trees difficult and time-consuming). A plot establishment/remeasurement strategy is missing.

FRI and its linkages with G&Y

Participants frequently cited situations where G&Y and the current term 1 (T_1, 2006-2016) FRI do not mesh well (MIST was developed prior to T_1) and linkages are problematic:

1. Model inputs are often not linked to FRI attributes. For example, FRI contains a stocking measure, needed for the old Plonski yield curves. Often, the stocking estimate in the FRI is better correlated with crown closure than actual stocking. Stocking estimates vary from interpreter to interpreter, leading to inconsistent estimates. Stocking is the link to basal area, a key attribute predicted in the newer benchmark yield curves. Errors associated with these misalignments result in potentially large variances in yield projections.
2. FRI provides an interpretation of two-cohort stands. Analysts have developed workarounds but there is no formal or standard way of dealing with these in MIST.
3. The FRI does not work well for some conditions, including mixedwoods (it would be really helpful to have FRI information on the height and age of the secondary species), tolerant hardwoods and forests managed using shelterwood systems.
4. For shelterwood and selection forest units, stage of management is important and the FRI is often out of step with management. With a 25-year cutting cycle in selection management, if the FRI is 10 years old, 40% of the stands have been cut since the FRI was produced.
5. The silvicultural intensities (SilvInt) in the FRI do not have standard definitions. This may also be true of other attributes such as age (e.g., age of dominant/codominant vs. age since disturbance).

Participants unanimously identified that G&Y and FRI need to link seamlessly and work together.

Planning and checks on sustainability

Planning at the spatial/tactical/operational scales is not working well. The required level of accuracy (volumes ± 10 – 20% at the stand level) simply isn't there.

In some cases, legislation precedes implementation, such as in the case of post-harvest assessments. The Forest Operations and Silviculture Manual (OMNRF 2017) requires the MNRF maintain a silvicultural effectiveness monitoring program for carrying out assessments of regeneration and "*direction for the assessment of regeneration may be set out in policies or guidelines issued by the MNFR and made available as part of FOSM's associated policies*". Drafts of these policies or guidelines have been developed but the final guidelines have not been issued and are outside the scope of this review. However, the forest management planning manual requires the regeneration assessments be linked to yield prediction.

There are no formal checks on G&Y or FRI. There is no formal process to relate actual harvest volumes to inventory, G&Y predictions, and plan volumes. There are no formal analyses done at the regional level. If poor decisions are made, whether due to inadequate data or tools, this needs to be identified and something should change. If poor decisions are based on inadequate tools, then tools need to be improved. If tools are poor because they are based on inadequate data, this needs to be addressed. The G&Y assumptions in management plans must be substantiated with quantitative results or well-documented rationales. G&Y should be the *poster-child* for adaptive management. Furthermore, G&Y is not linked to post-harvest assessments including regeneration assessments and performance surveys. Performance survey protocols have not been finalized. Within-block treatment and response variability are huge. Finally, the scale at which post-harvest assessments are evaluated is unknown (e.g., are they evaluated at the stand level or the strata level?).

Partnerships

The masterplan anticipated field delivery would be expanded to include partnerships with industry, academia and other government organizations. Most of the large advances made by the G&Y Program in the last two decades may be attributed to partnerships, such as the Forest Ecosystem Science Co-operative Inc. (1999 to 2013) and the Forestry Research Partnership (1999 to 2012). Both partnerships have ended and since then, little has been done, little has been communicated and there are few incentives for engaging forest industry.

Partnerships with SFLs in the southern region were pursued in the early 2010s, but lack of MNRF staff and resources meant little support, training or communication.

Communication

Since the dissolution of the partnerships, the G&Y program has not communicated the activities of the program well with its clients. This includes communicating current priorities, the status of the PSP/PGP networks and remeasurements, and the tools that are available (particularly the products that may be embedded in tools but not obvious to the user, such as taper models and height-diameter curves). Supporting documentation and training for tools were identified by many participants as a high priority but lacking or extremely weak.

Within the MNRF, communication between the perceived "silos" is considered to be poor or near non-existent. Communication between the G&Y program and its clients, ROD, Policy Branch and forest industry, needs considerable improvement. All regions identified a lack of oversight (e.g., MNRF management, through to the lack of a working-group-type structure) as being problematic for communication.

The G&Y Program itself has not been internally or externally reviewed every 5 years as recommended in the masterplan. A formal, periodic review may have raised some concerns within MNRF about the state of G&Y.

Budget

Participants noted a forest-industry willingness to contribute to G&Y, but lack of tenure security and input in decision making have weakened any support that exists. There is a perception that non-timber beneficiaries of G&Y data and tools are not contributing their fair share of program costs. Although not discussed at the workshops, it should be noted that sustainable forest management requires consideration of non-timber benefits.

Emerging issues & opportunities for the G&Y Program

Looking forward, there are several short- and longer-term factors that are emerging; some offering opportunities for G&Y, others presenting challenges. The new-generation FRI, for example, presents opportunity to directly address some of the data gaps identified in the current G&Y program. Issues like climate change, on the other hand, mean that G&Y will need to anticipate and incorporate predictors responsive to climate change into models of forest productivity and succession and review and revise workplans as new information becomes available. There was discussion about using a risk-based approach to set priorities and assign resources. For example, participants felt that priority ought to be given to G&Y data and information most likely to affect long-term sustainability and influence decision making.

Integrated Monitoring Framework (IMF) – an opportunity

The goal of the IMF broad scale territorial design team is to develop efficient, long-term, provincial-scale monitoring programs to serve as tools to better understand landscape systems and changes in support of planning, policy development and public reporting (**Appendix A1.3**). IMF is attempting to re-engineer terrestrial data collection to efficiently and effectively address a wide range of policy and planning needs. It will integrate satellite-based remote monitoring, the FRI and a ground plot network. The IMF is currently being designed to be client-driven with cross-collaboration amongst plot-based programs (e.g., G&Y, FRI, ELC, Natural Heritage and Information Centre, the remote sensing group that conducts change-detection and land-cover mapping, etc.), with open, shared data on a well-designed information management platform. This is an excellent model. There is, however, concern that IMF may force a one-size-fits-all approach to plot and network design that could compromise existing programs. G&Y and FRI will be key participants in IMF and it is critical that both programs articulate their requirements in terms of plot and network design. G&Y is not primarily a monitoring program per se and the plot and network design for developing G&Y tools is much different than the needs of monitoring programs. There ought to be significant opportunity for synergies and efficiencies where component programs overlap while recognizing

that large portions of each program have unique needs. IMF should be charged with the task of pulling disparate data sets together and making them available for use, as there is huge potential for data-loss with the wave of retirements that is imminent. IMF also offers the opportunity for badly needed information management and technology to be resourced as part of core business.

The new FRI – an opportunity and a challenge

The FRI program is entering its second ten-year cycle (known as "T_2"). Proposed changes to the FRI will have profound impacts on the G&Y program. The two programs need to evolve together and be closely linked.

The proposed T_2 FRI will likely shift from polygons to rasters. This means that a 50-ha stand that previously had a species-string assignment, age, average height, and stocking in the T_1 inventory will likely now be comprised potentially of 1,250 20-m × 20-m cells, each with its own species composition and predictions of basal area, volume, various height measures, and diameter distribution, among other attributes. The highly accurate digital terrain model (DTM) planned in T_2 will provide each of these grid cells with slope, elevation, aspect and, potentially, well-predicted site quality variables such as depth-to-water table, soils, and ELC. Such an inventory could reduce the need for MIST and yield curves to assign volume to the inventory, as volume will be predicted directly to each cell. The T_2 inventory may also directly predict substrate and productivity. This presents an opportunity for G&Y to improve SFU classification and site productivity (particularly in the south). The challenge for G&Y will be to ensure a direct link to the variables that are being predicted in this new FRI. The challenge for planning will be to decide how much, if any, of the polygon-based planning to retain and how.

The second big change planned in the FRI is that it will become a "continuous forest inventory" (CFI) model. The FRI will no longer be refreshed every 10 years. The inventory will be updated with depletions and disturbances and the remaining areas "grown" forward in time. Growing the inventory will clearly be the responsibility of G&Y and this task will bring almost immediate demand for growth models across all forest types - something that has been identified as a large data gap and weakness in the current program. Growth and mortality projections will be needed for individual rasters or clusters of rasters with similar attributes. Ultimately, users will want an assessment of the accuracy and precision of the new inventory, as well as an assessment of the accuracy and precision of the growth projections.

Users are demanding more detailed information for mixedwood stands. If the leading species is not dominant, information on the height and age of the secondary and tertiary species is needed. There is a need to distinguish between balsam poplar and other aspens, and identifying minor species (e.g., hemlock) is important for wildlife habitat modelling. In addition, technical specifications for interpreting multi-storied stands are required, including specification of the primary layer, and need to be linked to G&Y. Projecting multi-storied stands will be a challenge at the polygon level and even more challenging at the plot (and raster) level.

Forest management planning – an opportunity and a challenge

The raster-based T_2 inventory, with accurate volumes and piece size information will help support better prescriptions in all jurisdictions and tendered sales in the southern region. The more detailed inventory will better support spatial planning, as well as tactical and operational planning. For example, industry is looking for volume predictions for areas of interest that are ± 5 – 10% at the stand or block level, as well as estimates of product potential. Experience with LiDAR-derived raster inventories in the boreal show promise for such precision, given proper calibration, and can facilitate planning needs for specific products, economic criteria and indicators, and carbon/biomass.

The move from aspatial to spatial planning has implications for G&Y. A raster-based inventory will likely demand fairly dramatic changes to the current planning process itself, whether spatial or aspatial. For example, it is unclear whether polygons will be created from the rasters, or what role polygons will play in

the future planning process. While a raster inventory may have clearer application in spatial planning, how the raster information will be rolled up to develop aspatial plans is unclear. In considering spatial planning, many workshop participants felt there to be too many interest groups involved in FMPs to automate spatial planning and they forecasted that much planning will continue to be done aspatially. In addition, spatial planning tends to break down somewhere beyond the 20-year horizon due to disturbance effects such as fire that are not currently predicted/modelled spatially. It is therefore likely that there will always be a mix of spatial and aspatial planning needed. Undoubtedly, the spatial planning that is done will demand more from the G&Y program in terms of data and tools to support better stand-level succession and localized yield projection.

Aboriginal involvement in forest management is increasing. This may have implications for the management of non-timber values and lead to additions to what is measured on PGPs/PSPs.

Currently, Independent Forest Audits (IFAs) and certification systems do not appear to pay much attention to G&Y or make recommendations concerning G&Y.

The "new" or regenerating forest – a challenge

More G&Y data and better models for new or regenerating forests are a current need. These are also *emerging* issues as an increasing proportion of tomorrow's wood supply depends on second-growth forest since much of the historic forest condition is gone (what is left is largely locked up in parks or reserves). Nearly a century of constantly evolving silvicultural methods and protection have resulted in forests that are more complex in both species-composition and structure than historic forests.

Participants at all four workshops identified specific G&Y needs (data or tool gaps) for the new/regenerating forest that will be our future wood supply:

- G&Y models are lacking for post-harvest stands and mixed species stands. Post-harvest stands include pure-species plantations (with and without density regulation), mixed-species plantations, low density plantations, stands arising from natural regeneration following a huge range of silvicultural interventions. Few older plantations exist and plantation silviculture is changing, making the modelling of current plantations challenging. G&Y models are lacking for mixedwood conditions. These may arise from harvesting conifer-dominated stands and leaving them for natural regeneration. Models are required that incorporate the effects of leaving residual trees on site including trees deliberately left for habitat and those left because they are not marketable. Mixed species stands and plantations are becoming an important part of the wood supply. There are implications for wildlife habitat (and the stand & site guides). How long do the retention trees remain alive? How long to they remain standing? How long do they contribute to wildlife use? What effects do these residuals ultimately have on G&Y (the growth and development of the future forest and wood supply)? The use of herbicides is declining coincident to increased use of less intensive silvicultural methods, adding to the creation of mixedwoods and complex stand structures.
- Post-renewal and natural succession models are required and need to be linked to current G&Y models. Draft natural succession models have been developed for the boreal and these are being used (Lennon 2016). These need to be supported with documentation, training and maintenance. Post-renewal succession models are lacking everywhere (boreal & south). Quantitative data are lacking to link post-renewal surveys to G&Y curves. Many different approaches to monitoring of post-renewal conditions with respect to G&Y expectations have been implemented or proposed (e.g. free-to-grow, silvicultural effectiveness monitoring, silvicultural enhancement initiative, survey of artificially regenerating sites, silviculture implementation direction, etc.), but inconsistent and non-standardized approaches to data collection and management limit the degree to which this information may be useful to G&Y model development and refinement. Many

participants warned that performance surveys are not a surrogate or substitute for G&Y data. Discussions are needed to ensure there are formal linkages. Short- and long-term strategies are required to address the data gaps.

- Taper equations are required for tree species that typically have heavy branching and lack a single main stem, e.g., deliquescent hardwoods.
- The southern region has some unique challenges. Many of the tools in the southern region rely heavily on data from Algonquin Park. There is a need to localize these products to other southern SFLs. There is a need to incorporate quality in tolerant hardwood models. There is a need to model alternative treatments such as irregular shelterwood and group selection.
- The increase in mechanized harvesting has implication for partial harvest systems, particularly in the southern region, including selection and shelterwood. Damage to regeneration (especially pole wood and small trees), site and residual trees may be different than previously documented in traditional cut and skid operations.

There are opportunities to learn from data sources other than PSPs. On the topic of linking early stand development to G&Y, participants felt that there are opportunities to retrospectively learn from existing data, including harvest data and inventory panels[4]. Harvest (scale) data are collected across the province and could be used to evaluate the FRI and G&Y products. There are challenges linking scale data back to harvest blocks and to FRI polygons, and there are issues with retention trees, but there are examples in other jurisdictions and in Ontario (Domtar, Kenora) where this has been done. FRI panels could be used in the short term to link pre-harvest SFU, planned SFU, and post-harvest SFU to quantify silvicultural effectiveness and provide early links to G&Y. Many SFLs have at least 3 digital inventories from different decades, along with digital silvicultural records, that could be used for such retrospective analyses. There will likely be issues with shifting polygons (the original photography could be used) and changing silviculture (historic silviculture is part of our wood supply).

Technology - an opportunity

Participants widely agreed that we will never be able to afford "enough plots" to address all of our current and future G&Y needs. There may be enough plots to address some needs (such as provincial state of the forest reporting). However, forests and forest management are evolving so there will always be a need for more data to support silvicultural decisions. We therefore need to explore how technology can supplement ground-based data collection to increase inference and efficiency. Participants suggested further investigation of:

- Drones could be used to acquire "downward-looking" attributes such as crown closure for PSP/PGPs. Drones might also be used to assess mortality in larger plots and provide more intensive monitoring in young stands.
- Ground-based or terrestrial LiDAR could be used to measure permanent or temporary sample plots and perhaps estimate attributes such as branch size/angle, stem taper and form, base to live crown, merchantable stem height, biomass, etc.
- Sequential airborne LiDAR or similar products could be used to assess and measure change (growth and mortality) at the plot- or grid-cell level. Change determined in this fashion may be modeled at the plot- or grid-cell level as a function of the original stand attributes, and then applied to the current forest attributes to project them forward. Quantifying and modelling change at high spatial resolutions could be a powerful G&Y tool.

[4] Panel: a sample in which the same elements are measured on two or more occasions.

Climate change – a challenge

MNRF needs to develop capacity to model productivity, mortality, and yield in a changing climate. Ontario's Climate Change Strategy commits the province to contributing to global greenhouse gas emission reductions by preparing for a changing climate and continuing research to help understand climate change and its effect on the environment (MNRF 2017).

It is anticipated that insects, disease and disturbance events such as fire and wind will have increased impact on the forest. The effects of invasive species, although not necessarily directly linked to climate change, are also expected to increase. These invasives (e.g., beech bark disease) can have a profound effect on stand development, yet there has been little work done to model these.

Some steps have been taken to examine and model the effects of climate change on growth. For example, FRMS has published work on incorporating climate terms into G&Y including SI models (e.g., Sharma et al. 2015, Sharma and Parton 2018a and 2018b, Boivin *et al.* 2005). There is the potential to link to the work of Dan McKenney (CFS) and his group on different climate change scenarios. There are potentially large and currently unpredictable impacts of climate change on mortality and succession.

Barriers

Participants were largely in agreement about the principal factors perceived as barriers to the G&Y program delivering on its mandate: weak MNRF commitment, a lack of adequate resourcing, dysfunctional governance, poor communication, and cumbersome procedures/bureaucracy. In addition, it can be a challenge to retain corporate knowledge including the assumptions and decisions made during the development of policies, procedures and tools – a situation likely to become worse as MNRF staff retire.

Weak MNRF commitment

Some participants agreed that the MNRF "*has been little more than missing in action in recent years*". Comments were largely aimed at G&Y but included calls for clearer commitment to the forest sector. Given G&Y's importance in defining, demonstrating, and defending sustainability, many comments may be interpreted as barriers to achieving a productive, healthy G&Y program. Good forest management should not only be viewed as an investment in the future but also as a current responsibility associated with harvesting now. Current decisions must be associated with a demonstration of sustainability. Industry continues to ask for security of wood supply and a commitment to recover silvicultural investment. The sustainability of Ontario's forests and Ontario's wood supply needs to be supported and demonstrated. For the G&Y program to be able to fulfil its mandate, the MNRF should acknowledge the critical role that G&Y plays in sustainable forest management and elevate its stature and support accordingly.

Lack of adequate resourcing

Resources are and always will be limited. Funding and human resource commitments are below what is needed to sustain the program envisioned in the masterplan – a program that can contribute to the adaptive management process in a timely manner. It has become difficult to find and retain qualified contractors and much time is spent on training and conducting quality assurance and control. Currently, it is difficult to find trained personnel at all levels. Under such limited resources, there is a growing lack of capacity to:

- develop new tools,
- maintain existing tools,
- collect the data necessary to support these tools, and
- maintain the data in a usable and available form (IM/IT support).

The impacts of decisions made using poor G&Y information and tools are generally not immediate and the person making the decisions may not have to deal with the fallout down the road. There is a need for a risk analysis, particularly in light of changes in forest management, climate and planning/policy. The current

monitoring program (NFI and Provincial Forest Inventory Growth Plots) is incapable of detecting significant change at the SFL level. For the G&Y program to be able to fulfil its mandate, a new funding model must be found.

Governance structure

Many participants identified that a lack of strong governance and inadequate resourcing are linked. G&Y clients, forest industry, policy division and ROD, expressed concern regarding a lack of governance of the G&Y program. A governance structure is needed that allows these clients to have more input and control over program and delivery. There was agreement on the need for an advisory or technical committee with representation from all stakeholder groups. The current lack of stakeholder engagement in the program is seen as a main reason for the poor service-provider – client relationship that exists. Ultimately, improved governance with stakeholder input and representation can only work with strong MNRF management providing the overarching leadership.

Poor communication

Perhaps stemming from a lack of governance, there is poor communication within the MNRF and people tend to work in silos. This causes issues in delivering existing programs and makes it even more difficult to plan for the future. There are many things happening within MNRF that ought to be linked and communicated to G&Y but little interaction has taken place to date For example:

1. Significant changes are coming to FRI and the second-phase (T_2) FRI has not been finalized. G&Y needs to links directly to this new FRI but the technical specifications are not yet available.
2. Post-harvest assessment protocols have not been finalized. These need to be linked to G&Y in the preparation of a management plan.
3. Policies and planning are evolving, as they should. What will be the replacement for SFMM and will it have different G&Y requirements?

The G&Y program needs to be fully engaged in these changes so that it can adjust and maintain flexibility to provide the tools needed by these programs in the future. Poor communication exists between the G&Y program and SFLs, regions, and other stakeholders, leading to low levels of cooperation. Communication barriers must be overcome before the G&Y program can properly fulfil its mandate.

Cumbersome procedures and bureaucracy

Some participants felt that the current G&Y plot measurement protocols, detailed in a 600$^+$-page manual, are more cumbersome than necessary. There is the perception that much of the data collected under this detailed protocol is not used. The cost of PSP installation and measurement according to this protocol is seen as a significant barrier to the G&Y program achieving its overall goals and to forest industry participation. Many participants felt that to overcome this barrier, plot measurement protocols should be flexible to target specific data priorities such as model building. Moreover, if data are being collected to support non-timber interests, these interests should be included in discussions of plot measurement protocols and the design of the plot network and contribute resources.

Measurement procedures aside, the MNRF's procurement process is seen as a huge deterrent to maintaining field and contractor staff, capacity and expertise, and a constraint to getting work done efficiently and effectively by the *right* people. The current process is said, for example, to prevent having SFL staff collect G&Y data, when they are often the right people, in the right place, at the right time to collect the data.

Discussion and Recommendations

The authors' discussion and recommendations stem from the workshop discussions and a review of background material including the G&Y masterplan. They also reflect the experiences of the authors in G&Y and FRI in Ontario and elsewhere, and incorporate review comments on an earlier draft of this report.

Through the course of these workshops, it was clear this project is not "breaking new ground". The 1993 masterplan (OMNR 1993) outlined many deliverables and aspirations that, either unattained or partially attained, still stand as legitimate goals and targets today. The 2010 internal review (OMNR 2010) identified many of the issues and concerns echoed by the attendees of the four 2018 workshops. It was Rich Greenwood, manager with the OMNR at the time of the drafting of the 1993 masterplan, who suggested looking at these earlier documents as a lens through which to determine *what worked, what didn't and what's left to do* on the path towards the sustainable management of our forests.

A look in the rear-view mirror

The 1993 G&Y masterplan was a huge step forward and identified excellent technical objectives for the short-, medium- and long-term. It also identified technical strategies, many of which are still relevant today. Initially, the program was close to being fully funded and many of the short-term objectives were met, including development of an initial stratification system, the design of a sampling strategy, drafting of plot measurement protocols, quality assessment and auditing procedures, the development of four regional masterplans, the screening of existing PSPs for inclusion, the initiation of a PSP network, and generation of first approximation G&Y models. Funding quickly declined and most of the medium- and long-term objectives have not been achieved. All of the 1993 planned deliverables that were not fully achieved were raised in the workshops and cited in the ***Results – summary of participant feedback*** section under ***Shortfalls in the current G&Y Program***.

The emerging issues identified in 1993 still have much relevance today and have yet to be fully addressed by the program:

- Estimation of potential yields from the new or regenerated forest.
- Accurate prediction of treatment response and future timber supply from all stands and forest types.
- Better understanding of stand dynamics, with a focus on young ages, stands past peak production, mortality, and ingrowth.
- Demands of new initiatives such as ecosystem management, conserving biodiversity, and protecting endangered spaces. New clients for G&Y include ecologists, wildlife biologists, economists, and the public. Foresters are being asked to predict stem volume, but also variables related to biological diversity, wildlife habitat, and other non-timber values.
- Quantify underlying processes which influence forest growth, development and productivity. This knowledge will be needed to predict forest responses to new treatments and to a changing environment.
- G&Y information must be available to support decision-making at all levels and scales of planning across many programs.

In 1999, Bob Carman (Provincial Forest Policy Committee) made the following observations about putting science into practice (Bell *et al.* 2000) - observations echoed by workshop participants:

- We still need a significant amount of research and improvement in our knowledge of growth and yield and related models but it's time to get on with our business and … implement what we already know.

- Technology transfer needs to be better funded in the province. In the past, new foresters had the opportunity to travel across the province and learn the business in the field, on the ground. This is no longer the case, therefore we need to communicate best practices in other ways.

Further, Sobze *et al.* (2006) looked at better prediction of Ontario's wood supply and came up with the 5 areas considered most in need of improvement (in order of importance), again, all echoed by workshop participants:

1. Improved linkages between forest resources inventory and growth and yield data (for example, development of a method to calibrate/validate one with another, and improved methods of assigning growth and yield curves to stands in forest resources inventory).
2. More realistic information to predict and validate successional changes at various stages of stand development.
3. Additional growth and yield curves for planted and naturally regenerated stands.
4. Forest resources inventory updated more frequently.
5. Better data on factors affecting site productivity (for example, soil moisture and nutrient regimes) and inclusion of these factors in growth and yield models.

Many of the issues identified above have been identified in previous reviews, often several times. The 2010 program review (OMNR 2010) identified deficiencies in achieving the medium- and long-term deliverables of the G&Y masterplan. For example:

- G&Y models are not available for all conditions, particularly managed and mixedwood conditions.
- Early assessments still are not linked to growth curves.
- Someone needs to be made responsible for delivering on these programs and reporting progress. Government must start addressing the deliverables or reporting why they are not addressing the deliverables.
- Many of the deliverables are core business – they have not changed and are still relevant.
- As a consequence of inaction and lack of results in the past, there may be skepticism regarding new initiatives and a lack of enthusiasm to embark on new commitments.

What happened?

There are a number of possible reasons for the lack of review and low level of resourcing for the G&Y program over the past decade. The program is expensive, complicated, and seemingly "never-ending". Because the effects of poor G&Y are seldom evident within the span of a single career, G&Y is not viewed as critical a component of forest management compared to competing shorter-term priorities funded from the same, limited resources. There have been discussions about *adaptive management*, but we are unaware of any quantitative or qualitative assessment of sustainability, either locally or regionally, or any example of assessment or monitoring of a forest management plan as to whether the results of the assumptions and models were achieved. Ultimately, the status of the MNRF G&Y program today reflects limited resources, a focus on meeting short term goals at the expense of longer-term goals, and an aging masterplan that has not been updated to reflect current funding.

What if nothing is done?

If the G&Y program were halted today, there would be little impact in the short term. Current tools, largely developed using data from natural-origin stands and historic silviculture, would be applied to an ever-shrinking portion of the land base. These tools would have to be jerry-rigged for application to the regenerating forest and decisions would be made with limited or no data, with unknown accuracy and

precision. In a short period of time, uncertainty would increase and wood-supply estimates would have to be downsized to compensate for this uncertainty. Poor, and likely costly, decisions would be made as a result of the lack of data. Mills would be forced to close. There would be huge opportunity costs as the province foregoes significant investment opportunity. The sustainability of management practices and plans would be open to challenge with no data or evidence to defend them. To remain in the forestry business, the province would eventually be forced to undertake a massive re-investment in the G&Y program – an investment that would arguably be much larger than if a stable level of funding had been maintained through the years. In addition, there would be a painful decade or more time-lag in realizing the benefits of any such reinvestment, until adequate time-series data are obtained.

To some managers, the fact that gross total volume in Ontario appears to be increasing[5] might be a tempting ruse towards maintaining the status quo or terminating the G&Y program. But *is this volume economically accessible and suitable for the products that are in demand*? In fact, consistent access to affordable, quality wood in Ontario continues to be uncertain[6]. **There has never been a more critical need for leadership in the management of Ontario's forests**.

Moving forward, what should be done?

Workshop participants were passionate about forestry and about G&Y. Based on workshop input, review of background documents, discussions and reviews of a previous draft of this report, the following steps are suggested as critical for the revitalization of G&Y in Ontario. These are organized into the necessary or *prerequisite* steps that should be taken before any improvements to G&Y may be realized, the *short-term (0-5 years)* priorities, and *longer-term (6-20 years)* needs.

As one participant noted, G&Y is a long-term proposition and long-term commitments are required.

Prerequisites

Renewed commitment to G&Y as a key part of sustainable forest management in Ontario

First and foremost, the MNRF should act to acknowledge the importance of G&Y as a key part of its commitment to sustainable forestry in Ontario. Given the value of the forest sector to the people of Ontario (e.g., more than $13 billion in revenue and $2 billion in wages (cfs.nrcan.gc.ca)) and the MNRF's strong commitment to sustainable management of the forest resource, the MNRF should immediately restore stature, commitment and support for the G&Y program. A renewed commitment would best be voiced in an updated forest strategy and, consistent with requirements for sustainability, a renewed G&Y strategy and masterplan that take into consideration all of the criteria identified below. The G&Y strategy should contain clear performance indicators that measure success and progress.

Efficient and effective communication and collaboration is necessary no matter what organizational structure the MNRF adopts. Monitoring, including checks and assessments in the planning process, is a necessary part of adaptive management and sustainability. G&Y is linked to other programs within the MNRF and management should ensure accountability through clearly defined roles and responsibilities.

G&Y involves more than the Biodiversity and Monitoring Section of the MNRF. MIST is a G&Y Tool but Forest Policy Branch is responsible for maintaining MIST while Regional Operations Division are the primary users of MIST. Developing a Responsible, Accountable, Consulted and Informed (RACI) model can be useful in clarifying roles and responsibilities for projects or activities that involve more than one department or section. A sound inventory requires tools provided by G&Y, including site quality and volume models.

[5] https://www.ontario.ca/page/forest-growing-stock
[6] http://www.ofia.com/ofia-2018-pre-budget-submission.html

Currently, G&Y does not seem to be on the radar of certification and Independent Forest Audits (IFAs). G&Y information and tools are required for good forest management and that should be sufficient motivation. However, audits may be the *stick* needed to ensure adequate resourcing for G&Y. As noted by one of the workshop participants, only the SFLs are affected by certification or audit results. MNRF is unaffected.

IMF facilitating G&Y

The IMF goal is to foster more efficient program delivery, bringing all plot-based programs together to ensure that there is cross-communication, coordination, sharing of information, and efficiencies in data collection and use. However, there is danger in forcing too much of a *one-size-fits-all* mandate under this new program. There should be acknowledgement that plot networks designed and intended for *monitoring* are NOT the same as those designed and intended for *modelling*. Monitoring plots should be distributed in a manner that will sample conditions of interest with known probabilities. Modelling plots must be distributed to purposely sample the range in conditions of the feature being modelled. Monitoring plots may serve a role to validate and offer additional calibration to models, but modelling plots are seldom useful for monitoring. Nevertheless, there is opportunity for G&Y and FRI to benefit from IMF including standardized data formats, information management and a central database for plot-based programs.

Revitalization, governance and funding for G&Y

Forestry is an important source of revenue (Crown stumpage) and employment in Ontario. Forest growth rates in Ontario are much lower than those of Finland and New Brunswick - areas with similar climates and productivities. There are business opportunities for forest products as well as opportunities for non-timber benefits. There is value locked in Ontario's forests and G&Y is the key to understanding this. With IMF in the developing stages and FRI on the cusp of entering its second phase, the timing is opportune for G&Y revitalization.

A primary objective of the second cycle of forest resource inventory (called T_2) is that it will be "continuous". Full refresh inventories are expensive. Continuous inventories implicitly require G&Y data and models to *grow* them between potentially lengthy update cycles. Additionally, the G&Y program will need to adapt to the new T_2 FRI through the development of tools and products that are compatible with its new raster format. There are very likely synergies in linking plot networks of the two programs. This next phase of continuous forest inventory will demand that FRI and G&Y fully mesh and function as one in defining, demonstrating and defending sustainability.

In its last 10-year cycle, the FRI had third-party governance and dedicated funding through stumpage royalties under the FFTC. A combined FRI-G&Y program within this same or similar governance model would allow the G&Y components to take advantage of this coordination and funding support.

The next iteration of FRI, as proposed, is a huge opportunity for G&Y. Combining the FRI and G&Y as a single business unit would be an important step to guarantee full integration of the programs and renewed stable support for G&Y; something that seems compatible within the evolving IMF. In addition, the G&Y program should be linked to researchers within the MNRF.

Short-term (0-5 years)

In the short term, the G&Y program requires a workable strategy and goals that meet client needs. The strategy should include discussion of how the program will be funded.

Partnerships

Ultimately, the current Ontario government's "open for business" philosophy[7] will place increased demand on FRI and G&Y to demonstrate that any increases in pressure on the forest capital are sustainable. The provincial government appears ready to work with forest industry to revitalize the forest sector, which could

[7] https://www.ontario.ca/page/open-business

also open the door to renewed partnership models in the funding and execution of G&Y work under the FFTC.

The largest gains made by the G&Y program in the 2000's may be attributed to partnerships, as called for in the masterplan. For example, more than 2600 of the PGPs used by the program were forest-industry lead through the Forest Ecosystem Science Cooperative Inc. and the Forestry Research Partnership. Compromise will undoubtedly be needed to balance partner objectives and willingness to pay. For example, past forest-industry-lead plots were suitable for yield-curve development and quantification of growth, but they lack the larger, more expensive 0.64-ha tree mortality plot recommended for modelling forest dynamics, stand composition, and structure (forest succession). Nevertheless, partnerships were viewed by most workshop participants as being key to generating the momentum needed to complete all the work demanded of the G&Y program.

Key to a functional partnership is sound oversight with representation from all stakeholder groups. Many participants felt that G&Y would benefit from having a science advisory committee consisting of technical subject-matter experts that could guide FRI-G&Y-Policy linkages. Suggested models for oversight included the Forest Inventory Data Advisory Group (FIDAG) and the Provincial Forest Inventory Advisory Committee (PFIAC).

Review and communication

A lack of periodic review and communication with clients undoubtedly contributed to the G&Y program's decline during the past decade or more. Participants emphasized that the integrated FRI-G&Y program and the G&Y strategy / masterplan ought to be reviewed annually and measured against commitments that are updated every 5 years. Such review should include opportunity for communication amongst stakeholders. Many participants noted the current workshops were the first opportunity for a conversation about G&Y in 25 years. Periodic review should continually develop, assess and revise short- and long-term goals; longer-term goals should not automatically become the short-term goals 5 years from now.

There is an urgent need to improve communication within and across programs within the MNRF and with industry. This would be a priority mission of any oversight body, but also of MNRF management. The science/technical advisory committee, while guiding G&Y-FRI-IMF-policy linkages, would provide the foundation for communication between MNRF and industry. The establishment of a G&Y *working group*, with representatives from government and industry with a mandate to review and report on the status of G&Y in Ontario, would guarantee that this communication is constant and effective. This group would recognize that the forests in the southern region are different than the boreal, with different needs.

In the interest of communicating outside of the forest profession, G&Y should generate simple fact sheets for SFLs and their clients. These would cover the value of the G&Y program and its products (e.g., yield curves, growth curves, stand dynamics, products, carbon), as well as how G&Y is dealing with issues such as climate change, biodiversity and carbon accounting. The MNRF should have a broader initiative to develop fact sheets for the SFLs on how the MNRF (not just G&Y) is dealing with these same issues. These should include summaries of the research being undertaken.

Information Management

Under the Integrated Science Action Plan (ISAP, MNRF 2015), *open science* is identified as a priority for the ministry. The ISAP states that scientific data, information, and knowledge are to be made available through information management that provides accountability, accessibility, and reliability. While the G&Y program has demonstrated willingness to share data and tools, more needs to be done. Many data sets have not been digitized, databases and products have not been made available to users; and products have not been well supported, maintained, or transferred. Consistent with ISAP, information management should be hard-wired into future G&Y programming, budgeting, and delivery for timely, open-source data and products. The G&Y database and tools should be accessible and available.

Adapting to the "new" forest

G&Y needs to focus on second rotation forests and all silvicultural systems. Much of the G&Y data and many of the products are relevant to a natural or historic forest condition. The *second rotation forest*, resulting from a wide array of silviculture and disturbance, is different from the old and underrepresented by current G&Y sampling efforts. This includes forests arising from much of the silviculture in the south, such as uniform and irregular shelterwood, single-tree and group selection. Throughout Ontario, mixedwoods and uneven or multi-aged stand structures are now common in many forests, with limited data and models to predict how these will change over time. Increasingly, market-driven harvesting is leaving highly variable and unplanned residual structures that will undoubtedly affect the productivity and value of the future forest. Increasing pressure to reduce reliance on herbicides and use less expensive treatments will reduce silvicultural intensity and further promote mixed species compositions and structures.

The past approach of developing a set of static yield curves to represent a specified stratum satisfied strategic modelling for historic forest conditions. The second rotation forest has a wide range of stand-types, created across a site productivity gradient and influenced by climate change. Instead of static yield curves, a more *mechanistic*[8], individual-tree growth modelling approach may be more efficient and effective at projecting these unique structures through time, modelling treatment response, accommodating non-timber-type values, and understanding climate change scenarios. MIST works well for certain forest conditions and applications, but new models are required to answer questions about response to changes in climate and growth of complex forest conditions. A single model is not likely to meet all needs.

The choice of modelling framework should support the decisions that need to be made and the planning process now and as they evolve through time. Regardless of model choice, empirical data will be required for development, calibration and validation. It is likely these models will be used to project inventories in time so compatibility with the FRI is important. Future sampling should directly support the calibration of more mechanistic, tree-list models as a means of addressing the complex second rotation forest that is now tomorrow's wood supply. Ontario's planning models incorporate assumptions about future forests in determining today's wood supply.

Calibrating a tree-list model such as FVS or Open Stand Model (OSM) necessitates a heavy focus and priority on measurements through time, from early development stages onward. In the interim, stand dynamics and succession data may be obtained through the mining of historic FRI sequences and tracking natural and post-harvest succession. Regeneration assessment, silvicultural effectiveness, performance or enhancement, Survey Of Artificially REgenerated Sites (SOARES) - whatever of the name used - needs to be linked with G&Y. Compliance surveys generally involve extensive surveys that assess the achievement of silvicultural targets and are not designed to link to G&Y models. Early stage calibration data for tree-list models should be collected from permanent sample plots. These should be established during early regeneration stages, tracked to link results from PGPs and PSPs, and measure mortality and succession. Calibration of FVS or OSM would provide a tool to link regeneration establishment and subsequent yield development. The impact of today's silviculture on the forest capital must be projected in order to gauge sustainability.

G&Y data priorities

As part of the development of a G&Y Strategy and new masterplan, a data gap analysis is needed. This analysis will determine the plots that are still useful and available for remeasurement; the areas/strata that are under-represented; the data that are needed to upgrade tools and develop new tools; and useful data available from other jurisdictions.

[8] In a mechanistic model, hypothesized relationships between variables in the data set are specified in terms of biological processes that are thought to have given rise to the data. The parameters in mechanistic models have biological definitions and can be measured independently.

Following immediately on the heels of this gap analysis:

1) Data currently sitting in the queue for entry and analyses should be prioritized and incorporated immediately.
2) Review the existing plot network and stratification.
3) Prioritize the existing plots for remeasurement and remeasure the highest priority plots. Remeasurements offer the greatest immediate return on investment and such data are critical to the modelling of forest growth. Focus should be on returning existing plots to a 5- or 10-year measurement cycle, as needed.
4) The G&Y program should look at new technology for acquiring data. The G&Y program within the MNRF should contact other jurisdictions to learn how they are acquiring data and the tools they are developing and using.
5) New installations should be planned and established to support G&Y priorities. Particular attention should be given to the next phase (T_2) FRI and the need for G&Y to support raster-based, tree-list data and grow these data over time. Attention must also be given to the development of models to support the new or regenerating forest (FVS or OSM) and to linkages to the predictive substrate layer in the new FRI (ELC, productivity, site index).
6) The PSP/PGP measurement protocols should be reviewed.
7) The use of scale data should be investigated.

Tool priorities

The G&Y program needs to support estate-level modeling for wood and habitat supply. Confidence must be instilled in existing tools. In the short-term, tools should include a back-drop display of supporting data so users can judge model applicability to their particular circumstances. Expressions of error should be made available for all of the components in a wood supply analyses (e.g., FRI, G&Y, strata aggregation, etc.) to enable error budget analyses. This requires cooperation and coordination across programs.

In the short term, MIST should be fixed, documented and supported with training for those responsible for forest management planning as well as other users. Updates to MIST should be coordinated with the T_2 FRI. *CROPLANNER* (the density management diagram developed by the Canadian Forest Service with data support from the MNRF) should be made available.

While SFUs are relatively well-defined for the boreal forest, there is no consensus on their definition in the GLSL forest. The development of a standard forest stratification in the southern region should occur for further advancement of G&Y in the southern region.

Move the yardsticks on succession rules; build on prototype work (Lennon 2016) and expand it to the southern region and the second rotation forest in general.

Evaluate & Refine

Forests are constantly changing as is forest management. There is a need to continually evaluate the information and tools used in forest management planning. This evaluation piece is missing in Ontario. A new FRI is delivered and a new forest management plan proposed. There is no assessment of the FRI or of the G&Y assumptions in the management plan. This needs to change. Options for assessing the G&Y assumptions should be investigated including regional evaluations (*are there significant differences in assumptions within a region?*) and comparisons to harvest volumes.

Long-term (6-20 years)

All of the longer-term G&Y needs involve research. Specifically:

1. Determine how technology (e.g., terrestrial LiDAR, drones, airborne LiDAR, multi-sequence image sets, etc.) can be taken advantage of to fill data gaps and improve programs like G&Y. Without question, some of these technologies will greatly improve our knowledge base.
2. Integrate productivity measures into G&Y; explore the use of ELC and/or T_2 FRI predicted substrate in succession and G&Y.

The Assessment of Wood Attributes from Remote Sensing (AWARE) program, the Canadian Wood Fibre Centre, and FP Innovations are opportunities for collaboration and partnerships in such research. The MNRF should also explore opportunities in other jurisdictions to share data, tools and technology. While many of these technologies are currently being applied in various roles, we caution that none will fully replace the need to collect plot-based data (i.e., "*if you don't measure it, you can't model it!*"). Currently, resources should not be directed at pursuing these technologies at the expense of collecting the data needed for modelling Ontario's forests through proven methods. Given limited budgets, resources should be directed to data collection; management and modelling and G&Y-related research and development should largely be left in the hands of partners including CFS, FRMS, CNFER, and academia. G&Y should be a partner in setting research priorities and in contributing data.

Finally, there is an ongoing and increasingly important need to better understand the impacts of climate change on the forest capital. Specific to G&Y, there is a need for better forecasting of impacts on growth and productivity.

About the authors

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Appendix 1: Background documentation provided to participants

A1.1: Growth and Yield (G&Y)

History

Workshops, facilitated by ESSA, were held in the early 1990s, resulting in "A master plan to examine forest growth and dynamics in Ontario". The key deliverables of the program were to be:

- An ecologically-based stratification for sampling.
- A provincial network of PSPs.
- Validated G&Y productivity models suitable for use as planning tools for forest regions and individual forest stands.
- G&Y models that predict short-term response to treatments and disturbances and long-term stand development and successional trends.
- Tools and methods for quantifying relationships between site and forest growth and productivity.

The Master Plan was to have a formal review every 5 years and include academia, industry and other government organizations and interested parties. Subsequently, regional growth and yield masterplans were developed. Two main partnerships were initiated:

The Forest Ecosystem Science Co-op (FESC) – The FESC (MNRF, industry, CFS, academia) began in the late 1990s. The FESC pooled resources and collected data to one standard and had a single data custodian and manager. A network of plots was established to cover a matrix of conditions (forest units, development state, management, etc.), not necessarily by MU or ownership. The goal was to support sustainable forest management in Ontario and reduce uncertainties associated with forest management decisions. The FESC did not extend to the southern region and ended in 2013.

The Forestry Research Partnership (FRP) - The FRP (Tembec, CFS and MNRF) also began in the late 1990s with the goal of increasing the allowable harvest level by 10% over 10 years. One of the FRPs flagship projects was to produce statistically defensible yield curves for the analysis of wood supply using the standard forest units and the available growth and yield plot data. This led to the development of Modelling and Inventory Support Tool (MIST). The FRP ended in 2012.

Current State

Plots

PSP/PGP program – Permanent Sample Plots (PSPs) are a cluster of three 0.04-ha fixed area plots embedded in a 0.64-ha fixed area mortality plot. Permanent Growth Plots (PGPs) are a single fixed area plot, generally 0.04-ha in size.

Under the FESC and FRP, a network of PGPs was established and re-measured. With current resources, the MNRF is unable to maintain the PSP/PGP measurement schedule; is unable to add plots; and is unable to initiate new projects with partners. Approximately 2,600 plots were established (Table 1). Most of these have two measurements and some have three and four measurements. Nearly all of these plots still exist and could be re-measured in the future, given adequate resources (Figure 1).

Table 1. Ontario Permanent Growth Plots (PGPs) established and remeasured by the Forest Ecosystem Science Co-op (FESC) and the MNRF between 1999 and 2015 and Permanent Sample Plots (PSPs) established and remeasured by the OMNFR from 1980. The PGPs are primarily located in the boreal region.

	FESC	PGPS	MNRF	PGPS	BOREAL	PSPS	SOUTH CENTRAL	PSPS	SOUTH	PSPS
YEAR	Estab	Remeas	Estab	Remeas	Estab	Remeas	Estab	Remeas	Estab	Remeas
1980			75	-	-	-				
1981			63	-	-	-				
1982			73	-	-	-				
1983			45	-	-	-				
1984			-	-	-	-				
1985			-	-	-	-				
1986			-	-	-	-				
1987			-	-	-	-				
1988			31	236	-	-				
1989			38	-	-	-				
1990			-	-	-	-				
1991			-	-	-	-				
1992			1	-	54	-	11	-	16	-
1993			-	-	160	-	78	-	71	-
1994			15	34	202	-	85	-	97	-
1995			-	-	113	-	61	-	69	-
1996			-	2	12	-	10	-	2	-
1997			-	24	2	23	-	16	1	11
1998			-	54	1	34	-	35	-	57
1999	80	–	-	57	28	28	9	33	-	29
2000	252	–	19	100	4	14	4	40	-	31
2001	458	–	50	69	15	24	-	20	-	26
2002	498	8	67	25	13	12	-	-	-	1
2003	445	–	26	2	-	28	-	13	-	-
2004	289	80	28	68	7	139	-	29	-	3
2005	188	245	45	20	12	81	4	6	-	16
2006	119	498	-	12	5	16	-	7	-	4
2007	239	436	11	11	4	22	1	-	-	7
2008	22	432	-	55	3	24	-	9	-	24
2009	1	343	3	54	1	6	-	7	-	19
2010	1	244	32	54	18	11	-	6	-	18
2011	0	210	19	6	12	39	1	7	-	8
2012	11	304	5	6	1	12	-	1	-	12
2013	–	361	3	-	1	22	1	10	-	14
2014	1	299	-	-	-	22	-	11	-	10
2015	–	133	6	16	2	22	1	13	-	7
2016			-	34	4	37	1	12	-	15
TOTAL	2,604	3,593	655	939	674	616	267	275	256	312

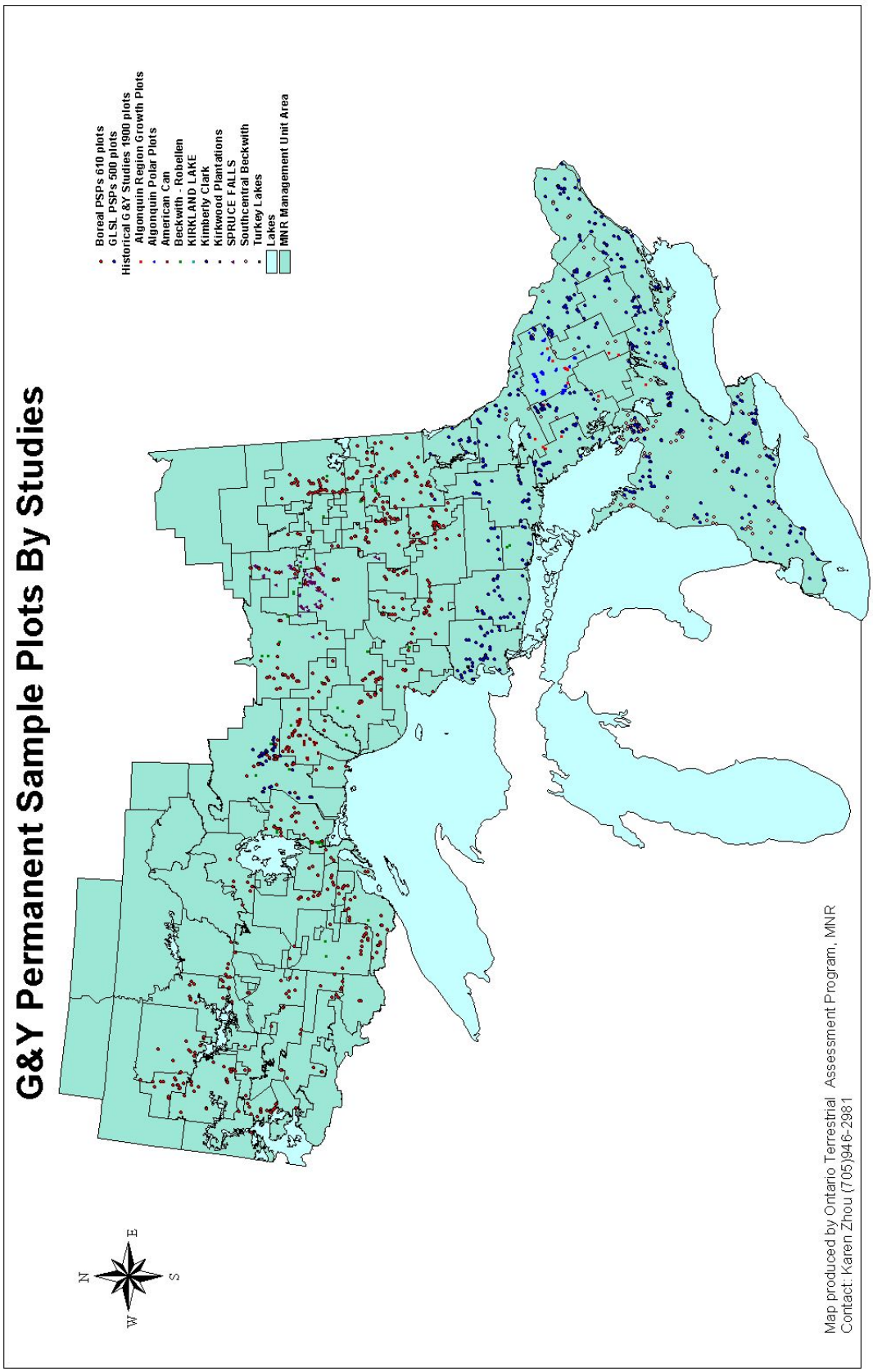

Figure 1. The locations of the permanent sample plots and growth plots are given.

The National Forest Inventory (NFI) network is fully established in Ontario. All plots have been measured twice and the 3rd measurement is starting in 2018 (10-year cycle). The NFI monitoring program is established on a systematic, 20- x 20-km grid. There are approximately 200 forested plots in Ontario (based on a 100% grid sample in southern ON and a 10% sample in the boreal). The NFI protocol is the same as that for the PGP, but with additional soil & carbon measurements. The CFS co-pays for the measurement of the NFI plots. NFI plots are not protected.

Provincial Forest Inventory Growth Plots (PFIGs) – More recently, approximately 1,000 additional PGPs were established on the NFI grid and will be sampled on the same 10-year cycle. These are G&Y plots that are complementary to the NFI network. As with NFI plots, these are not protected. These plots are part of the FRI and funded by FFT.

Table 2 gives the number of plots established in the boreal region, by source, and the number of remeasurements.

Table 2. The approximate number of boreal plots and remeasurements to 2017. The number of MNRF PSPs and PGPs established and remeasured are taken from Table 1.

Source	Established	Remeasured to 2017
MNRF PSPs	674	616
MNRF PGPs	655	943
NFI	209	186
PFIGP	987	23
Other (AmCan, KC)	320	1,261
Total	2,845	3,029

The Ontario State of Forest report comes out every 5-years. The primary source of information on growth rates and coarse woody debris is from the NFI & PFIG indicators of forest productivity and structure.

The G&Y program maintains operational trials and experiments such as logging damage and spacing trials. It does not establish research trials or experiments, except in partnership with the research community.

The current program consists of a provincial coordinator and three forest productivity specialists. These work with a management team and a technical team to deliver the program. A good information management team is now in place. There is a backlog of trials & historic data that are not yet in the provincial database.

Tools

The current tools produced under the G&Y program include:

- MIST– A G&Y model for use in forest management planning. The role of transferring & training MIST to FMP teams no longer sits with G&Y. The development, maintenance and approval of MIST now sits with the Forest Modelling and Management Unit (FAMU) within Policy Branch. Training is the responsibility of the Integration Branch. Support of MIST has varied over the years and users have been given the model with little training and information. MIST has not been updated with respect to changes in other programs including the FRI, planning, etc. MIST is a strategic, long-term prediction tool. It is calibrated for approximately 80% of the forest types in the province but data gaps remain, particularly mixedwoods.

- Site Index (SI) curves – Now cover planted red and jack pine and white and black spruce. Climate terms have been added for jack pine and black spruce and planted white spruce and red pine. Growth intercepts have been developed for site index assessment in younger stands of some forest conditions.
- Taper models – are available for main species (except larch). The bulk of the taper data come from data collected in the 1970s.
- Product recovery (size class distributions).
- Stand Density Management Diagrams (SDMDs) are available for pure, even-aged stands of jack pine and red pine.
- Succession – Ken Lennon's work on species composition changes in the boreal.

Future

PGPs/PSPs – there is a serious need to reinvest in field measurement and data management. The field protocol should be reviewed with consideration given to predicting future conditions, particularly under a changing climate and with respect to product value.

LiDAR - The move to using LiDAR for inventory may require a new type of data for calibration. Calibration plots should be compatible with the G&Y plot network (although it is recognized that these plots will be situated for FRI calibration and not necessarily ideal for G&Y model calibration/validation). There is potential for individual tree prediction (potentially compatible with the single-tree growth model FVS).

Cull – The cull estimates currently being used are from the 1950's. New (managed) stand conditions are likely to affect cull occurrence. Cull will also be affected by new harvesting techniques, moving seed sources, new pests and diseases, and climate change, including drought.

Tools under development or needed:

- Density Management Diagrams - *CROPLANNER* has not been released from CFS – jack pine, black spruce and jack pine/black spruce mixtures.
- FVS – Has been partly calibrated for Ontario conditions. This model has good potential for projecting growth following shelterwood and selection. However, it requires a tree list (currently not available in the inventory). Growth models need re-measurement data. To improve the calibration of FVS in Ontario, more resources may need to go toward the re-measurement of PSPs (at the expense of PGPs) because of the larger mortality plot.
- Succession – improving succession models requires re-measured PSP/PGPs (temporal plot data).
- Need to link to early assessment to future development. We need to work towards consistent definitions of attributes such as site index and site occupancy.
- Monitor the effects of logging damage – vigour, product value, assessment.

FRI – There is a need for G&Y to provide tools for FRI update (i.e., "growing" the inventory up to the plan year). G&Y and FRI should review the attributes (e.g., site index, FEC, stocking/crown closure/BA) to ensure common definitions are used in FRI and G&Y.

Some emerging issues (to be expanded upon at the workshops) include:

- Industry has G&Y needs (e.g., tactical and operational estimates for responses to silviculture, certification, and product yield) that are beyond the more strategic needs of government.
- Carbon & Biomass - Measuring G&Y cores for specific gravity and other wood/fibre properties for better biomass quantification and estimates of product value.
- Climate change will undoubtedly affect mortality models. Factors such as increased drought incidence and duration, as well as disturbance scale and frequency, will change.
- Far north? The Northern Boreal Initiative is outside of the scope of the current program.
- Invasive species and their impacts on G&Y are likely to increase – e.g., beech bark disease, emerald ash borer, etc.
- G&Y models are needed for complex stands, including multi-cohort stands, mixes of species and age classes, multi-canopy layers, etc. Our managed forests are far more complex than natural forests.
- G&Y models are needed for enhanced silviculture including mixed species plantations.
- G&Y models are needed for selection and shelterwood silviculture.
- Afforestation – there are generally different objectives for management on private land.

A1.2: Forest Resources Inventory (FRI)

History

The initial ten-year cycle (T1) for the enhanced Forest Resources Inventory (FRI) ran from 2006 – 2016. There is one over-riding principle that was endorsed by the Provincial Forest Inventory Advisory Committee (PFIAC) members in 2006: all forest inventory production projects would be contracted out by 2016. With a two-year production process to create a forest inventory in mind, this has subsequently resulted in the 2016 projects not being completed until December 31, 2018.

Current State

The second ten-year production cycle (T2) for the FRI runs from 2017 – 2027. The FRI program has secured approval to acquire optical imagery for the entire project area and digital elevation data for the year-one objectives. The digital elevation data will be derived from single-photon LiDAR. Imagery and LiDAR are being flown closer to the inventory start date which, for the most part, has been scheduled 4 years prior to plan start. There is some risk in trying to capture large areas with such narrow time windows, however, stakeholders felt this was more important than front-loading all imagery capture at the beginning of the cycle. Inventories are to be updated through the identification of targeted areas (areas of known change, areas of planned operations, interpretation errors, etc.). The remainder of the inventory would also require an update to reflect the changes in height, age, density, etc. This will require updated models.

The current FRI program, through its vendors of record, delineated and described the ecological land classification attributes within the forest inventory. Both field sampling and photo interpretation training were provided to vendors of record and numerous other client groups in support of production. Moving into the next cycle, there has been some consideration and discussion on how to maintain and update that information, but no approved plan is in place at this point.

Currently, inventories are updated to the planning year by planning teams through incrementing age and, in some cases, growing height.

Future

The FRI program is currently seeking approval to acquire digital elevation data for the remainder of the EA Area of the Undertaking, excluding large provincial parks and national parks.

One of the key objectives of the enhanced FRI program announced in 2005 was to evolve from a periodic inventory ("wipe the slate clean model") to a continual forest inventory production model. That objective was again endorsed by PFIAC in 2016.

As the FRI program considers the potential for collecting LiDAR data and the direction of the Integrated Monitoring Framework (IMF), it will be critical to review and revise the program's field sampling strategy. Discussions to develop a field sampling strategy – a single monitoring design and network - that supports photo interpretation, LiDAR calibration, satellite imagery classification and inventory assessment objectives are ongoing. The plot design and stratification are described in more detail in the IMF section. Ideally, LiDAR and imagery calibration plots and inventory validation plots would be collected to the same standard, at the same time, and by the same contractor.

The FRI program does feel, if successful in securing approval to acquire LiDAR, the stage will be set for implementation and utilization of raster-based inventories in the future. This may avoid the need to discuss whether polygon boundaries are relatively static. This would require changes to current policy, technical specifications and procedures (including moving beyond SFMM to a spatial planning tool). LiDAR and fixed area plots are compatible with an area-based inventory (potentially augmented by some individual tree classification).

There is the potential to add new attributes and to derive some traditional attributes from non-traditional sources (e.g., LiDAR). The FRI program, with review support from the Forest Information and Data Advisory Group, is reviewing and considering all the potential LiDAR data will offer for standardizing and automating specific forest inventory attributes. Early thinking is that attributes like height, stocking, crown closure, vertical and horizontal structure etc., could all be described directly from the new single-photon LiDAR product.

There will be a need to "grow" more attributes in the inventory, including stocking and/or crown closure.

Questions

Outstanding questions that the FRI group has include:

- How to leverage existing fixed-area plots across programs, including wildlife, FRI, NFI, etc., given different sampling objectives and designs?
- How to move from a static polygon inventory to a dynamic, raster-based inventory?
- How to move from periodic (complete refresh) inventories to continuous inventories? Some areas will be re-inventories and some will be "grown". Which attributes will be updated and how? Height? Age? Site occupancy?

A1.3: Integrated Monitoring Framework (IMF)

The goal of the IMF broad scale terrestrial design team is to develop efficient, long-term, provincial-scale monitoring programs to serve as tools to better understand landscape systems and changes in support of planning, policy development, and public reporting.

Human and financial resources are limited. To ensure efficiency, the design team is seeking to maximize the use of remote sensing data available in the public domain, and significantly streamline field measurement protocols and plot networks.

At this time, it is believed that a single, vegetation plot network, with a standard measurement protocol could serve to calibrate LiDAR, support photo interpretation, improve forest growth and yield models, as well as serve a variety of monitoring needs into the future. Ideally, plot data would be collected to the same standard, at the same time, and by the same contractor.

The plot design will be guided by the structural and spectral variability associated with the LiDAR point cloud and digital imagery. The plot selection approach is based on a matrix that includes: species compositional groups, stand age classes, managed vs. unmanaged stand conditions and is blocked across ecodistricts to ensure good geographic representation. It will utilize and build on a selection of existing PGP, PSP, NFI and PFIG plots. Plots will be randomly selected from the pool of existing plots to populate the matrix. Any conditions not covered by existing plots would then be identified and new plots established to fill empty cells in the matrix.

The intention is that these plots will be permanent plots, re-measured on a 10-year cycle, corresponding with the FRI acquisition cycle. A FFT-funded pilot project is underway in the Romeo Malette Forest to support the design of a LiDAR calibration network. Results from this pilot will be used to inform the final design.

IMF is in the early stages of working with Forest Research and Monitoring Section (FRMS) and the Biodiversity and Monitoring Section (BAMS) to document a standard method to predict yield and predict growth using SPL data and an area-based approach.

In addition to the development of a multi-purpose vegetation plot network, the IMF broad scale terrestrial design team is also looking to improve the design of the multi-wildlife species monitoring program. Although the design team will explore the feasibility of an integrated plot selection and sampling approach, a purpose-specific measurement standard is expected. Plot data would likely be collected through a separate delivery model.

A1.4: Forest Policy

Current state

Forest management plans are generated on a 10-year planning cycle with a 5-year update. They contain a 5-year operating plan and 1-year annual plan. Most current plans use the SFMM and SFMMTool or MIST to develop a forest management plan and determine harvest levels. Currently, planning is aspatial using the linear programming optimization algorithm (SFMM). For spatial modelling, SFLs are using Patchworks or Woodstock with the same inputs that they've used for SFMM (separate yield curves and succession rules).

Challenges exist with incorporating shelterwood and selection into planning models. For shelterwood, the stages of management are modeled as separate intensities. Selection uses a basal area growth rate and a volume to basal area ratio (vbar).

The biggest recent change to the planning manual deals with the Silviculture Enhancement Initiative (SEI), based on the results of performance surveys. The manual states that "yield curves or growth projections will be developed consistent with results of performance surveys". The performance assessment is a field check on the FMP G&Y assumption. The performance survey will be based on silviculture stratum and the entire AOU will be covered. The protocols for surveys have not been finalized. There has been much discussion on the direction and internal drafts circulated. The protocols for the boreal are more advanced than for the south.

The silviculture guides are based on Bayesian Belief Networks (BBNs) that explicitly describe the cause and effect of silvicultural actions using expert opinion and validated/updated based on focused literature reviews. Over time, the guides will be refined using quantitative data from SEI (performance surveys), research results and monitoring programs. Results from the G&Y program can be used to refine and validate the BBNs.

The stand and site guide relies heavily on the inventory attributes species composition, height and stocking. Height and stocking have traditionally been projected in the inventory using Ontario Wildlife Habitat Assessment Model (OWHAM). Better information on water flow from a more detailed digital terrain model would improve habitat modelling.

Forest certification is the responsibility of the SFLs.

Future

The intent is to move toward spatial planning. It is anticipated that the G&Y requirements will be similar. SFMM will no longer be supported. Woodstock can handle a combined yield & succession curve, possibly incorporating Ken Lennon's succession work. However, it is likely that yield curves will continue to be separate from succession rules.

There is likely going to be a need for more precise piece-size or size-class distribution to better describe stand-level product potential. Current planning focuses on biological sustainability; focus may shift to include economic sustainability.

Biomass is now included in forest management planning. Provincially, carbon reporting will likely be at the strategic level and can be addressed by the CFS' Carbon Budget Model. If companies are interested in pursuing carbon credits, other models can be used. Carbon reporting has financial implications and is likely to require approved growth & yield models and accounting methods and/or empirical validation.

Appendix 2: Questionnaire

The following questionnaire was circulated to workshop participants prior to the workshop and also to people unable to attend a workshop.

Scoping an Enhanced Growth and Yield Program – questionnaire for Regional Workshops

The objective of the series of workshops to be held across Ontario this fall is *to identify the G&Y needs to support sustainable forest management in Ontario over the next 20 years and beyond.*

This survey is intended to solicit input from stakeholders prior to the workshops. Results will be used to help frame discussion at the workshops and referenced in proceedings that will be presented to MNRF for priority setting and program planning. **If you are unable to attend the workshops, filling out this brief survey will ensure that your thoughts and ideas are captured.**

Using your word processor, please enter your answers directly below each question. When you're finished, please save the document as a WORD (*.docx) file so that we can easily retrieve your answers for compilation.

1) Name and organization (optional):
2) Are you planning on attending one of the 4 workshops (Y/N)?
3) What region and sector do you represent?
4) How does your organization currently use G&Y products?
5) Do you view your G&Y needs as mostly strategic (long-term 10- to 20-year horizon); tactical (5-year horizon); operational (1- to 2-year horizon), or other (please state)?
6) Very simply stated, the mandate of the G&Y Program is to *monitor and model Ontario's forests*. What G&Y data/products do you (your organization) use to make **today's** decisions about sustainable forest management?
7) Strengths - what elements of the current program are working well and meeting your needs (i.e., should be maintained at the current level)?
8) Weaknesses/gaps - what elements of the current program are not working so well (and need change or modification)? Are there elements that should be included?
9) What emerging factors/issues do you see changing your G&Y needs in the future?
10) Can you identify specific G&Y data/product needs to meet these emerging factors/issues over the short and long-term?
11) What do you see as barriers to getting the G&Y products that you need?
12) Any additional comments, suggestions, or concerns are welcome:
13) Would you like us to contact you for further discussion? If so, please provide your name and email address or phone number.

Please send the completed questionnaire to Margaret Penner. If you have any questions or concerns please contact Margaret or Doug.

Margaret Penner	705-635-1314	mpenner@forestanalysis.ca
Doug Pitt	705-989-6034	douggpitt@gmail.com

Appendix 3: Workshop participants

Location	**2018 Date**	**MNRF**	**Industry**	**Other** (CFS, FFTC, consultants, academics)	**Total**
Timmins	Nov. 13-14	14	5	3	22
Sault Ste. Marie	Nov. 20-21	22	0	2	24
Thunder Bay	Nov. 26-27	27	9	15	51
Peterborough	Dec. 4-5	16	12	6	34
Questionnaire only		2			2
Total		81	26	26	133

Appendix 4: Workshop notes

The following are transcriptions of the flip-chart notes taken during each of the sessions. Input is coded by workshop: NE (Timmins); SM (Sault Ste. Marie); NW (Thunder Bay); PB (Peterborough); and W (written feedback). Some points were made in more than one workshop; some points belong in other sections; we have generally left each point under the section in which it was made unless this was not explicit. We have also attempted to group similar comments under each heading.

General Points

G&Y is Important

- G&Y tends to live in the shadow of the overall forestry agenda, which has undoubtedly contributed to its loss of resources and a 25-year lack of attention (NW). This may never change without determined commitment within MNRF at the senior level (NW).
- Bottom line to anything that we do is that *if it doesn't influence the decisions we make; change our direction; change the outcome; what is the point*? We should prioritize by "*what are the things that will lead to better decisions*?" (SM).
    - What are we trying to achieve and how? What practical effect is G&Y having on industrial investment? … going forward, we will have to resonate on this issue (SM). What can the estate produce to attract investment?
    - If G&Y stops today, *what catastrophes will happen*? What bad management decisions will be made? What wood flows will be affected? Will effects be muted because they are long term? Lack of the right data can close mills – we've seen examples of this! (SM).
    - We need to demonstrate why G&Y is a good investment of resources (SM).
    - What are the components contributing to the greatest uncertainty? Can we effectively address these? Prioritize and spend resources where it will have the greatest impact (SM).
- G&Y needs to support today's management; how we manage and plan will change with the next cycle of FRI – G&Y must evolve in sync (PB).
- The 5 "D"s of G&Y: Define; Defend; Demonstrate; Develop; and Data (John P.) (PB).
- Planning is really a function of inventory; growth projections are influenced by G&Y (PB). Therefore, the impacts of poor G&Y are longer term (PB). Shorter-term operational issues are really an inventory problem; G&Y is critical for strategic long-term planning (PB). *If you make a mistake in G&Y, it may take 30 years to notice* (PB).
- The results of a model should inform a decision; not <u>be</u> the decision (PB). We will always need professional opinion informing the outcome (PB).
- Everyone's livelihood depends on our being sustainable – G&Y is the data foundation for guiding us towards sustainability and ensuring that we've achieved it (PB).
- We don't know what products will be needed in the future (NW). The forest is growing well; do we really need to change anything? But how do we become credible in saying that "everything will be OK"? (NW).
- ON has lots of wood; but is it economically accessible; is it the right size and quality? (NW).
- We need well-defined objectives (e.g., affordable wood) (SM).
- The volume and complexity of data that must be dealt with at the start of a plan is overwhelming! (PB). We work in a complex forest that is often unpredictable (W).
- Yield curves, growth projections and succession rules are primary drivers in the forest estate modelling required under the Forest Management Planning Manual (W). All of these drivers depend on having robust data and analysis (W).
- G&Y program currently does not have an adequate sample of long-term remeasurements to generate growth curves (W).
- Before identifying specific G&Y needs, we first have to understand the current state of the growth and yield program. (W).

G&Y and non-timber values

- A broader discussion is needed on who pays for what data products; e.g., if inventory and G&Y is needed for wildlife purposes, then those interests should contribute appropriately to the acquisition costs (PB).
- Questions have become more nuanced than they were – it's not just about volume; it's product, caribou, habitat, etc. (NW).

GLSL forest is unique

- The GLSL forest is DIFFERENT, requiring different tools, different data, G&Y, inventory, monitoring, etc. (PB). There is concern that too much of a broad-brush approach has been taken provincially in the past (PB).
- The GLSL forest has basically been orphaned in G&Y (PB). There is a great opportunity to build something cooperatively that is not hampered by history (PB).

IMF

- IMF should link/integrate ELC – G&Y – FRI – RS – NHIC (Natural heritage information centre) to provide seamless provincial products (NE).
- Get too broad and you risk losing accountability (pay attention, IMF!) (NE).

Currently Working Well

- Focus for 'working well' are things that are contributing to the health and sustainability of our forests (SM). Things that provide checkpoints on sustainability (SM). *Are we looking for "good predictions" or good/useful outcomes*?
- Nothing is working well as there are no people and lack of apparent vision on where the program fits or where it is going (W).
- Boreal component is G&Y's strength (currently at expense of GLSL) (W).

Legacy Plot Network; existing data

- Existing "legacy" plot network is our best asset (PB) (W).
    - Recovery and remeasurement of existing plots are priority #1; the value in repeated observations is key (PB).
- GLSL forests have huge SEM data sets – this is said to be working well for GLSL now and represents an opportunity to support analyses and inventory updates now (Gord C.) (PB).
- We have a solid existing data /plot network that is high quality, spatial and digital (NE, NW, SM).
- PGP/PSP network is getting larger (NE).
- Existing plot network and data sets (PSPs, PGPs, NFI are anchors for predictive models) (NE).
- Spatial data w. high collection standards (well defined and documented) (NE).
- Commitment to information management (clean & user-friendly) (NE).

G&Y Tools

- **SFUs** are available and documented in the Northeast (NE).
- **G&Y tools** developed to date, e.g., tree marking, MIST (with its work-arounds), new empirical yield curves, V-Bar, HT-DBH curves (PB). *G&Y has produced many tools that many practitioners don't even realize they are using in day-to-day work* (PB).
    - Base models (benchmark yield curves, taper equations, site index, H:D curves, SDMDs, FVS), given room for improvement (NE) (W).
- The GLSL forest is very accessible and we can accept less precision in our tools because we have boots on the ground to compensate (PB).
- Proto-type **DMDs** seem to work well, **but the CFS should be encouraged to deliver a final product soon**!

    - *CROPLANNER* looks promising but the CFS should be pressed for finalization and delivery (SM).
- **SFMM** kind of works well for strategic planning in the GLSL (PB).
    - Aspatial modelling for strategic planning with area (volume) targets is working relatively well (NE). Aspatial, strategic planning for AHA (👍)(NE).
        - Non-spatial, strategic planning for mostly area-regulated cut – working (NE).
        - Estate models (using spatial now (Patchworks or Woodstock/Stanley), and links to habitat models (NE).
- **Yield curves** for the NW natural forest are generally working well (NW). Science behind empirical curves for natural forest is sound (NW).
    - The present (natural) and extensive curves are said to be solid and dependable (SM). The basic and intensive curves are not working as well (there are different interpretations between management units (definitions differ); fewer data to support managed stands (SM). Managed curves rely on user inputs, whereas natural and extensive inputs come from the inventory (this could change in T_2) (SM). This has policy implications for G&Y – outcomes rely on the yield curves (SM).
- **Succession** – Ken Lennon's rules are a great first cut (NW).
    - Standardized succession rules for even-aged stands (boreal) are working well (SM). These need to be fully transferred and built on further (SM).
    - Natural succession implementation in the boreal is working. The planning teams are working with the available information and making use of it. (NE) (W).
    - Succession work from Ken Lennon was used for the 2019 Wabigoon FMP this also simplified the forest input process (W).
- **MIST:** We did move the yardsticks with **MIST** (the target of effort was FMPs, but we should have included G&Y interests) (SM).
    - MIST (current link between G&Y and FRI) (NE).
    - MIST (once the bugs in the software were worked out, and after the NER meeting with Margaret Penner, May 22, 2018) although version control is weak (W).
    - The G&Y program input in to the Modelling and Inventory Support Tool (MIST) functions well for some forest units (W).

Communication/collaboration

- Communication, while poor in the past, has improved (i.e., PSPs are being identified prior to harvest so that they can be remeasured before and after) (PB).
    - Relationship between industry and government researchers has been good and this needs to be built upon (PB).
- G&Y Program collaboration (both internal (e.g., Mahadev, Morris, Bell) and external (CFS, Industry, CIF-SEEK) (NE).
- Linkages (e.g., ELC, NFI, CFS, Academia, FRI (room to improve) (NE).
- Willingness to share data (both internally and externally) (NE).
- Documentation of program history and evolution (Master Plans, published papers) (W).
    - One has to trust that periodic updates and tools for planning are improvements over prior products (W).
    - There are documents on the background of the models, though they are not systematically combined to give full picture (W).

Expertise

- Internal MNRF expertise (though recognize attrition) (NE).
- Fundamental knowledge base for mensuration is very strong: lessons learned in methodology and protocols is well documented in provincial manual (W).
- Core research community still exists, but is getting smaller all the time (W).
- Strong and competent regional analysts within MNRF to support planning efforts (W).

Currently Not Working Well

GLSL Forest

- Need a lot of information/tools! (PB, NW); GLSL (NE).
- Uneven-aged stands need much attention (NE).
- Is not organized to work cooperatively on G&Y and other issues – this needs to change (i.e., need a southern working group) (PB). Need to establish what the priorities are; common issues; key questions (PB).
- Can't, as yet, agree on common SFUs (PB). This is problematic for G&Y to move forward (PB). Custom SFUs are not efficient (PB). Need to find a *common currency* (PB). This represents an opportunity to build on this in T_2 moving forward (PB).
- **GLSL is not the Boreal!** Data, tools, procedures, models don't apply (PB).
- Disproportionate spending / support between boreal and GLSL: most diverse region of forest cover and silviculture has the lowest level of G&Y investment (W). GLSL has high demands to account for variety in silviculture and diversity of forest – investment needs to focus on where the data gaps are; not where the most area is harvested (W). Similarly, a random grid cannot feasibly provide adequate coverage of the range of GLSL conditions (W).
- GLSL - we need remeasurements and new plots (W).
- Limited data for GLSL SFUs and plantation forests (W).
- Much or most of the previous data supported first management entry stands in selection; now we are into second and sometimes third cuts with no representation in active measurements (W).
- Lack of information in southern region forests (W).
- Lack of information in shelterwood and selection systems (W).
- Lack of information on managed forests (W).
- Lack of early successional information in shelterwood systems – e.g., how much regeneration is enough to proceed to next stage of management (W).
- Better understanding of impact of logging damage to our growth rates (W).
- Need to reconcile MNRF role south of the AOU (W). Legacy of plot measurements and past investment in the south is huge – is it supported?
- This region is harder to model at the stand level. The pre-cut and post-cut surveys could provide information for the FRI (update the FRI?) (W).

Resourcing

- Staff retention is a problem (NE).
- Contractor retention – spending a lot of time on training and audits (spending almost 50% of the time on training and auditing) (NE).
- Field program delivery – lack of capacity (W).
- Low (constantly eroding since mid-1990s) support for G&Y (W).
- Poor data management due to many corporate factors – need to ramp up data support to make the data collected usable (W).
- Lack of program modellers (W).
- Lack of field staff to deliver program (W).
- Lack of remeasurements (W).
- Lack of contacts in the program that can provide assistance (W).
- Lack of improvements to models with new data (W).
- Lack of data entry of plots that were remeasured (W).
- NFI / PFIGP program – while supported by federal money it consumes a lot of G&Y resources and aside from plots in the far north contributes very little to G&Y needs: most plots cannot be used for modelling as they are transitional or include unconventional cover types (W). NFI is not a substitute for G&Y (W). Likewise, the PFIGP plots add little value as they by design proportionally represent only the most common cover types (not necessarily where the most important data gaps occur) and are also often transitional and cannot be used for modelling (W).
- Governments, industry and individual foresters have had a love-hate attitude toward G&Y PSPs for over 100 years in Canada and I don't see that changing in the foreseeable future (W). Millions of

dollars have been spent on them only to have them abandoned before yielding useful results (W). Sweden in particular, and the Nordic countries in general, appear to have maintained successful G&Y monitoring over the same period (W). Can we learn from their techniques?

Management/Policy; Validating, Demonstrating Sustainability

- How do we prove or demonstrate the sustainability of a plan? We currently use assumptions…(SM).
- Legislation is preceding methodologies and an ability to comply (PB). *To roll out ideas without forest manager involvement is a fundamental flaw*!
- Currently there are no consequences to making poor decisions as a result of having weak or no data (SM). We talk about "adaptive management" and using the "precautionary principle", but we don't walk the talk (SM). There is no quantitative or qualitative assessment of sustainability and feedback loop or consequences (SM).
- No feedback loop from harvest to inventory/G&Y predictions / planned volumes (NW). In the old days, the inventory was updated annually with 'logging turnout' (NW).
    - There needs to be true adaptive management (NW). Renewing the plan every 10 years is a form of adaptive management; but are we really being sustainable over the long term? Are we really being adaptive? G&Y should be the 'poster-child' for adaptive management (NW).
    - We need good predictive ability, but we also need good monitoring for adaptive management (NW). We will face increased variability in the future (NW).
    - The *learning* component of adaptive management is important (NW).
    - Few companies report depleted FUs (SM). We have a good planning process, but quality control on reporting (G&Y, depletion, silvicultural effectiveness, is lacking) (SM).
    - The "full cycle" on an FMP process has never happened in ON (SM). We tend to look at **what we're doing** and not **what we did or achieved** (SM). We're not asking: *are you doing what you said you'd do and did you achieve what you expected*?
    - If things aren't being done right, this should influence the next plan (SM). There should be consequences (SM). There is a need for capacity on the operational and policy side to use these data to adjust and make change (SM). Bottom line is *who is accountable for the health and sustainability of our forests*? We need to do a better job of closing the loop (SM).
    - There is no broad policy analysis going on and there is no forum to discuss the impact of policy. A number of years ago the auditor general identified that harvest levels are below the sustainable harvest level. As a result, the actual renewal activities are below the renewal targets in the FMP and forest management activities are not necessarily sustainable (W).
    - FMPs are required to include information on economic feasibility – volumes by species group and broad product groups. This is done at the FMP level with no regional or provincial analysis. Too much is going on only at the FMP level. There is no regional analysis happening – partly because no one seems to have responsibility for regional analysis and partly because there is no time (W).
    - In our definition of priorities, we need to identify the consequences of failing to implement (NE).
- The **service-client relationship** needs to be better defined (SM). There was much discussion about the back and forth about MNRF structure (silos vs. culverts) – there are pros and cons to each, but the bottom line is that either structure requires **good management** to force and promote collaboration and communication (SM). The opportunity exists for good communication/collaboration – we just need the right environment – people need to work together (SM). There was discussion about whether or not we need a Chief Forester or perhaps a Blue-Ribbon panel that would sit as an oversight committee, providing external review (SM).
    - There is a lack of responsibility and clearly defined roles. If there is an issue or question, it is not clear who to call (W).
- A clear scope of what the program does and does not do would be helpful (W). Quite often one hears "oh yeah, doesn't G&Y do that?"
- Need better definition of "clients" and allowance for clients to have input and understanding (NE).
- Do we need a science advisory team consisting of technical subject-matter experts that will guide FRI-G&Y-Policy linkages?

- Could the Forest Inventory Data Advisory Group (FIDAG) be expanded to include G&Y? Provincial FRI Committee?
- Forest Industry needs to be consulted more! (SM).
- Decision support tools are needed to inform policy and management scenarios) (NE).
- R&D – need to have some research from OFRI and beyond to address some questions (NE).

Program

- Lack of program vision/modelling objective (W).
- Lack of responsiveness to client needs in a timely way (W).
- Lack of focus on new and emerging issues (see next) (W).

Partnerships

- Are weak or non-existent in the southern region (PB). Around 2012, partnerships between MNRF and SFL in the southern region were pursued. People were trained, plots were measured but there is no evidence the data became part of the PSP/PGP master database and there are no people within MNRF responsible the data or who can respond to questions (W)
- Successes that we've had in the past with the COOP and FRP – we no longer have that infrastructure (PB).
- The benefits of communication within partnerships alone are huge – these are now missing (PB).
- We'd love to see a cooperative arrangement resurrected and continue (NW).
- We need to re-establish partnerships (NW). We need partnerships moving forward (NW).
- We rely on partnerships for everything – we need to build on this! (NW).
- Better coordination between all partners in plot data collection (GLSL, FRI, SFL's, research > may come with IMF) (NE).
- Loss of partnerships (W).
- Linkage to industry clients (at least to us) is limited or entirely lacking (W).
- A structured approach to cooperative effort is needed (W).

Communication

- We need simple communication tools aimed at the level of understanding of LCC, MNRF managers, staff, SFL Board of Directors, forest industry and the general public (PB).
- Reports on status of PSP/PGP programs are needed (👍 IMF) (NE).
    - What is the remeasurement cycle? (NE).
    - What new plots need to be established? (NE).
- The SFL's need a series of simple fact-sheets outlining how MNRF is dealing with climate change, biodiversity, and carbon (PB).
    - Look to organizations like the CIF to do a better job of communicating with the public and showcasing the good things that are being done (NW).
- We need fact sheets on G&Y program; how G&Y is dealing with climate change; the value of the program and its products (yield, FMP, products, value, growth curves, stand dynamics, responses to harvest and other disturbances, succession) (PB). Simple and high-level (PB).
- Need oversight to break-down silos or at least hard-wire them to communicate (NW). We must have more and better communication (NW).
    - We need good communication to break down or properly bridge the silos (NW).
    - We need to re-establish a G&Y working group; something like the G&Y Business Unit (NW). (NW). An industry-MNRF working group? (NW).
    - Having a direct link and communication between users and people measuring plots is important (NW).
- This is the first time that we've had a conversation about G&Y in 25 years (NW).
    - These workshops were cited as a good example of the kind of interactions that are needed going forward! (SM).
- Political change – need to be able to maintain a consistent message of the importance of growth and yield to forestry, and its economic and environmental benefits. May need to rebrand but not refocus or redirect the Growth and Yield Program (NE).
- Industry (operational focus) vs MNRF (strategic focus) = need agreement on user requirements and G&Y deliverables, such as required degree of confidence of delivered results (NE).

    - No formal process to communicate directly between industry and G&Y program (NE).
- Better MNRF communication is required relative to policy development, conflict resolution, and misalignment with means/methods of implementation (NE).
- Communication and response to ROD concerns, needs and priorities around the G&Y program is lacking (W). For example, ROD has submitted several documents outlining concerns, needs and priorities during Integrated Monitoring Framework sessions (W). To date, ROD has not received a response from the Biodiversity and Monitoring Section of the MNRF indicating how ROD's input has been or will be addressed (W).

Transfer

- Education/training on new inventories and tools is a must (PB). (e.g., variable definition, how to use/interpret, etc.) (PB). Everything should come with proper training and communication (PB).
- We need better transfer of things like V-Bar, other tools, documentation, and background (PB).
- Training is inadequate (W).
- Need to complete the package of G&Y supporting documents produced so far, in a sequential order (at present one has to browse through a number of separate pieces of documents produced over the last decades to get an understanding of the whole process) (W).
- Lack of documentation for selection basal area growth curves (W).

Information Management

- There needs to be open-source thinking and development (PB, NW).
- Access to data is currently a significant barrier (PB).
- There has been lots of data collected, but it is not currently available (PB).
    - The current backlog is a red-flag for future partnerships and commitment moving forward – partners want to see a built-in commitment to data entry, analyses and management before they commit resources in any partnership (PB).
    - Backlog of PSP/PGP data (require timely processing) (NE).
    - GLSL PGP/PSP data are not available – there is a backlog of data to be entered into the corporate dataset (NE).
- Data collected from PSPs and PGPs for GLSL are not processed (W).
- Bringing all existing data on line and in a usable format must be a priority (PB).
- Plot network and associated data are not available (hard to get) (NW). Not making it to practitioners in the field (NW). Limited availability makes it dangerous right now (easy to make the wrong query) (NW). Need to build SQLs for common queries (NW).
- We have lots of data but it's not very accessible (NW). Challenge is making it available and useful (NW).
- We don't know what plots we have (difficult to find this out) (NW). (There are 2 people assigned to this right now) (NW).
- Raw data are close to being available, but scripts need to be written to permit access (NW). We need to enable mining of existing data, to see where the gaps are (NW).
- Other potential datasets must be considered (e.g., CFS plots, Hearst LiDAR calibration plots) (NE).
- Documentation on the status of the network is lacking (NE).
    - What data do we have now and where is it? (PB).
    - Potentially IMF will address the documentation of PSP/PGP network status (NE).
- Databases and data support – much of the historic data is in disparate data sets, needs cleaning, and requires consolidation in useable forms (W). Lack of inclusion of south / central data and legacy plot networks in provincial database infrastructure has been a serious barrier and created a backlog (W). Investment in data management has not been a priority (W). Support for data management needs to be priority #1 (W).

Data

- Not enough plots; remeasurement isn't done; data aren't cleaned and entered; plots are too small (W).

- Re-measuring existing plots has to be a priority (PB). Re-measuring existing PGP/PSPs for shelterwood and selection in GLSL (more directly usable data than new plots, which have a longer-term payoff) (W). There is a needs window in the FMP planning cycle that makes GLSL G&Y data a particularly high priority (W).
- Need to prioritize remeasurement to protect current investment in PSPs and PGPs. Then need to prioritize efforts moving forward to fill in the gaps (NE).
- We don't have a good understanding of the understory and how to manage it (PB).
- Net-down (GTV > NMV) is a big gap for hardwoods (PB). Cull factors need updating (PB).
- Logging damage studies of the past are not based on the mechanized harvesting practices of today – implications need to be evaluated (PB).
- We're dealing with a highly variable forest – we can never have enough plots! (PB).
- G&Y needs to become more adaptive and versatile, especially with respect to the attributes measured (NW). There's concern that if you measure all the attributes needed to satisfy **all** questions, the protocol becomes unwieldy and unsustainable (NW).
- There are a variety of activities going on to monitor our forests – we need to link these (NW).
- We need better recognition of the long-term value of existing plot networks (NW).
- We should be mining data supporting yield predictions vs. harvest recovery + unutilized (the latter can be difficult to quantify) (SM). This could involve the Tenure and Measurement sections (SM).
- Core PSPs need to get back to a 10-year measurement cycle (now 25 years), means about 100 remeasurement/year (minimum) (NE). Too long a period between remeasurements adversely affects the information available with respect to trends (NE). Five to ten years remeasurement cycle was considered to be the most appropriate (NE).
- Need a G&Y PSP/PGP remeasurement strategy (NE).
- Remeasurement cycle (needs to flex with forest region, stand type, age, development stage, productivity, existing data gaps) (NE).
    - Remeasurement cycle is not being kept up (NE).
- Plot size (should be larger in GLSL) (NE).
- We focus on "plots" but don't miss alternate opportunities to get data/results (we need other tools in our toolbox) (NE). (Al T.).
- New establishments as necessary is not being kept up (NE).
- Plot networks – most (other than NFI and a portion of PSP/PGP) are derelict / abandoned, many to the point of being unrecoverable (W). Some may be recovered where there is good location information and last measurements were within 20 or 25 years (W). Remeasurement of existing plots is 'priceless' (W).
- Plot methodologies – provincially adopted protocols are prohibitively expensive; much of the 'required' data is not used (may prove useful at some point but far too much time and cost is tied up collecting data that has no immediate purpose) (W).
- Is vast discrepancy in accuracy between forests that can be due to an infinite number of factors or combination of (e.g. eight, age, stocking, species composition, slope, soil, etc.) (W).
- Lack of data from northern forests within AOU (Gordon Cosens, Ogoki, Whitefeather (W).
- Clear AOC prescriptions for southern region G&Y plots including their locations (W).
- Need to revisit tree height sampling: we have great Ht/DBH models for normal trees – probably only need to measure heights going forward on a smaller sample of normal trees and focus on measuring the abnormal ones (W). This will save a lot of time and money and correct what is probably an over- or under- estimation of heights on a lot of predicted hts (W).
- Take the MasterCard perspective: "New plots established to serve multiple purposes: $100,000 (W). New plots established to serve multiple purposes with LiDAR coverage: $1,000,000 (W). New plots established to serve multiple purposes and recovery and remeasurement of existing plots: Priceless" (W). The idea of randomly selecting some of the existing plots for future measurement should be discouraged (W). We should look for the existing plots that fill data gaps (there are a lot of gaps!) and be sure to make remeasurement of those a priority (W). Need to focus on the 'book-end' conditions too; the far ends of the productivity, density, age, geographic range… random grid sampling won't address these needs (W)."

New/Regenerating forest; Silviculture Link with G&Y

- Too few plots in second-growth stands (the new forest now) (W). Limited data for GLSL FUs and plantation forests (W). We have SFUs and intensities with little or no data (W).
- We need post-harvest data regardless of how it's managed!
- There are not good yields available for the regenerating forest (NW).
- *Where we feel good about a yield curve - that landbase is shrinking*! *Stop worrying about the present (natural) forest; it's all in reserves*! *We're on the 2nd rotation now* (NW).
- Lots of uncertainty around curves and approach used for the regenerating forest (NW).
    - The "new" forest ('managed' and unmanaged) (NE).
    - Regenerating stands today are not the same as those 30 years ago (NW). Typically, we have one "managed" curve for a SFU, sometimes 2 (NW). We do not really understand the results of different silviculture on the outcome (NW).
    - The quality of information on regenerating stands has been poor (NW).
- Do not have a generic yield model for historic plantations that can make use of measured height and BA (W).
- Regeneration standards, silvicultural ground rules, silviculture performance, and yield curves need to be linked (NW). Establishment surveys are a legal requirement; performance surveys are on hold (NW). Silviculture link to G&Y: The lack of an agreed-upon process; lack of a connection to G&Y is a concern (SM). SEM, then SEI, now SIDs (Silviculture Implementation Direction) were all supposed to address this (SM). We need to move beyond just finding the right name for the process/program (SM). There are no plots in the regenerating forest, therefore we have no data on regenerating stands (SM). Qualitative assignments have never been validated (SM). (T_2 Inventory may quantify these stands, but a conscious effort will be needed to link what is there to what was done to put it there) (SM).
    - The 0-20 age data are lacking; there's no link of early establishment to the yield curve (NW) (W) (NE).
- SEI (early assessments) and G&Y must be aligned (NE). Implement a data collection program to get this linkage established in the short term (NE).
- MNRF in their SEI seems to be transferring G&Y-type responsibilities to SFLs in performance surveys that will tell us very, very little about G&Y realities (W).
- Need to link regeneration to yield curves (pre- and post-harvest monitoring) (W).
- Use harvest volumes as a check on inventory and to adjust estimates of future stand volumes and succession (W).
- **Mixedwoods and all-aged stands**: We're modelling growth of mixedwoods based on leading species which can be as low as 30% (SM). In the south, we don't manage *strata*, we manage stands (SM). MB says strata-level yield curves are still needed > Mixedwoods and all-aged stands are a problem! (SM).
    - We're doing less intensive silviculture than we used to (NW). This is generating lots of mixedwoods (NW). It's the mixtures that are a problem (NW).
    - Need data for mixed species and ages (W).
- Need data and tools that accurately estimate species volumes from mixedwood stands at all levels, particularly operational (W). Need more research on mixedwoods (W).
- Expert-opinion is relied on heavily when it comes to yields in managed stands; we simply don't have the data (NW). We've gotten away with experience driving the "fudge-factor"; this experience is quickly retiring! We need accurate information to add to professional opinion (NW). (This is what the Auditor General's report was about) (NW).
- Silviculture verification/validation (whatever the name) needs to link with FRI and G&Y (SM). This will be an ongoing problem, since the way that we're managing our forests today is very different than 30 years ago; it will continue to change into the future with increasing pressure to use a "softer" touch and the potential loss of tools such as herbicides (SM).
- We've been doing silviculture in ON for a long time, but we're not mining the results of these efforts to learn from the past (stand dynamics, succession) (SM). Will technology help? - change stack with Landsat, LiDAR? Jorma pointed out that our FRI interpreters make calls on 10-30 year-old stands > this offers an easy opportunity to take these stands and compare them to the original broad forest unit and to the planned forest unit, given the silvicultural inputs – generate a site x silviculture

interaction matrix over time (SM). Doug R. says that these stands could be difficult to interpret the species comp in; we may need to simplify definitions to evaluate outcomes (SM). Such an exercise could be used to target plot network aimed at measuring "new" forest (SM). MK suggests that there are lots of research plots to mine as well (SM).

- SGR connection to yield curves – critical bits are (NE).
    - Volume at peak (NE).
    - Volume at first operable (NE).
- Site-specific variance in silvicultural outcomes to treatments needs attention from G&Y (PB). We need to be able to better predict these outcomes (PB).
- Pine regeneration development needs attention (W).

Planning

- Spatial, tactical or operational planning requires information on products ()(NE).
- Industry is looking for volume accuracy at the stand level of 5 – 10% (for conifer & for hardwood) (FRI T2) (NE).
- Industry needs HT and DBH distribution ± 10% - this is an inventory need (SM).
- None of Spatial/tactical/operational/economic planning are working (NE).
- Stronger linkages with FMP requirements to ensure adequate data and tools area available (W).
- Lack of connection between products used for short- and long-term planning (W).
- Spatial modelling. SFMM is being used for current plans but the move is toward spatial modelling. Going fully spatial in planning tends to break down somewhere beyond the 20-year horizon due to disturbance effects such as fire that cannot be spatially predicted/modeled. The current forest estate model contenders include Woodstock/Stanley, Patchworks and FSOS. It is not clear to what level the MNRF will support these models including developing G&Y inputs or components for these models (W).

TOOLS

MIST

- Right now, MIST is for power users; it's not very user-friendly (NW); generally felt to not be working well in GLSL (PB); MIST Documentation is not working (NE). Information on development and underlying models is not available (NE).
- MIST is not a practitioner tool (steep learning curve) (NW). Training is informal – not working (NE).
- Software is unstable (W).
- MIST ≠ GLSL (a new model is needed) (NE).
    - The lack of standard FUs forces custom solutions and is highly inefficient (PB).
- Amalgamation of SFUs (NE).
    - would like a tool to combine Forest Units in MIST (NE).
    - Would like a tool to combine Forest Units in succession (NE).
- Stocking/BA inputs do not come from the inventory! (PB).
    - There is a need to drive MIST off of canopy closure instead of stocking (NW).
- We need a working growth model (PB).
- Undersize and defect equations are needed in MIST (PB). Net-downs, waste, breakage, are all from the boreal and have no GLSL equivalent (PB). We can't adjust for wind throw (PB).
- Product classes should be a reporting element (PB).
- Need to be able to produce summaries more easily (NW). There's the feeling that MIST won't be needed in T_2 because volume surfaces will be in place (NW). *If we get a volume product that we can trust, we won't need MIST* (NW).
- Area-weighted average stocking, site index, and species composition are the 3 inputs varied in MIST to generate the various outcomes (NW). PSP/PGP data, where available, are used to validate the estimates (NW).
- Need to establish confidence in MIST (NE).
    - Training – informal or non-existent (NE). (NE).

    - Lacking information on MIST development
    - Lacking information on data behind MIST. Would like a description of source data. (☝ IMF) (NE).
    - Lacking information on the goodness of predictions (CIs) (NE). Would like some quantitative measure of reliability (NE).
- Lack of understanding of "G&Y user requirements" (NE). What does ROD and forestry want in terms of accurately and precisely defined requirements to implement the Ontario forest management (NE).
- Planning teams are told they must use MIST (NE). Planning teams are not aware of alternatives (NE).
- **MIST** requires both updating of coefficients with broader temporal and spatial representation of plot data; particular forest units are less robust due to data limitations (mixedwoods, tolerant hardwoods, hemlock, cedar, lowland mixes); software application (2.0 in development – yet to be released) requires upgrading and improvements along with training and support (W).
- MIST and G&Y data are not suited to mixed stand conditions (W).
- Tools are not being supported adequately to support forest management planning (e.g. MIST) (W).

Site Index

- Doesn't work in the GLSL because we don't have age (PB). We don't have an alternative productivity measure (PB).
- We need better site quality evaluation (this may come with the T_2 inventory) (PB).
- None of our current G&Y models are informed by ecosite (PB). Ecosite is felt to be more accurate in T_1 FRI than species composition (PB). Could/should incorporate Hill's work from the 70's (PB). ELC is "good"; site class is not (PB). (Ecosite is correlated with species composition, but not so well with productivity) (PB).
- We need better productivity measures for tolerant hardwood (perhaps linking eutrophic grid with ecosite) (PB).
- **Site index** – some species poorly represented with local models / data but perhaps published models from other jurisdictions are sufficient (W).
- Need site productivity products that are driven by ecology/ecosites (W).

Taper /volume models

- Many tolerant hardwoods may be poorly represented (W).

Yield Curves

- Models – products are generally dated and limited in scope (W).
- Current stocking is assumed to stay the same through time (W). We assume all plantations track the same (W).
- Are felt to be too aggressive moving forward (PB). The fact that we're not cutting our current allocation is saving us in the short-term (PB). (Reasons we're not cutting allocation include economics, markets, lack of contractors) (PB).
- Need to capture quality and cull (PB). As the proportion of AGS increases, this should be reflected in yield (PB).
    - Cull factors (NE).
- Working on the extremes of the yield curves is weak: far-end for caribou and carbon; young-end has lots of uncertainty (NW).
- Species compositional changes are problematic (NW).
- Product potential on a shorter timeline is becoming critical (NW).
- available yield curves work well for the natural forest, but this is largely gone now; we're largely working on 2nd rotation forest now (NW).
- There is a need for greater confidence in the yield curves being used – this simply means that the users would like to see the data points in the background (how many plots are there; where are the

gaps; where are they from, etc.) (NW). This does not mean CI's in the statistical sense (NW). This would help focus sampling efforts moving forward (NW). Users want to be able to "see the plots during planning" (NW).

- Want scatter plots available for benchmark yield curves, along with data summary statistics (sample size, range of site conditions, age ranges, indication of the proportion of stands that are stand replacing disturbance origin or succession origin, and natural disturbance history) (W).
- Lack of documentation of the science behind the yield curves (W). (As part of the forest management planning process, ROD staff uses a MIST exercise to determine, negotiate, and approve localized yield curves for each Forest Management Plan (W). Staff rely on adequate knowledge of the type (site and stand conditions) and strength of data on which regional benchmark yield curves are based in order to gauge if SFL-requested adjustments to yield curves are appropriate (W).) Prior to reliance on a model with abundant information, professional opinion was used (W). Professional opinion was open to scrutiny (W). Role of experiential knowledge is not well described in ON's planning framework (W).
- Uncertainty on yield also leads to erroneous assignments of operable age and therefore harvest levels (W). (as lower operable ages are predicted, harvest levels increase) (W).
- Lack of transparency/documentation on how the model functions (W).
- Staff require informative data descriptions for each benchmark yield curve (W). Documentation of methods in any scientific tool must be sufficient that the sampling could be repeated with roughly the same conditions especially when plots are not located randomly or systematically (W).
- Unable to assess risk associated with existing curves (W). (What's behind a given curve?) (W). Uncertainty in yield curves leaves ROD open to EA requests, particularly in the southern region where yield information is poor (W). Uncertainty causes undesirable interaction with industry, forcing approvals that are not supported by data and science (lots of dependence on negotiation and gut-feel) (W). Without sufficient G&Y data, MNRF runs the risk of not being able to demonstrate sustainability (W). Meeting on Feb. 20, 2018 – ROD placed priority on developing CIs on benchmark yield curves for SB1, PJ1 and MW2 (NER); and ConMx(sb leading), present PjMx1 and SbMx1 for the NWR; present HDUS, present BY, and PWUS4 for SR (W).
- Expectations of our planning and modelling processes are high, but error and uncertainty are not often quantified (W).
- MNRF planning staff recommend to District Managers and the Regional Director on the accuracy and precision of the yield curves and succession rules used in forest estate modelling (W). Without confidence intervals around the G&Y tools, it is impossible to assess risk associated with critical forest estate modelling inputs (W). At minimum, an error budget associated with the different components used in yield curve and succession rule development is necessary (W).
- Inventories change, but the effect on AHA is minimal (NW).
- The strata average is not adequate for strategic or operational planning and will even fail at the strategic level if too broadly defined (NW).
- **Sensitivity analyses** are needed to know how errors propagate through the planning process (SM). Until now, we were willing to accept the risk that Plonski's estimates of changes in height and BA were accurate for inventory – a risk that was never quantified (SM). We need to know the error budget that includes inventory and G&Y (SM).
    - Like to see error budget around allowable cut (NE).
- Need sensitivity analysis on final outputs (test case on RMF or Hearst) (NE).
- **Current modelling of carbon stocks** depends on the yield curves (SM). Right now, the yield curves show a decline (sometimes sharp) after peak yield (SM). Because of a dearth of older plots, this decline is more or less an estimate – but NGOs like to think that there is no decline (SM). What really happens in these older stands? This is particularly difficult in stands with long fire cycles, where it is difficult to assign age since disturbance (SM). We don't really model *stand development*; we model *current stand condition* (SM). This is a binning-classification problem, since we have little data on succession (SM). JP: we run our process with NMV – when we get into older stands, stocking profile and cull kick in (SM). To properly model mortality, we need large plots (SM).
- Conifer mixedwoods are very challenging (NW).
- Encourage *chronosequence method* as a check of current yield curve assumptions (W).
- No yield curves for cedar and larch (W).

- Have used stand origin (disturbance type and date) rather than BH age and found it superior in another jurisdiction (W). Projections were made using both date of stand origin and BH age and origin date was superior relative to harvest turnout (W).
- Require strong growth models to help investigate the implications of silvicultural strategies (W).
- Require yield models for existing stands that link well with the FRI, for reliable short-term estimates of yields (W).
- Require yield models that link well with data derived from LiDAR – I see LiDAR-derived individual tree inventories growing quickly in Ontario (they are strong elsewhere already) (W)."
- Need to update yield models used in planning ASAP (W).

Cull

- Largely based on Morawski, need newer data that is more reflective of modern careful logging practices and 'reversed high-grading' in hardwoods (W).
- Now that we are starting to harvest more in second growth stands, we need better cull factors to estimate NMV (W). Cull factors from the 50's no longer cut it (W).
- Need additional net down factors (waste and breakage, non-productive areas in stand) (W).
- Much of the G&Y for GLSL is based on older work when cut and skid were the most common harvest method, now it is mechanized harvesting with bigger trails, bigger footprint with hotsaws (etc.) (W).

DMDs

- Final versions need to be delivered ASAP (PB).
- DMDs for hardwood represent a gap (PB).
- **SDMD / CROPLANNER** – need to incorporate additional species and provide a software application to forest managers (W). (great tool but needs broader application and circulation, as with FVS) (W).
- SDMDs are available for Pj, Pr, and Sb without measures of uncertainty (W). CropPlanner has not been released yet (W).

Succession

- No succession models existent in GLSL!; Natural succession in GLSL (NE).
    - Currently using the Landscape Guide (PB).
- Succession in the managed forest is a data gap (species shifts and growth; pathways of development) (PB).
    - Post-renewal succession (boreal or GLSL) is needed! (NE).
- Needs greater refinement (NW).
    - Current rules are viewed as a prototype (NW).
- Weak when applied to spatial models (NW).
- OK for wildlife planning, but not for product and quality (NW).
- We need better data on mortality; this requires bigger plots; these could be assessed using drones and thermal imagery (Alex Bilyk), with targeted verification on the ground (NW).
    - *Do mortality plots really need to be 6400 m²?*
    - We need to better understand mortality and its effects on harvest timing (NW).
- Insufficient plot data resulting in incomplete coverage by SFU or ecological region (e.g., no succession information compatible with planning models in the GLSL) (W).
- **Succession** – probably the most challenging product to develop and most difficult to support with data; need a plan to move forward (W).
- Need gap analysis for succession rules (W). With spatial planning, need more precise succession that uses moisture regime rather than just SFU (W). Need science-derived succession rules for GLSL, similar to Lennon et al. 2016 for boreal (W). Bayesian-Belief Networks combine expert opinion with data-derived results (W).
- Need plots in disturbed areas (fire/insect) to follow succession after disturbance (W).

FVS

- Some are finding it useful in GLSL, but gaps exist in calibrating some species and size classes (PB).
- Better mortality and succession data are needed to calibrate FVS (PB).
- FVS is a gaming tool that would enable exploration of outcomes of different management scenarios (PB). It can be run with cruise data and will predict species composition shifts (PB).
- There is potential in FVS, but it is largely unknown (PB).
- FVS could provide yield curves to MIST (and not replace MIST) (NE).
- **FVS** – 'open fvs' platform exists but has not been utilized; need to move forward with development; must have a true G&Y model to support strategic silviculture planning, quantifying responses to treatments; huge utility in risk analysis, invasive species impacts, demonstrations to FMP teams and LCC, development of public confidence in sustainable forestry, validating other models and planning assumptions / decisions… limitless untapped potential here (W).
- Possible use of FVS Ontario for selection system to better reflect BA growth, AGS improvement, and size class distribution (W).

FRI itself

- Current FRI and tolerant hardwood management are not a good mix (PB).
- Current inventory doesn't capture (build on?) historical silviculture treatments/investment (NE).
- FRI – production and quality control issues resulting in mediocre forest classifications which affects future projections and yield predictions (W).
- Need more confidence in interpreting CC and BA in FRI > errors have huge impact on yield (W).

Linkage with FRI

- We're still populating a stocking estimate based on Plonski's, with site index, but the inventory is not based on these (NW).
- Should be a hard linkage between FRI and G&Y (NW).
- T_2 inventory will still need plot data and these should also support G&Y and vice versa; we need to work together, as there aren't enough resources to go around and do our own thing (NW). We need to find ways of capitalizing on strengths (NW).
- There needs to be integration of the different things going into an inventory (NW).
- HT-AGE available in T_2 will be crucial to put good Site Index curves in place (NW).
- From a planning perspective, there must be a standard volume product (NW). This references the notion that FRI may only provide a suite of base products (LAS files, CHM, DTM), with user's calibrating their own inventories (NW).
- We need good documentation for T_2 products; we need to demonstrate the data behind the tools to generate a comfort level (NW).
- *Stocking* has too many interpretations – we need to move to crown closure, which can be measured by inventory (NW).
- FRI not connected to MIST (two cohort stands) (there is a disconnect between the FRI, SFUs and MIST (results)) (NE). FRI attributes not linked with models. The FRI now has 2-layer stands and MIST can't handle these. Two-tier stands and one stocking attribute, etc. (NE).
- Lack of connection between FRI attributes and the model inputs – i.e., stocking (W).
- Lack of connection with other products such as FRI (W).
- FRI attributes and their tie to yield is definitely lacking - stocking is definitely a weak (W).
- Stand attributes such as height or site class could be used to more accurately estimate stand yield (W).
- The FRI program must be integrated with the G&Y program to ensure products are compatible (W). Forest industries deplete areas but harvest volumes (W). We need to ensure the FRI and G&Y can provide accurate and predictable volumes, not areas to deplete (W).
- Stronger linkages with FRI in development of a continuous inventory approach (W).
- The newly created disconnect between vertical structure in the FRI and G&Y, succession, and planning is a massive problem! This needs to be rectified in the FRI (W).

Funding Model

- G&Y has been under-resourced at the program and science levels (SM).
- Moving G&Y under FFT presents opportunities to broaden funding sources (funding through stumpage revenues) (SM). But there are other benefactors that could be contributing to the "trust" fund; right now, forest industry is the only contributor through stumpage (SM). We need "other" forest users to invest in the forest estate (SM). Forests are for the benefit of all, so perhaps the province and possibly federal government should be contributing on behalf of these *other* forest users (SM).
    - FRI has been successful because resourcing was moved outside the provincial government (SM). This gave temporal stability to FRI and encouraged partnerships with forest industry (SM).
- Because forest industry is a big contributor, they need to be adequately consulted (SM). There does need to be discussion about who should pay for what (specifically when it comes to the tactical/operational detail) (SM).
- How do we judge "public good" vs. "private interest"? Technology is creating this dilemma (SM). Both parties (and others) need to be at the funding table (SM).
    - Caution - In the final days of the Coop, folks sought a financial commitment from other users – this did not work (NW).
- There is current opportunity in a constrained environment, with the imminent forest sector strategy talks: If G&Y is identified as a need there, this will be a strong incentive (SM).

Emerging Issues

<some of these are current, but are left here>

Information (Data) Management

- How do we make all these data available for users to make better decisions? We need *value to data* (SM). IMF is moving in the right direction in terms of having a client-driven design with cross-collaboration amongst plot-based programs – IMF should be at the forefront of design (SM).
- Products take 20 years to build; during this time, things change and needs continue (SM). The more data we collect and make properly available, the more clients can continue to make informed decisions independent of the tools (SM). A good, accessible data base will foster users to develop their own tools (industry can be much faster than government!) (SM). We should be aiming to provide organized information that everyone can use (SM).
- We collect lots of data, but we don't always have the capacity to analyse them properly; we don't always have the people to build the tools (SM) This is illustrated in the short-term with GLSL data being collected, but not available due to a backlog for input (SM).
- IM/IT support is needed to bring all the disparate pieces together (SM). There are many orphaned data sets sitting in different places (SM). **There is a huge potential for loss of these data as people retire!**
- IM/IT must be resourced properly as part of planning – as part of core business! Not having IM/IT up front is a fail (SM).
- Good IM/IT support is key to transferring science to implementation (SM).
- We need to do a better job of using and integrating the data that we have! (e.g., NFI, ELC, etc.) (SM).
- We need to get rid of barriers to data accessibility (SM). Existing structure and rules are too complex (SM).
- IM focus has been on storage and not on dissemination (SM).
- Should this be a 3rd-party job??? (SM).
- **IM is a bigger issue than just G&Y! (SM).**
- Land Information Ontario (LIO) should include all plots. Should plots be publicly available? (NE).

Spatial Planning

- Currently there is a mix of aspatial and spatial planning going on (NW). Most are doing a mix (NW). Aspatial for strategic vs. spatial for tactical output to strategic – these are different (NW). Is currently not being done in the GLSL forest (PB).
- Several forest management plans in the NE Region are currently using spatial models which will likely become the normal in the next round of FMPs beginning in 2026 (for 2029 FMPs) (W). Yet growth & yield and succession inputs were largely developed for aspatial modelling (W).
- There are too many social pressures to go spatial on many forests; you have to do this manually (NW). Therefore, we can't do away with aspatial planning completely (NW).
- Concerned about moving to spatial planning tools with the current state of forest inventories and G&Y information in the southern region – inadequate stand level attribute information and forest successional information (W).
- There will be an increased level of detail necessary for spatial modelling (W).
- Will need MUCH better succession and G&Y data for spatial planning in the GLSL (PB). Movement towards spatial planning will need better data to support stand-level succession (PB).
- G&Y needs to support better localization (e.g., Swan Lk. ≠ many of the sites we're operating on) (PB).
- Should inform operational decisions first and then inform the planning process (PB).
- For the 5-year plan, there is a need to have ± 10% at the stand level (NW).
- Require tactical G&Y estimates, with degrees of confidence, both
    - spatially (stand level), and
    - temporally (annually) (NE).
- Spatial planning and G&Y (NE):
    - Complacency in data collection, R&D and knowledge transfer to users (NE).
    - Lack consequences of
        a. Using poor G&Y data and products (NE).
        b. Poor understanding of proper use of G&Y data and products; subsequently (NE).
        c. Poor judgement with implementation of G&Y data and products in FMPs (NE).
- **Variability –** currently, we average averages, and then model forward (PB). We don't have the data for spatial planning!
- Planning and FRI are going to be spatially explicit and structure based instead of age/height based (W). G&Y may be done using remote sensing data at scales larger than the plot (W).

The New/Regenerating Forest

- Disconnect between current silvicultural performance and future species composition (W).
- Need to address new factors (e.g., beech bark disease, emerald ash borer) (PB). Is mortality rate increasing? *How do we maintain responsiveness with G&Y*?
- Second rotation forest is a function of less intensive silviculture being applied (NW).
- Levels of silviculture are changing over time (ST, LT) (NE). Past plantations (e.g., FMA era) are not the same as today's plantations and will require different yield curves (NE). Increased sampling effort in the "new" forest should help (NE). Evolving silvicultural practices (W).
- Harvest today has moved to the poorer sites that were bypassed years ago (NW). These will be even more difficult to regenerate (NW). We are in a wood-supply crunch right now! (NW).
- Timing of harvest (season) affects regeneration (PB).
- Currently, once an area is declared successfully regenerated (free-to-grow in pre-SEI terminology) it is magically assigned a yield curve (W). Under SEI, performance surveys are supposed to be the intermediary check between early regeneration and yield curve determination but the G&Y program needs to be involved (W). Right now, we have yield curves from age 30 onwards with the front-end flapping without a direct tie to early regeneration (W).
- SEI and G&Y need to work on the linkage between early assessment and G&Y (NE). Implement a data collection program to get this link in the longer term but also look for an interim solution) (NE).
- Integration between SEI and G&Y could foster greater industry commitment (NE).

- Performance surveys and upcoming discussions are perceived as confusing commitments related to regeneration and G&Y (PB). Performance surveys are not a surrogate for G&Y (PB). Silviculture Enhancement Initiative (SEI) – it's not a substitute for G&Y requirements (W).
- Past performance should be a feed-back loop to FMPs (PB). But within-block treatment and response variability are huge, creating a complex problem that is currently "smoothed" out using experiential knowledge (PB). This experiential knowledge and professional opinion now speak "louder" than any available data (PB). Fragmenting creates a huge, complex sampling problem (PB).
- Past performance has 3 steps: 1) SEM, 2) Enrichment from adjacent management unit data, 3) adjustment based on expert opinion (PB).
- During Silvicultural Enhancement Initiative discussions, it is clear that there is no link between early regeneration (free-to-grow or establishment) and growth curves (W). Without this link, improvements to managed yield curves will not be very effective (W). The current situation is not satisfactory (W).
- At what scale is post-harvest assessment reconciled? Stand? Strata? (PB).
- We need to better understand post-treatment mortality (i.e., we start with 3000 sph and move to 800 sph; which stems will fall out?) (NW) (W).
- Use chrono sequences of digital photos to better understand what was there; what was planned vs, what is there no visa vis what silviculture was done (NW).
- The interpretation of young stands is informed by FTG surveys (NW). But often, silvicultural records are not available to the interpreter (NW). G&Y data are not available to the interpreter (NW).
- Annual report data is a legal record and, moving forward, should be the base for FRI (we need a standard format!) (NW).
- All plot data available (e.g., SOARS (Survey of Artificially Regenerating Sites), G&Y, other) should be available and utilized (we need cross-talking amongst, plot-based efforts -should come under IMF) (NW).
- What is the connection between what's on the ground now vs. the Yield Curve used?
- The residual stand structure left on the ground today (for wildlife, because of economics) is high and variable (NW). What effects will this have on silviculture, the future forest, and G&Y? (NW).
- How will we deal with all the mixedwoods? Right now, we often have a leading species that represents less than half the BA in a stand; do we run more than one model and then partition? Is there a way to better model these? (NW).
- Mixedwoods are becoming increasingly prominent on the landscape (NE). As a rule of thumb, 50% of our calibration effort should be placed in mixedwoods for both inventory and G&Y (NE). Individual tree models like FVS are seen as a solution to modelling mixedwoods – but they depend on lots of calibration data and would benefit from the stem-mapping of plots (NE). Require better mixedwood yield curves (W).
- Good performance standards will help focus inputs to G&Y (NW). The role of the performance survey is to put stands on the right yield curve (NW).
- Need growth and yield models for:
    - Young stands (NE).
    - Stands with reduced herbicide treatments (NE).
    - Older, managed stands (NE).
    - New SGRs without plots (e.g., mixed species plantations, low density plantations) (NE).
    - "Marketability harvest" where basically large merchantable and marketable stems were removed and less or unmerchantable or unmarketable stems are left standing (NE). This pertains to past, current and future harvest—utilization specifications (NE).
- Need to model multiple strategic silvicultural options (we currently only model 1 per SFU) (W). Each SFU can have multiple intensities, each with its own yield curve.
- Need to model 'other' treatments such as irregular shelterwood, group selection, etc., (W). Need process for developing yield curves for other silvicultural systems (W).
- Wood supply gap is here now; G&Y can be a tool for addressing this gap, by allowing us to analyse and focus strategies to address this gap (W).

This requires G&Y tools that allow us to investigate the implications of future yields from different silvicultural strategies and land-use strategies (W).
- G&Y can be a used to encourage more productive use of Ontario's forests (W).
- Permanent silviculture plots (PSiP) needs to be established during the early regeneration stage and tracked to link to results from PGPs and PSPs (W). This is a long-term need (W).

Plots/Data Collection

- Dealing with a lack of confidence in data and results. Consideration that not all conditions require the same level of confidence. (NE).
    - Consideration for the variety of degrees of confidence; specifically, in the confidence in growth and yield as result of the cumulative error compiled from the system of measurements and equations (NE).
- Desire for predictions of product by species at the stand level (at the operational/tactical level). (NE). Also a recognition that FMPs are moving toward economic indicators (at the strategic level). (NE). Would like versatility in specifying species products: product quality size (amount, volume) and wood-fibre quality (NE).
    - e.g., veneer, quality in tolerant hardwoods, fibre qualities in pulp. (NE).
- Continuing need for long-term baseline data (W).

Yield Curves

- We currently assume that stocking remains the same over time (ST, LT) (NE). We need to be able to model stocking over time (NE). Resolution will change with increased spatial planning and inventory (W). Clarification – the stocking profile for the "present" intensity is derived from the inventory and a variable stocking option is available.
- Increasing stakeholder involvement in forest management decisions can result in reduced yields, necessitating an increased footprint on the landscape in order to maintain wood supply (NE). We could lose herbicides in the future (NE). Current yield curves become useless under such changes (NE). The G&Y program should highlight where it is serving non-timber values such as habitat (NE). A move towards individual-tree models like FVS could help predict consequences (NE). Silviculture has positive effects on habitat and this needs to be recognized (NE).
- Certification/IFA – are there any G&Y needs? (NE).

Succession

- **Succession rules** for landscape estate planning are critical (SM). There needs to be a plan in place to further the development of succession rules (SM).
- There must be increased effort in the development of forest succession plans; none exist for the GLSL (NE). There is a need for science-derived natural succession rules for GLSL (W).

T_2 FRI

- Inventories have been coming late, with little or no support (PB). This can't happen in T_2 (PB). There is a planning timeline and we need the products in time to do the job ("*industry should be able to bill MNRF for costs associated with lost time*") (PB).
- Will help with tendered sales; more accurate volumes; better prescriptions; more targeted boots-on-the-ground (PB).
- Will there be a mechanism to tie product recovery back to G&Y and inventory? At the local level at least?
- We need to make sure that our models are using inputs that that we are quantifying well (PB). This needs to be well-considered as we move forward with T_2 (PB).
- Need to build SFU's for GLSL as we move forward with T_2 (PB). ("Common currency") (PB).
- There should be an analysis of T_1 vs. T_2 inventories (PB).
- Assess differences between old approach and new (T2) approach (NE).
- The production of the inventory needs SFL involvement from the start!
- Inventory is the biggest hurdle in any plan (PB).

- A quality inventory is needed for planning confidence (PB). The FRI needs to be continuous (up-to-date, locally accurate, and maintained) (PB).
- Need to build substrate into T_2 and link with G&Y (PB). (Ecosite is correlated with species composition, but not so well with productivity) (PB).
- The new DTM (from LiDAR) is providing standard and consistent predictions with the opportunity to predict ELC and possibly affect Ontario forest policy (e.g., forest management guides for conservation of biodiversity) and models, including productivity models (NE).
- Under T2, given a good DTM, modelling elements of site quality (growth potential) will be possible (ELC, slope, elevation, aspect, DTW, soil condition, etc.) (NE). New predictive tools will be required (NE).
- Need a unified approach to a predictive soils layer (including depth to water table) (NE).
- Include carbon and biomass (NE).
- Under a continuous inventory scenario, would it not make sense to use a continuous plot network (one that is well-planned, with guidance from G&Y on sampling)? These plots could then be used to support all of the boots on the ground work and monitoring for succession, etc. (PB).
- Under continuous forest inventory, each time we go on the ground, data could be added (pre-harvest assessment, tree marking, post-harvest assessment, performance) (PB).
- moving forward, much is hinging on this happening… *what if it doesn't happen?*
- There seems to be some variance in what the T_2 inventory will entail or consist of (NW). The outcome will have a significant effect on G&Y needs moving forward (NW).
- Enhanced forest inventory requires a linked growth and yield program (W). LiDAR inventories can make use of plot database and remeasured observations from PSP/PGPs can be useful for imputing finer scale inventory attributes (W).
- There are lots of opportunities coming with T_2 – what *condition* is a stand in? What's the age since disturbance? T_2 should enable better retrospective analyses (NW).
- We are depending heavily on LiDAR doing a good job of things like volume and piece size (NW).
- IMF is stalled because it needs LiDAR (NW).
- LiDAR – require accurate geo-referencing for PGPs. For PSPs there are multiple plot centers (NE).
- Need for lidar attribute results presented by Ian Sinclair (introduction presentations), plus:
    - Cull predictions (NE).
    - Stem taper monitoring and predictions (NE).
    - Mortality monitoring and predictions (NE).
- Need for accuracy of predicted inventory attributes (NE).
- Use of a raster attribute inventories (e.g. 13 layers presented by Ian), rather than a single polygon summary, will require changes (many layers of data) to the directions given to ROD and planning teams, for the development of FMP planning and modelling inventories: expectations and limitations on the use of the new suite of predicted attributes in raster layers. (NE).
- In the FRI, need to distinguish between balsam poplar and other aspens (balsam poplar is not a merchantable species) (NE). He vs. Pw vs Sw, hard to distinguish. Identifying small quantities of hemlock in a stand is important for wildlife habitat modelling (NE).
- Desire for consistent labels of silvicultural (yield) intensity in the inventory (NE). Inten1 does not have the same yield meaning across SFLs (NE). Should it? Do silviculture treatment labels (e.g. SGRs) need consistent labels and/or relationships to silviculture (yield) intensities? (NE).
- New technology such as LiDAR will give point in time volume estimates – this may need to also be supplemented to provide accurate yield projections (W).
- LiDAR acquisition will be part of the new FRI (W). Since we will have a direct measure of polygon volumes, the inventory support component of MIST will no longer be necessary (W). However, the growth component will still be required (W).
- Plots may need to be larger and geo-spatially positioned accurately (W). Better sub-metre spatial positioning of plots (W). Electronic data capture for ensuring timely incorporation into database, summaries and products (W).

FRI-G&Y Linkage

- We cannot/must not separate inventory and G&Y – they "*are joined at the head and the hip*" (PB). Currently, the two entities are seen as silos, with little communication between each (PB).
- G&Y and FRI should be linked and delivered through a third party (i.e., FFT) (PB). This is particularly true as we move to T_2 and G&Y will be needed to grow the inventory (the two will need to be linked and work together) (PB).
- LiDAR calibration plots can provide additional data to G&Y and visa-versa (PB).
- Continuous Forest Inventory => growing the forest means bringing together FRI and G&Y (NE). The remote sensing group in MNRF does change detection and land cover mapping (inc. near north and SORUS(?)) (NE). IMF should link/integrate this and the ELC, G&Y, FRI, Natural Heritage Information Centre, SEI, and other monitoring programs (NE). We still need to maintain accountability… (NE).
- Should this also include remote sensing group (change detection and land cover mapping)? This group covers the areas outside the Area of the Undertaking (AOU) including the near north and the South (NE).
- Will be totally reliant on G&Y to "grow" the inventory and make it "**continuous**" (PB) (W) (NE). T_2 Inventory will precipitate new planning methods and a sea-change in G&Y (PB). G&Y will end up being necessary to validate grown-forward inventory (NE). This will demand well calibrated mortality functions (NE). Will enable more detailed modelling within a stratum (PB).
- Products from G&Y will be needed to develop T_2 inventory and grow it forward (make it a CFI) (SM). T_2 will get things right at time 0, but we have to grow the forest inventory from that point on until a refresh is needed – G&Y is needed to do this (SM). FRI is moving towards CFI, but G&Y support and infrastructure is not there (SM). We need to link G&Y and FRI moving forward so that attributes match and so that there are synergies in plots and resourcing (SM). G&Y is the key to unlocking / leveraging maximum value from the inventory (SM). G&Y will help identify where new inventory refresh is needed (address decisions around when/where do you grow vs. when/where do you re-inventory) (SM).
- There was indication that T_1 inventory will also need to be grown (HD) (SM). This will require a different set of tools from those developed to grow T_2 – the two are very different (SM).
- Having to grow T1 would mean that T2 inventory and CFI must be viewed as separate events from a G&Y perspective (SM).
- Evolving FRI linkages to G&Y (NE):
    - Improved communication between all programs – FRI/IMF/Policy/G&Y & industry (NE).
    - Need a new, formal strategy for cross-division communication and coordination within MNRF and with industry (NE):
        d. This involves accountability. Do we need a chief forester to address coordination across stakeholder and to provide individual accountability for implementation decisions? (NE).
        e. This process/strategy will require periodic review (NE).
- Misalignment between G&Y and inventory could get worse with T2 (ST) (NE). Better integration of these programs is needed so that the two support each other (NE). It is recommended that the two programs actually be bundled under the IMF, and heavily linked with other monitoring programs such as SEI (there is a need to break down the silos) (NE). This could better facilitate a shared cost model for program delivery (NE). In such a model, MNRF's contribution needs to be sound and leading the initiative (NE). This speaks to better "selling" / repackaging / re-engineering the program (NE). Al T. warns that we can't just recommend going back to the good-old-days of measuring plots, as this will fall on deaf ears (NE). This also speaks to a governance model that goes beyond MNRF (NE).
- G&Y and FRI need to say the same thing at time 0 and beyond (user should not have two volumes to choose between) (NE).
- Enhanced forest inventory requires a linked growth and yield program (W). LiDAR inventories can make use of plot database and remeasured observations from PSP/PGPs can be useful for imputing finer scale inventory attributes (W).

Climate Change

- This includes changes in drought, insects, disease, etc. (PB) (NE). We need to be able to assess risk moving forward (PB) (NW). Increased impact of invasive species (NE). Increased impact on fire cycle (NE). (W). Effects on hardwood growth (W).
- Need to consider how growth and yield will be impacted due to a changing climate (does a site quality adjustment downward account for the expected changes (windstorm frequency, droughts, etc.) (W).
- Climate change (ST, LT) (NE). Increased incidence of fire, insects, disease, blowdown, drought, snow, and ice damage will affect yield and mortality (NE). Greater flexibility (nimbleness) is needed in the G&Y program to address emerging issues including CC (NE).
- New forest pests that will have a profound impact on forest stand development but seems to be almost no work done (e.g., beech bark disease) (W).
- Climate change will cause projections to be inaccurate (W). (e.g., the next budworm epidemic or wind storm may invalidate projections based on any amount of precise stand data) (W).
- Climate variables need to be included in our models as we move forward (PB). Sharma site index models are a great start; need to incorporate into FVS and other models; need to develop capacity to model productivity / mortality and yield in changing climates (W).
- We rely heavily on natural regeneration, but where we move seed, there are potential G&Y implications (PB). Look at assisted migration (W). Consider climate change in the seed/breeding zones (NE). Consider climate change in genetic improvement (NE).
- Current approach is to build CC sensitivity into G&Y via site index (PB). OFRI (Sharma and Ter-Mikaelian) are doing this research (PB). Need more stem analyses in plantations (PB). BUT, mortality rates are a big gap (must have lots of data on short remeasurement cycles of large plots to model) (PB). The SFL's need a series of simple fact-sheets outlining how MNRF is dealing with climate change, biodiversity, and carbon (PB).
- Currently, we incorporate CC effects into SI models as a modifier (SM). Dan McKenney (CFS) and his group have built some products to run different scenarios based on Lat/Long (SM). These could be run to evaluate the potential effects on G&Y to see what variability looks like (SM). Seed sources/genetics need to be considered (SM). Need to grow forest over time under different scenarios to quantify outcomes > adaptive management (SM).
- The SFL's need a series of simple fact-sheets outlining how MNRF is dealing with climate change, biodiversity, and carbon (PB).
- Lots of debate about whether impacts will be positive or negative and where (SM). We have to be careful not to rely heavily on our past knowledge in a future that may or may not be following the same trends (SM).
- Moving forward, do we still have the temporal/spatial scale correct for a future which is more variable? Can we use sensitivity analyses to test the validity of current planning scales with different climate scenarios? (NW)
- Cull, defect, mortality of the second rotation forest under CC means we need more plots in the regenerating forest (SM). G&Y and succession are needed to forecast climate change impacts (SM).
- Yield curves need to be continually assessed and developed using cause-effect process-based parameters from PSPs/PGPs: growth models (NE).
- Carbon accounting (ST, LT) (NE). Will become increasingly important with climate change (NE). Changing and conflicting policies are seen as a problem with respect to viewing forests as carbon sinks vs. carbon sources (NE).

Technology

- We will never be able to afford *enough* plots; we need to take as much advantage of technology as we can (e.g., drones, T-LiDAR) (PB).
- We need to look outside the province (our neighbors) to see how G&Y is being done (PB).
- Technology may enable a retrospective analyses (PB).
- We need a **strategic plan for G&Y** that incorporates technology into weaning us off of large plot designs (SM). Technology can be brought to bear on modern data collection and more focused data collection (SM). Need key performance indicators that will measure success and progress (SM). We

need a provincial strategy, recognizing that we have different forests with different needs (SM). We need a **forest strategy** to drive what needs to be done in ON (SM).

- Use of technology is increasing; number of people and associated experience on the land is decreasing (SM). This means that we need to use technology to build on the past (SM). Are we truly going to move beyond 50's approaches as a base for what we do and how we make decisions?
- We want to be able to wean ourselves from Plonski's in the near-term (SM).
- We need to identify the best bets for science and technology moving forward, given minimal funding (SM).
- We need to use technology to modernize and focus data collection (SM).
- We need to look to the future and identify what we need for forest management planning and not focus too much on "fixing the jalopy" (SM).
- Use of drones – for verification of inventory attributes (NE).
    - In PGPs/PSPs for acquisition of "downward-looking" attributes such as crown closure on the field plots. (NE).
    - Could be used in more intensive monitoring in young stands than practical with conventional LiDAR (NE).
- Disconnect between people and the landbase may get worse with technological change (even fewer boots on the ground) (ST) (NE). T2 inventory may help target boots on the ground so that fieldwork is more efficient (NE). Integration could foster greater industry commitment (NE).
- Ground-based LiDAR could be used to for development of better merchantable yield and biomass estimates (W). Mobile ground LiDAR may be a great tool to develop better models of merchantable and biomass volume in tolerant hardwoods and other species where taper / biomass estimates are poorer (W).
- Airborne LiDAR products to develop yield estimates across land bases (potential for development of yield models based on age or remeasurements through time) (W).

Markets

- Forest Industry Division needs to look forward at the products needed in the future so that we can inventory them and plan for them into the future (Glen W.) (PB). This is part of being "open for business" (PB).
- We will need to be flexible to changing markets in the future (PB).
- **Piece size- Fibre quality:** The shift from strategic to tactical/ operational type inventory will move towards giving us information on piece size and quality (SM). This is good, as our future will be tied to product availability (SM).
    - Need piece size integrated into strategic planning: this will take a G&Y product (SM).
    - Quality and piece size are critical to maintaining market flexibility (SM).
    - There needs to be further investigation with forest industry about who needs what kind of data and who is responsible… part of the need for this type of information stems from industry abandoning operational cruising. The flip side is the landowner wanting to attract and encourage investment (i.e., what do we have to offer?) (SM).
- Piece size x species @ stand level (ST, LT refinement) (NE).
- Rapidly changing markets require an ability to react quickly (ST) (NE).
- Utilization (ST, LT refinement) (NE). Linked to changing markets; lack of demand may leave some species and/or sizes unharvested in a given stand (NE). Current yield curves assume complete utilization (NE). What are the short and long-term impacts of leaving these residuals? There is concern for establishment silviculture and implications for yield trajectories under these varying conditions (NE). Implications for research and monitoring (NE). Potential solutions may lie in T2 inventory better characterizing these stands for product content; FVS-type model may be able to deal with the resulting stand conditions; plots in mixedwoods may help (NE).
- Changing products (W).
- Product value and product proportions, cull estimates – need to link to site quality, management intensity / silviculture regime (W).
- Stand yields by species are important to predict supply for various processing facilities (W).
- More accurately quantifying carbon capture will be important if a carbon market is established (W).

Aboriginal involvement in Forestry – emerging issue and a priority (NE).

- To aid in addressing the issue, recommendations:
  - Increased consultation (NE).
  - Collection of non-timber values on PGPs/PSPs (NE).
  - Increased involvement in data collection and forest management (NE).

Attrition (Human Resources)

- Attrition of HQP with quantitative skills is recognized, both in the G&Y program and in the science ranks serving the program (ST) (NE). Succession planning is needed (NE).
- Current and increasing inexperience within the regulator (MNRF) will also require greater reliance on information and data (W).

Other values

- Are there new values that must be supported by G&Y (W).
- The SSG prescribes retention of 'wildlife trees' in harvest areas. These trees are intended to stand for varying amounts of time, providing vertical structure through time, and gradually fall down to contribute to the pool of downed woody material. Models that predict how long different types of wildlife trees will stand (by species/size/condition) and how the mix of trees retained influences the pool of DWM through time would help us better define which trees (and how many) to retain at the time of harvest. Could the G&Y data be used to develop these kinds of models? (W).

IMF

- **We need to make IMF work effectively and efficiently.**
- Need to see if we can use all or some of the existing plots for multiple users (wildlife monitoring/inventory) to allow more plots to be measured for the dollars available (W).
- Greater societal emphasis on quantitative data-based solutions; means our understanding of long-term forest dynamics needs to improve exponentially (W).
- Adoption of a G&Y modelling framework (FVS – OSM, etc.) to identify data needs to ensure efficient data collection and refinement of plot network (W).
- Need to separate out data collection programs based on end use and what we can afford (a single plot protocol cannot meet all data needs affordably): for yield curves and succession models, LiDAR calibration we need a large number of observations with simple data (do not need measurements of really small trees, except for use in individual tree models like FVS) (W). Need to focus on what data limitations exist in FVS and feed those with specific plots, and yield curves and succession models can be fed with much more streamlined (affordable, quick, simple) plots that could also be used for LiDAR calibration (W). We need plot methodologies that are more streamlined to feed immediate and long-term data needs (simply put, for our most widely used forest management models we need more points on graphs, and a PSP measurement costing >$3,000 adds only 1 degree of freedom to the analysis – the same point on a graph can be provided with comparable accuracy at a cost of $500, but without all the 'extras' – do we need the extras (they are not being used)? To fully parameterise FVS we need more complex data, but not all of the currently required PSP attributes are required and are not necessarily needed on every plot (W). The biggest costs for a plot involve finding and numbering little trees (<9 cm DBH) – important for FVS but not needed for yield curve or succession or SDMD models (W). Individual tree (especially the small ones) measurements should be streamlined to where the data gaps occur; borrow data from other programs to fill gaps; perhaps also include more data from other jurisdictions (W).
- The timing of this project is odd as the MNRF Science program continues to plan its Integrated Modelling Framework efforts at the same time (W). I hope that the information learned from this exercise helps to inform the IMF work (W). My fear is that the needs gathered through this exercise may raise expectations that may not be met in whatever the IMF putts forward (W). I hope I am wrong (W).
- Need to look at integration w/ other programs such as the silviculture enhancement initiative (W).

Barriers

Resourcing

- Shrinking budgets/resources/horsepower (NE). Bundling of programs, shared cost model for delivery, restructuring governance, and truly integrated monitoring could all help (NE).
- In all the forest management planning complexity, G&Y doesn't end up getting a lot of attention, even though its role is foundational (NE).
- Lack of consistent financial resources and a reduction over time (NE).
- Governance and funding are immediate issues and linked (NE).
- We need to walk the line between doing a few things well vs. many things half-well (SM). We need to avoid not following through (SM).
- **Human Resources**: We need to focus new hires on multi-disciplinary knowledge and quantitative skills (SM). We need to have opportunities for professional development (SM).
    - Staff turn-over is seen as a big issue for loss of skills, knowledge and data (SM) (W).
    - What should the program be trying to replenish skills-wise (SM).
- **Staff/ trained personnel** – G&Y priorities HAVE been focussed on the regenerating forest and remeasurement of key existing plots! BUT they don't have the staff or the resources to do the job properly (NW).
    - Problem is that young people don't want to work in the woods today (NW). We have contracts out now that aren't being filled (NW).
    - We've lost a lot of the expertise that went into the 1993 masterplan (NW) (PB).
    - The next plans will have new technology, new people, less experiential knowledge of landbase (PB). There is a responsibility of organizations to transfer knowledge and there may be more human capacity there than we give current credit for (PB).
- **Resources** – extremely limited and unlikely to change (PB).
    - Human resources are limited (PB).
    - MNRF needs to show **commitment** to sustainable forestry in ON!
- There is unlikely to be any more money or people, therefore we MUST modify what we are doing (NW).
- Lack of support for data management (W).
- Policy that guides MNRF Commitment – policy should be update, any commitment is null w/out sufficient funding (W).
- If the reliability of our projections are to be improved, our knowledge will need to increase exponentially (W).
- I do not believe any agency has the financial wherewithal or organizational stamina to make significant progress, especially given our relative economic importance provincially (W).
- Support for data management needs to be priority #1 (W).
- Concern if the intent is to download to forest industry (W).

Landowner Commitment

- Landowner commitment needs to be front and centre (NE).
- The tenure system (NE). It provides no incentive to manage well at the stand level and fosters a lack of commitment and investment (NE).
- Incentives for intensive management by the government are necessary for encouraging economic investment on Crown lands (NE).
    - Commitment to recover investment (NE).
    - Security of wood supply and investment in intense (costly) silviculture treatments (NE).
- On the industry side, need to provide security to investment and a provincial commitment to forestry to attract investors (NE).
- Update strategies
    - Provincial wood supply strategy – requires inventory now and "true" projections into the future (NE). The "true" refers to using cause-effect process-based (growth models) models from PSPs/PGPs (NE).
    - Provincial G&Y strategy – needed (NE).

- Governments need to understand the importance of FRI and G&Y (NE).
- MNRF allocating the proper resource to assess its Crown resource by remeasuring and establishing new plot (W).
- MNRF has been all but missing in action in recent years (W).
- What sort of forest industry is the province interested supporting? The responsibility for this falls on the forest industry division and the forest policy division and currently seems to be falling through the cracks (W).

Communication

- Lack of information/knowledge exchange forums (e.g., like we had with the FRP) (NE). Need to recommend a 5-year review, with annual meetings (NE).
- Foresters need to speak out and advocate for G&Y and forestry and the benefits to Ontario. Advocates include MNRF, individuals, OPFA, FFT, OFIA (NE).
- **Lack of communication –** Among SFLs, Regions, and the coordination that stems from it (PB).
- The lack of communication and cooperation between the FRI Unit and G&Y Unit is disconcerting (W). This lack of cooperation has an impact on FMP planning where the FRI initially reported crown closure as an attribute yet Plonski-based stocking is the attribute needed for yield curve development (W). The separation of overstory and understory represents detailed information that does not fit in well with the forest units used in planning; therefore, an ad hoc blending process had to be incorporated (W).
- Lack of proper communication/transparency/training between users and G&Y program (W).

Governance

- Lack of good governance is reducing our ability to respond rapidly (NE). G&Y needs to mesh with 5 or 6 different groups (NE). Will IMF help solve this? (NE).
- Governance and funding are immediate issues and linked (NE).
- Can the FFT provide a framework for governance? They currently have a mandate for inventory. Is there some way to develop a G&Y equivalent to the provincial FRI advisory committee and technical committee? (NE).
- ROD is concerned about the governance of the G&Y program (W). To date the program has largely been unresponsive to ROD input through the IMF initiative, and ROD has no formal way of pressuring the program for a response (W). There has to be a governance structure where ROD plays a role in oversight of the program to ensure that our end-user (client) needs are better met (W).
- Proper governance is the key to keeping the G&Y program responsive to client (ROD and Policy Division) concerns, needs and priorities (W). Without clients having a role in oversight of the program, then it does not matter what the future program looks like since this disconnect between service provider and clients will continue (W). The relationship between the pre-transformation Science and Information Branch (of which the G&Y Unit was a part) and the Planning Unit was viewed as a "doctor-patient relationship (W)." What we now need is a "service provider-client relationship (W)." Fix the governance then client concerns/needs/priorities within an enhanced growth and yield program will be addressed continually and timely (W).

Organization

- **Organizational structure**: there are some serious organizational barriers to overcome (SM). We need better management/leadership to get us where we want to be (SM). Organizational barriers should be listed (SM).
- **Stature of G&Y:** A "surplus" of wood translates to a lack of urgency (SM). Somehow, the shortage of "economically" viable wood needs to resound (SM). In many ways, we're managing very extensively; do we really need better resolution to do this? What do we need if we want to make better decisions about intensification? Effects of bad G&Y are muted because they are long term (SM).

Red Tape

- The procurement process is a huge impediment to efficiency and effectiveness (NE). This process is also hampering our ability to recruit and maintain a viable work force (NE).
- Bureaucracy (W).

Procedures

- Area-based regulation is a relic of old management approaches that is not supported by current G&Y, which is volume based (NE). Allowable Harvest Area (AHA) is area-based, but may or may not support the volume calculated for harvest (NE). FTG is an area-based check; it does not place a stand on a yield curve (NE). As Baskerville (1986) stated, we need a strong link between volume and area (NE). T2 inventory may help solve this (NE).
- Provincially adopted data collection protocols are prohibitively expensive; much of the 'required' data is not used (may prove useful at some point but seems far too much time and cost is tied up collecting data that has no immediate purpose) (W).
- Field manual has become too cumbersome/expensive to implement and maybe could be paired down to (a) meet modelling needs only (b) just focus on critical tree attributes (W).

Tools

- Lack of a tree list is an existing barrier to the use of FVS (NE). Under T2, tree lists should be possible for many stand types, facilitating the use of FVS (NE).
- **Access to data -** Difficult to know what you have now; figure out what you need (PB) (W).
- Loss of capacity for plot remeasurement / lack of updated data (W).
- Data not readily accessible to clients in a timely way (W).
- A general preference by all areas of policy/science in MNRF to customize policy/tools for boreal forestry which is often times counter to what would be beneficial to GLSL (W).
- Time that takes to get useful data from newly established plots is long (W).

Climate Change

- Climate change and its impacts on precipitation, temperature, wind, and pests has the potential to invalidate projections of G&Y despite our best efforts (W).

Short-term Priorities

< these aren't totally exclusive – some are identified above>

Data

- Round up any and all data collected historically and make available for analyses (NW).
- Mine existing data (NW). Need a corporate, accessible data base that can be mined in the short term (NW).
- Revisit plots as necessary (NW).
- Address gaps. …G&Y say's they're doing these already (NW).
- Need to think *leaner and meaner*; ways of more efficiently acquiring data (NW). Are there attributes that we can drop or collect a different (more efficient) way? Make better use of technology (NW). Are there new opportunities to collect data? At the same time that we embrace technology, we have to be careful that we don't detach from the forest out there that we're managing (NW). Such could include drones for mortality monitoring, LSP for regeneration assessment, satellite image chrono sequences, etc. (NW).
- Need to prioritize new collections with risk-based assessment (*What are the things that will affect sustainability in the long term*? *What do we really need to get a useful product*? *What does industry really need from G&Y*?) (NW).
- We need clear short-term direction on what we're going to do today with limited staff and resources (NW). How we're going to use technology, how we're going to better use what we have (NW).
- We need staff to do the work, but we also need to take advantage of technology and automation (NW).

- Any data moving forward should be spatially tagged so that it will support decision making in the future (NW).
- We need to know what LiDAR will do for G&Y (NW).
- **Plots** - We need a GAP analysis of existing plots (PB). Many plots are research networks and they are spread all over (PB).
    - Need to move existing data (thousands of plots) into a useable form (PB).
    - We need to make sure that we get maximum 'value' out of the plots that we're measuring: Can we use a PSP-light?; Do we need full measurements everywhere? We need to identify data gaps and target resources (PB). The value in repeated measurements is highest (PB). The work being done needs to be targeted at the development of specific products (PB). The original model was that the MNR would undertake PSPs; the industry PGP-PSP-light > but we need a workable strategy moving forward (PB).
    - Data collection needs to be targeted at the tools that we want to support/develop moving forward (PB).
    - Plots need to be measured before and after harvest – could get 90% of value with a "light" measurement, which is better than none at all! (PB).
- Our forest is changing due to a variety of reasons; retooling and investment is needed to adapt G&Y to these changes (NE).
- Online datasets for use in inventory modelling efforts (W).
- Better support to partial harvesting systems – selection/Uniform Shelterwood (W).
- Process data collected for GLSL and add to improve model estimates (W).

Tools

- Need to instill confidence in G&Y products moving forward (NE).
- **SFUs** – develop a "common currency for the GLSL" (PB). Need to incorporate harvest history into SFU definitions (PB). Priorities in the GLSL are tolerant hardwood shelterwood, tolerant hardwood selection, and white pine shelterwood (PB). These are the high-value, high-area, forest units (PB).
- **Shelterwoods** - We typically don't model shelterwoods well – this is a priority for G&Y (PB). Moreover, these shelterwoods grow very differently on the range of sites out there (PB). (We typically don't have enough plots to capture the range of variability within a SFL, let alone between SFLs) (PB).
- **MIST** is now Hugh Higham's responsibility (PB). There is (will soon be) a new version and there should be a user's group established for its roll-out (PB). There should be something better than a cobbled-together MIST moving forward (PB).
- **Productivity** - Need better productivity measures for tolerant hardwoods and the GLSL forest in general (PB).

Rebranding / Partnerships

- G&Y is IMPORTANT, with BIG needs (NE).
- A long-term commitment is needed by the landowner and other stakeholders (NE). Industry buy-in is predicated on landowner commitment (NE).
- Governance and cost sharing model are needed that fully engages all stakeholders (NE).
- There should be full integration of G&Y, FRI, and other remote sensing and plot-based monitoring programs (NE).
- G&Y will need to re-establish partnerships moving forward (NW).
- Need to encourage academia, CFS, and others to partner in research such as succession (NW).
- IMF, G&Y, and FRI are all in the hands of a single director (Marty Blake), which is good for integration and coordination moving forward (NW). We need to encourage the required leadership (NW).
- **Programs** - There needs to be clear linkages between the programs (PB). The Forest Resource Advisory Committee meetings may call on G&Y to run different scenarios to see whether or not ON is really "open for business" (PB).
    - The annual ROD meeting (District Managers/General Managers) should have a G&Y presence (PB).

MNRF Commitment

- We're a $15 B industry, life-blood of the north; we need to invest now to make it sustainable! Forestry needs to be a priority of the government (NW).
    - Big industry, generates lots of employment, but it will be difficult to redirect general revenue to support G&Y directly (NW).
    - Environmental groups may be our best advocate for not doing enough (NW).
    - Legal challenges will get attention, unfortunately (NW).
    - MNRF must recommit itself to forestry (NW). Is it really "open for business?" (NW). This seems to be an underpinning need (NW). Minimize micromanagement and increase freedom to conduct core business (NW).

Communication

- We need to have good communication with public, managers, politicians (as a profession, we don't speak out enough) (NW). G&Y needs to be connected through a committee to FRI, ROD, IMF, etc. – these groups can't help what they're not aware of (NW).
    - These meetings should feed into and guide IMF evolution (NW). Help IMF design to address short-term gaps (NW).
    - This report will go to the director & recommend that the programs are hardwired (NW).
    - IMF has task teams – G&Y should be plugged into these (NW). IMF could largely define G&Y and its integration with other terrestrial programs – how will G&Y rank? We have to avoid having "too many cooks in the plot kitchen" (NW). There is a decided need for more coordination/cooperation among terrestrial data collectors (NW).
    - Technical documents, like the Master plan, need to be available in digital form (NW).
    - New Minister should be invited to 'tour' G&Y and FRI to better appreciate work being done and needs moving forward (NW).
- Practitioners need to be involved in the discussion moving forward; they have to be able to use the tools being produced (e.g., no stereo monitor, so T_1 could not be used to full advantage) (NW).
    - There needs to be proper tech transfer of new tools (e.g., delivery of LiDAR to the practitioners) (NW). This would apply to G&Y too (NW).
    - We need to get around any restrictions and make tools available (NW).
- We need a 5-year periodic review – this is what we did vs. this is what we said we'd do…
- Documentation of the science behind the yield curves is a short-term need (W).
- Given advances in satellite imagery and LiDAR now being used for imagery acquisition for the FRI, we need to see the plan and framework how a new G&Y program functions (W). For example, presumably we will have polygons with an associated volume estimate (W). So how will growth functions be generated? Can we continue to use a function based on stand yield as a surrogate for growth in a chronosequence-type model? How will growth functions be generated? How much data is needed for generating growth functions with "reasonable" confidence intervals? What timeframe is needed to gather the data to generate growth functions? I thought this was the purpose of the Integrated Monitoring Framework (W). Therefore, the report from the IMF initiative outlining this plan and framework is a priority G&Y need over the short-term (W).

To Authors

- Authors need to distinguish recommendations that are inside and outside the G&Y Program (SM).
- Could/should Authors get external review of our report? (SM).
- Authors should use the 1993 G&Y Master Plan as a lens for what is working well and what is not (Rich G.) (SM). Some of the gaps then are the same today, therefore not working well (SM). Technology will have addressed others (SM). Authors need to identify the critical questions relating to health and sustainability of our forests that can't be answered today because we don't have data (SM). The system is sound; problems came with implementation (SM).
- The workshops contained a lot of G&Y wienies; we need to engage *forest managers* in the basic questions of what needs to be done; why does it need to be done; and how much will it cost (PB). Focus needs to be on better understanding and prediction of forest dynamics resulting from

management intervention (PB). Communications need to be dumbed-down for the forest manager (PB).

- Authors need to look outside Ontario guidance and opportunities for data sharing (SM).
- **report** – The Forest and Lands Director's group should be the entity receiving the report (PB).

Appendix 5 – Additional comments received during review of the draft

A draft of the report was circulated to those who registered for the workshops. We received additional written comments that are summarized here.

G&Y history

The maintenance of tools for forest management planning including SFMMTool and MIST requires time and commitment from knowledgeable staff. This level of support is often underestimated by managers. A change such as moving from working groups to forest units requires coordination between FRI, G&Y and planning and requires significant changes to tools.

Science

There is misunderstanding at the Auditor General level that the science program is addressing G&Y needs. Most of the G&Y projects at OFRI have focused on stem taper or individual tree metrics or plantations (which cover little area). Many of the G&Y needs are yield curves at the regional or management unit level. OFRI is not addressing many of the G&Y needs.

MIST is a G&Y/Science product and the maintenance and training for MIST should not be in Forest Policy Branch.

FRI

Partnerships with ROD, Policy and SFLs need to be strengthened to ensure an inventory (planning composite layer) is delivered at the start of each planning cycle.

Inclusion/exclusion of attributes such as ecosite, stocking, or canopy closure in the FRI needs to be worked out with programs affected by the changes before the change is made.

The FRI now includes information on mult-tier stands and this has not worked well. MNRF is ill-equipped to deal with multi-tier stands (can't be handled by MIST). Additional data has been added but it is not being used.

Inventories are, in part, a G&Y product. Inventories are needed that contain attributes to make better use of the G&Y program. Indicators of stand health, for instance, are important in management decisions and post-harvest stand development.

SEI

A confusing and complicated program that should be run centrally by the MNRF rather than tacked on to an already over-complicated FMP system.

Modelling and Support

MIST is not fully functioning and should be. Shelterwood and selection management are poorly linked to data input from the FRI and from model representation. Most technical work is delegated to summer students and interns, as many forester/planning specialists in MNRF lack the necessary computer skills.

Planning checks on sustainability do not occur.

Specialists are retiring and not being replaced.

Training was re-allocated to integration branch but was not taken up. Training has fallen back to planning specialists who are do not have the time.

When writing an FMP, G&Y numbers and models are required whether or not G&Y specialists are satisfied that the numbers and models meet some threshold of reliability.

Focus on second rotation forests including all silvicultural systems. Build climate change adaptation into measurements. Ontario is considering implementing a **seed transfer** approach (BC has already done so) to provide opportunities to ensure that deployed seed and stock has a high probability of being adapted to its growing environment and produces well-adapted trees now and in the future.

Modeling should integrate **ecosite**, ecodistrict, ecoregion for many reasons including the ability to extrapolate, share results and improve overall understanding of relationships. This is even more important as Ontario's environment is changing.

Improve the use of **scale data**. This has been a long-standing challenge but with today's technology and the use of industry/MNRF partnerships it should be possible to resolve some of the road blocks to using these data.

G&Y field plots

The G&Y plot network should include measurements of **improved stock and superior provenances**. The majority of the planted jack pine and black spruce in the north is derived from improved stock (tree improvement orchards). A portion of the white spruce and white pine is derived from orchards or superior provenances as well. The genetic gains need to be tracked and recognized. Forest managers are challenged to have these recognized in planning even though provisions are included in MIST.

Plot design should **integrate with silvicultural plots – post renewal survey linkage** including documentation of management regime, such as prescription, density regulation, artificial regeneration (improved stock – y/n), competition control, site occupancy, etc. These could include new approaches from the Silvicultural Enhancement Initiative (SEI), past (e.g., SOARS) or existing establishment surveys. Is it possible to include the performance surveys envisioned under SEI as part of the G&Y program? If so, it might address an industry concern and generate necessary data to better inform the relationship between a prescription, treatments implemented, and resulting yield curve.