FOREST GROWTH ORGANIZATION OF WESTERN CANADA:

2020 RESEARCH UPDATE

FOREST GROWTH
ORGANIZATION OF WESTERN CANADA

Table of Contents

Message from the Chair

Melonie Zaichkowsky

FGrOW is approaching its fifth year of operations, which is an excellent time to reflect on the work that has been accomplished within the Project Teams to date, as well as an exciting time to look forward to what is coming up. Over the past five years, FGrOW has moved out of the start-up phase and into the stability and performance phase of organizational development. This has brought forward some exciting opportunities to help address the need for continued development of growth and yield research and expertise within the forest industry.

With input from its members, FGrOW has been focusing its efforts on investigating challenges and opportunities that are relevant to growth and yield in the forest sector; including areas such as remote sensing applications, climate change implications, and assessing the need for growth and yield capacity building.

It has been a pleasure to serve as Chair of FGrOW these past three years and to be able to participate in an organization that is always forward thinking in nature and strives to produce high quality, relevant research and answers for its members. I look forward to seeing some of the latest FGrOW endeavors come to fruition over the next couple of years and am excited to continue to participate in such an active and collaborative organization.

Message from the Director

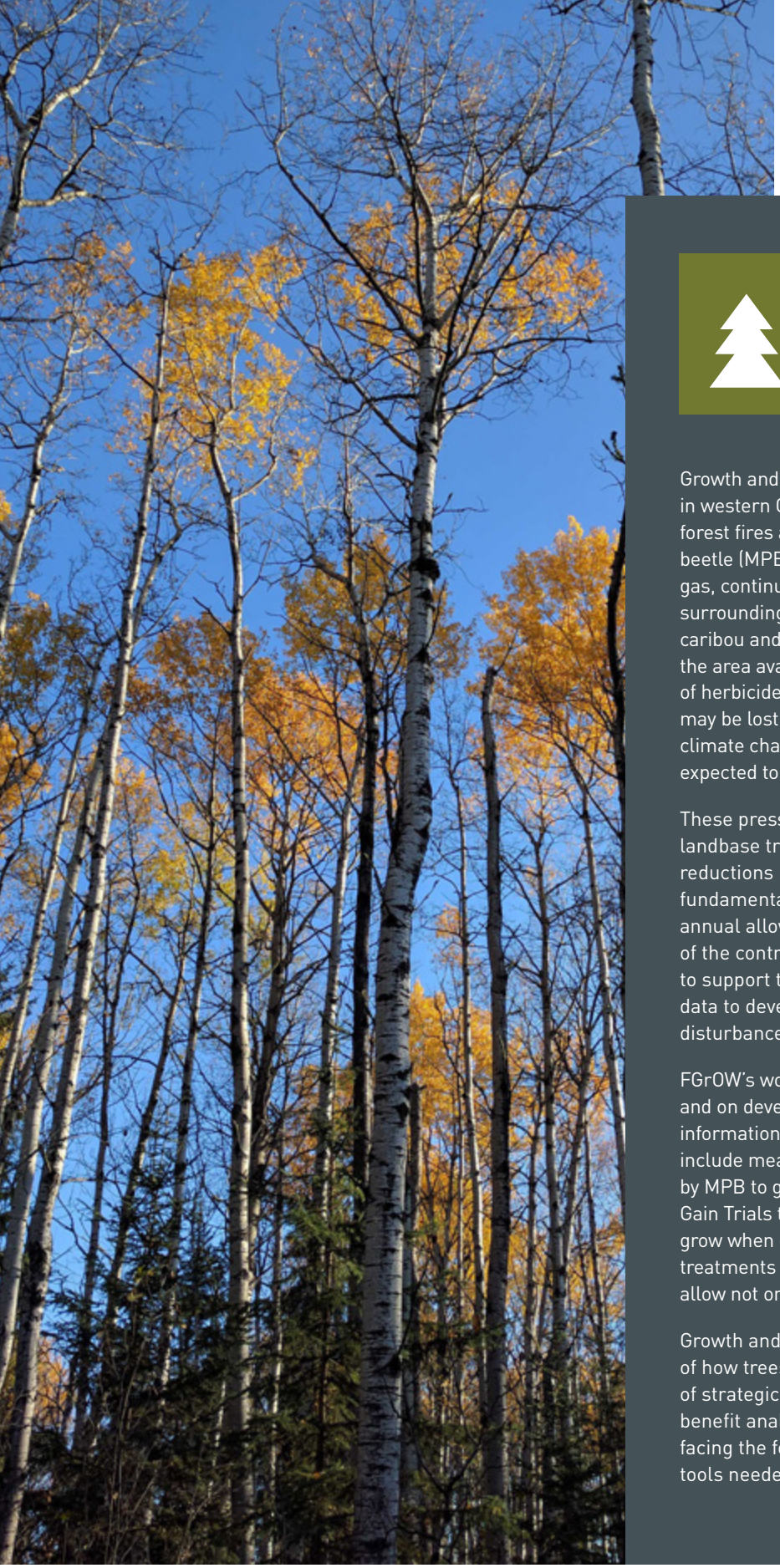
Sharon Meredith

Since its inception in 2015, FGrOW has maintained focus on its members' priorities, pursuing new research while delivering on existing projects. At the same time FGrOW has engaged in opportunities to deliver its program in new and innovative ways. For example, we are currently in discussions with the NAIT Centre for Boreal Research which would see them assuming responsibility for field measurements for a number of FGrOW projects. The proposed program will build the capacity of knowledgeable and competent field staff, helping to fill a need both for research and for forest companies' growth and yield program delivery.

It is encouraging to see the strong support for growth and yield shown by FGrOW members through providing funding for an endowed chair in forest growth and yield at the University of Alberta. The establishment of this position opens a new realm of possibilities for FGrOW's future direction and promises to lead to the development of badly needed capacity in growth and yield.

I am also excited to be spearheading the Canadian Growth and Yield Summit that will be held in 2021. It will be a tremendous opportunity for growth and yield practitioners from across the country to learn from each other and to be inspired by the accomplishments of researchers in other parts of the world.

With his planned retirement in 2021, I would like to take this opportunity to recognize the tremendous contributions that Dick Dempster has made to the Alberta forest industry, to FGrOW, and before it, the Foothills Growth and Yield Association. Dick's departure will leave a void, but I am confident in FGrOW's ability to adapt to this change and to take advantage of new opportunities moving into the future



Why Growth and Yield Matters

Growth and yield has never been more important to forest managers in western Canada than it is today. The last decade has seen massive forest fires and, in Alberta, unprecedented levels of mountain pine beetle (MPB) attack. Industrial development, particularly for oil and gas, continues to erode the harvestable landbase. Societal pressures surrounding indigenous traditional land uses and preservation of caribou and other wildlife habitat have the potential to further reduce the area available for forest management. At the same time, use of herbicide is under increased scrutiny and there is concern that it may be lost as a tool, as it has in some other parts of Canada. Finally, climate change is introducing uncertainty around how trees can be expected to grow in the future.

These pressures on the forest industry and on the harvesting landbase translate into concerns regarding the potential for reductions in sustainable harvest levels. Growth and yield is a fundamental driver of timber supply analysis, as important to annual allowable cut (ACC) calculations as an accurate accounting of the contributing landbase. Developing the yield curves needed to support timber supply analysis requires collecting and analysing data to develop relationships between tree growth and treatments, disturbances, site conditions, or other factors.

FGrOW's work focuses on understanding growth and yield responses and on developing tools that allow forest managers to apply this information. Its members identify priorities for study. Examples include measuring permanent sample plots that have been attacked by MPB to gain an understanding of how stands will develop; Realized Gain Trials to provide information on how tree improved stock will grow when deployed operationally; and research into silviculture treatments such as herbicide, thinning, and site preparation that allow not only yield predictions, but cost-benefit analyses.

Growth and yield provides critical understanding and quantification of how trees can be expected to grow; this is required for all aspects of strategic planning, from AAC calculations to treatment cost-benefit analyses. Growth and yield can't eliminate the pressures facing the forest industry, but it can provide crucial information and tools needed to evaluate and mitigate their impacts.

Full Members

Organization	Project Team Affiliation				
	Foothills Pine	Mixed-wood	Policy and Practice	TIA	WESBOGY
Alberta-Pacific Forest Industries Inc.		√	√	√	√
Alberta Agriculture and Forestry	√*	√	√	√	√
Alberta Plywood Ltd.		√	√	√	√
Alberta Newsprint Company	√			√	
Blue Ridge Lumber Inc.	√		√	√	
Canadian Forest Products Ltd.	√		√	√	√
Edson Forest Products	√		√	√	
Hinton Wood Products	√		√	√	
LP Canada, Ltd.					√
Manning Forest Products				√	√
Mercer International		√	√	√	√
Millar Western Forest Products	√	√	√	√	
Norbord Inc.				√	
Northland Forest Products Ltd.				√	
Saskatchewan Environment					√
Spray Lake Sawmills	√			√	
Sundre Forest Products	√		√	√	
Tolko, High Level		√	√	√	
Vanderwell Contractors**					
Weyerhaeuser Company, Alberta Forestlands	√	√	√	√	√

*Non-voting member

**FGrOW Member with no Project Team affiliation

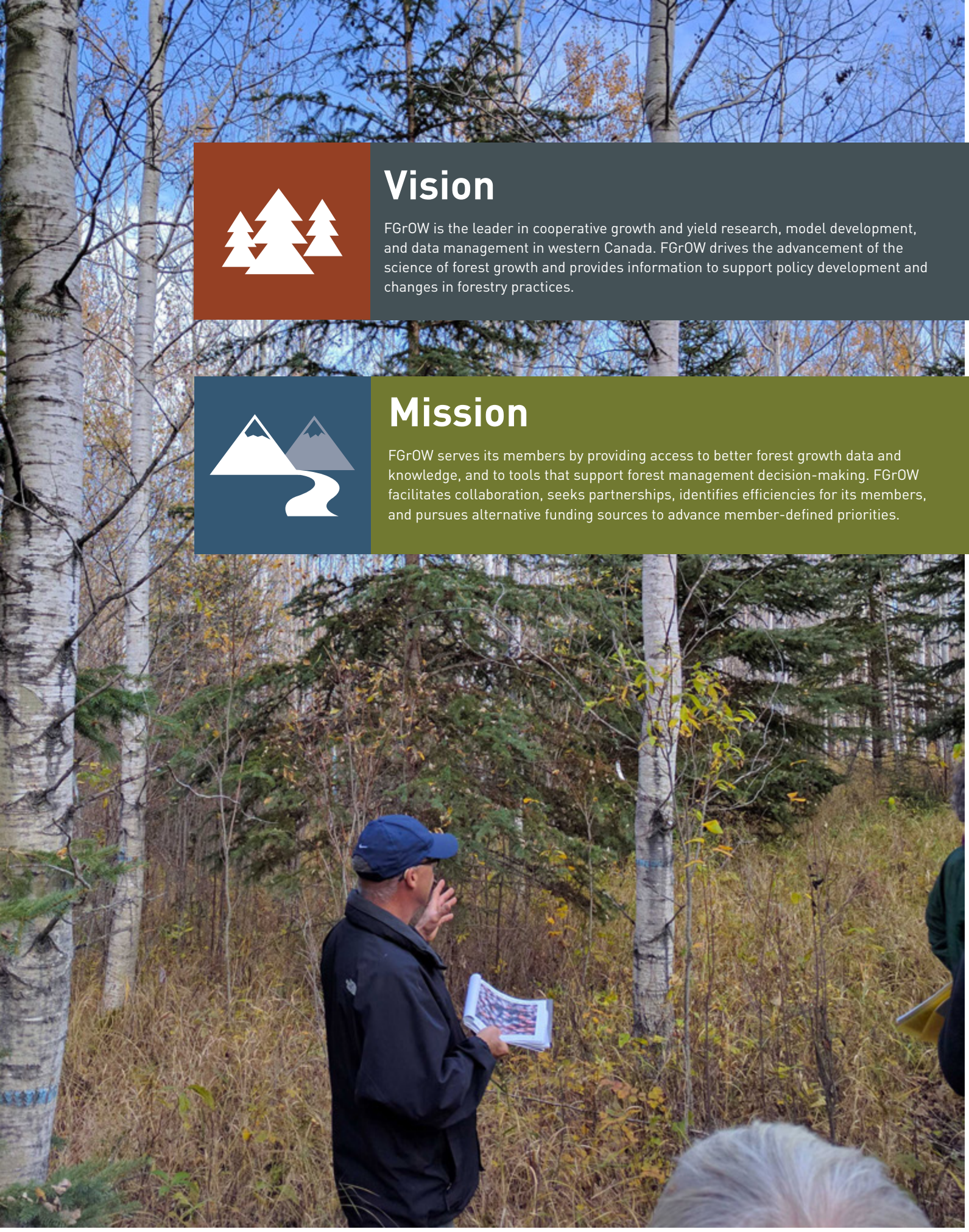
The University of Alberta and the Canadian Wood Fibre Centre of the Canadian Forest Service are associate members of FGrOW

Vision

FGrOW is the leader in cooperative growth and yield research, model development, and data management in western Canada. FGrOW drives the advancement of the science of forest growth and provides information to support policy development and changes in forestry practices.

Mission

FGrOW serves its members by providing access to better forest growth data and knowledge, and to tools that support forest management decision-making. FGrOW facilitates collaboration, seeks partnerships, identifies efficiencies for its members, and pursues alternative funding sources to advance member-defined priorities.



Executive Council

Melonie Zaichkowsky, Chair, Canadian Forest Products (2017–2020)

Darren Aitkin, Alberta Agriculture and Forestry (2015–2020)

Vashti Dunham, Weyerhaeuser (2019–¬2020)

Tim McCready, Millar Western Forest Products (2015–2020)

Shane Sadoway, Blue Ridge Lumber (2016–2020)

Sharon Meredith, FGrOW Executive Director, non-voting

Project Team Chairs

Foothills Pine Project Team
Matt Denney, Spray Lake Sawmills

Mixedwood Project Team
Dave Swindlehurst, Weyerhaeuser

Policy and Practice Project Team
Tim McCready, Millar Western Forest Products

TIA Project Team
Dave Swindlehurst, Weyerhaeuser

WESBOGY Project Team
Phil Comeau, University of Alberta

Workshops

Tree Improvement Alberta (TIA) held a Cone Induction Workshop at the Alberta Tree Improvement Seed Centre in Smoky Lake on May 3, 2018. Approximately 20 people were in attendance to hear Dr. Patrick von Aderkas from the Centre for Forest Biology at the University of Victoria.

The Foothills Pine Project Team (FPPT) hosted a workshop in Edmonton on September 27, 2018. The focus was on how research supports operational reforestation, yield planning, and risk management. It was attended by 17 people.

On November 14 and 15, 2018, the WESBOGY project team held and Mixedwood Growth Model (MGM) User Workshop. It was well attended, with 32 participants.

An MGM Technical Session and User Workshop was held in Prince Albert, Saskatchewan on February 21 and 22, 2019. Fifteen people attended this WESBOGY event.

October 2, 2019, the FPPT held a workshop that provided an update on and discussion of future plans for the Regenerated Lodgepole Pine Trial and FRIPSY. It was attended by 14 people.

The WESBOGY project team held a planning workshop at the University of Alberta on February 5, 2020. The 18 participants discussed plans for the project and for development and support of the Mixedwood Growth Model.

Field Tours

On September 13 and 14, 2018, 28 brave souls attended a snowy tree improvement field tour hosted by Hinton Wood Products. The tour visited sites in the Hinton and Edson area, including the Presslee Orchard.

The 2018 FGrOW Annual Field Tour was held on October 3 in the Peace River area and was attended by approximately 25 people. The focus was on Mixedwood Management and included a visit to the Hotchkiss Forest.

Blue Ridge Lumber Inc. hosted a field tour for the TIA Realized Gain Trial FRIAA Project on July 16, 2019. Approximately 29 attendees visited various sites in the Whitecourt area.

On October 9, 2019, the FGrOW Annual Field Tour focused on thinning and herbicide treatments. The tour attracted 42 attendees to the Whitecourt area.

Current Projects

Foothills Pine Project Team
Regenerated Lodgepole Pine (RLP) Trial

Cooperative Management of Historic Research Trials (HRT)

Remeasurement of MPB PSP Network

Mixedwood Project Team
Strip Cut Understory Protection (SCUP) Trial

Dynamic Aspen Density Experiment (DADE)

Mixedwood Regeneration Model Pre-feasibility Study

Policy and Practice Project Team
Provincial Growth and Yield Initiative (PGYI)

Alberta Research Database

Quantification of Herbicide Impacts on Timber and Non-Timber Values

Excel Toolbox for Forestry

Tree Improvement Alberta Project Team
Realized Gain Trials (RGT)

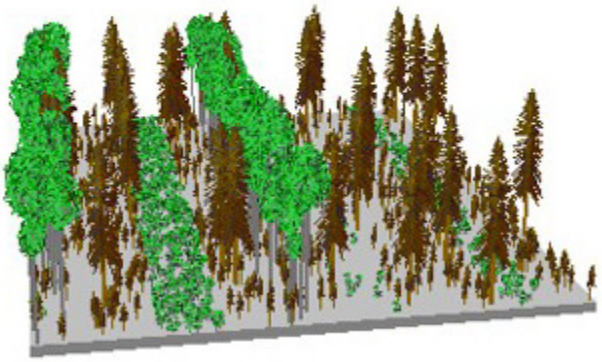
WESBOGY Project Team
Mixedwood Growth Model (MGM) Development

Long-term Study (LTS)

FRIAA Open Funds Projects
Developing and Enhancing the Mixedwood Growth Model (MGM) for Forest Management Planning, sponsored by Alberta Plywood

Effects of harvesting and site preparation methods on juvenile stand development of lodgepole pine, sponsored by Hinton Wood Products

Empirical Post-Harvest Stand Assessment, sponsored by Millar Western Forest Products



Upcoming Projects

FGrOW is constantly engaged with members and responsive to their requests for projects to address emerging issues. Two of the projects that are currently under investigation are a Mixedwood Regeneration Model and an Enhanced Forest Management Project.

Mixedwood Regeneration Model

Mixedwood Project Team Members have identified the need for a mixedwood regeneration model that could be used for:

- developing and comparing reforestation strategies at the yield stratum level to meet yield objectives
- defining or refining functional grouping of stand and site types for reforestation operations
- selecting planting densities and tending treatments for different groups
- identifying stand and site types with high risk of regeneration failure
- educating planners and silviculturists for improved linkage between silviculture and yield planning

A pre-feasibility study is underway to determine how development of a mixedwood regeneration model could be structured, and to identify any limiting information gaps. When the pre-feasibility study is complete, members will decide whether to proceed with model development, and if any new data collection will be necessary.

Enhanced Forest Management

A need for more quantitative information on stand response to enhanced forest management treatments was recognized by the Policy and Practice Project Team. Work is underway on a proposal for a project that would:

- Develop predictions of stand response to pre-commercial thinning, commercial thinning, understory protection, and fertilization in managed and natural forest types across Alberta.
- Develop a plan for policy recommendations which will enable incorporating EFM response into timber supply analysis.

WESBOGY Long-term Study

Background

Mixed stands of trembling aspen and white spruce are a prominent component of our western boreal forests. Despite the fact that aspen can slow the growth of white spruce, there are a number of advantages to managing mixedwoods, compared to converting to monocultures. Advantages can include higher total yields, reduced incidence of frost damage to spruce, reduced vigor of understory competitors, and higher spruce wood quality. Long-term site productivity may also be enhanced by the presence of aspen, which takes up nutrients and retains them on site. Maintaining mixed stands in landscapes where they are naturally common also contributes to sustainable management objectives such as preserving biodiversity, protecting wildlife habitat, and preserving visual characteristics in the landscape.

Despite the advantages to managing for mixed stand types, this does involve added complexity. Improving our understanding of stand dynamics and growth in these complex stand structures is important to accurately predicting outcomes from mixedwood management practices. The Western Boreal Growth and Yield Association, now the WESBOGY Project Team of FGrOW, recognized this need and began to establish a Long-term Study (LTS) in 1990 to advance our understanding of the dynamics of spruce/aspen mixedwood stands. Today, the study includes a total of 615 plots established across British Columbia, Alberta, Saskatchewan, Manitoba and the Northwest Territories (see map).

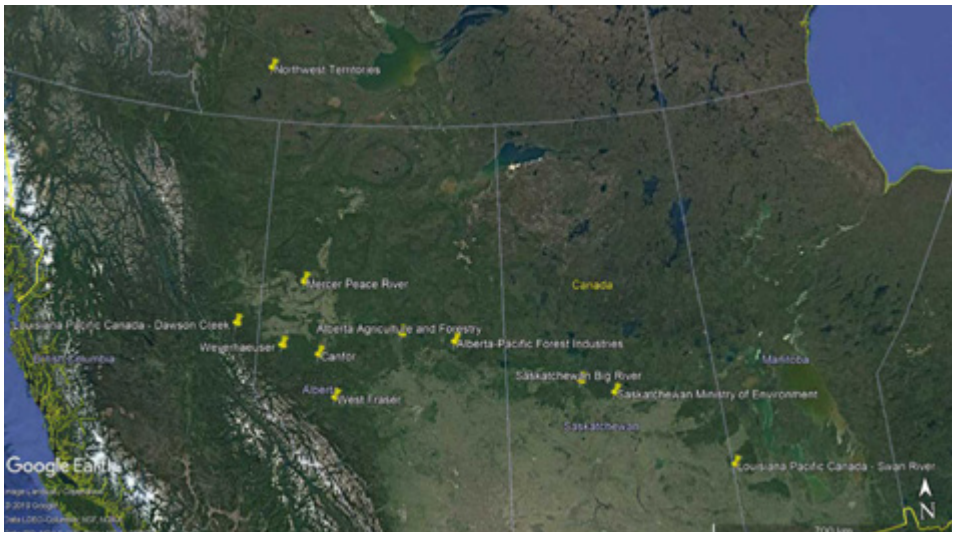


Figure 1. Location of WESBOGY Long-term Study Installations.

Overview

This study involved planting white spruce seedlings in recently clearcut areas where aspen regeneration had already been established. Five years after planting, spruce and aspen were thinned to desired treatment densities (Table 1). Each installation consists of two replications of 15 treatments. Measurement plots are 20m by 20m (0.04 ha) with a 5–10m wide treated buffer on each side of the measurement plot. Trees are measured annually for the first 10 years of the study, every 2 years between ages 10 and 20, and then every three or four years. Collected data are all stored in a database that is maintained on a secure server at the University of Alberta.

Results

At age 20, (15 years after thinning) aspen heights are similar across treatments but are smaller in the 200 sph treatment than in the 4000 or natural. Aspen diameter at breast height (DBH) and crown width (CW) decrease, while slenderness and height to live crown (HTLC) increase with increasing aspen density (Table 2).

Table 1. Treatment numbers for the 15 spruce and aspen density combinations created in the WESBOGY LTS.

		Aspen Density (sph)					
		0	200	500	1500	4000	Natural
Spruce Density (sph)	1000	1	2	3	4	5	6
	500	7	8	9	10	11	12
	0	x	x	x	13	14	15

Results 15 years after thinning show that aspen has significant effects on spruce size, with spruce in the unthinned natural plots having the smallest height and DBH (Table 3). At age 20, spruce height, DBH and crown width decrease with increasing aspen density while slenderness and height to live crown increase with increasing aspen density. Slenderness and DBH show the strongest response to aspen density. Reductions in crown width with increasing aspen density are linked to reductions in branch diameter and, together with an increase in height to live crown with increasing aspen density, could lead to reductions in the number and size of knots on the lower stem of these trees as they mature. The photos below show spruce at age 20 in the 1000 sph spruce / 0 sph aspen treatment (left) compared to spruce 1000 sph under natural untreated aspen (right).

Table 2. Effects of aspen density on aspen at 15 years after thinning. Values represent the averages of the top trees (100 largest DBH per hectare) for the 8 oldest LTS installations. The lowercase letters following the parameter estimates represent the results of a Tukey's test on means. Parameters with the same letter within each column are not significantly different.

Treatment Density	HT	DBH	Slenderness	CW	HTLC
200	12.28b	16.14a	0.77d	2.16a	3.17d
500	13.03ab	16.04a	0.82d	2.23a	3.76c
1500	13ab	14.86b	0.88c	1.85b	4.24c
4000	13.3a	13.89b	0.96b	1.7b	5.25b
Natural	13.3a	11.31c	1.2a	1.39c	6.04a

Table 3. Effects of aspen density on spruce at age 20, 15 years after thinning. Values represent the averages of the top trees (100 largest DBH sph) for the 8 oldest LTS installations. The lowercase letters following the parameters represent the results of a Tukey's test on means. Parameter estimates with the same letter within each column are not significantly different.

Treatment Density	HT	DBH	Slenderness	CW	HTLC
0	5.79a	9.22a	0.67e	1.28a	0.55b
200	5.67ab	8.8a	0.73de	1.3a	0.57b
500	5.66ab	8.01b	0.76d	1.23ab	0.59ab
1500	5.31bc	6.86c	0.84c	1.16bc	0.61ab
4000	4.93c	5.84d	0.92b	1.97c	0.64a
Natural	3.89d	4.29e	1.04a	0.87d	0.67a

Future Role of the WESBOGY Long Term Study: Climate Change

Since LTS installations cover a wide range of climatic conditions and are distributed widely across the western boreal forest, continued monitoring, coupled with monitoring of climatic conditions on site (with instrumentation being installed in connection with the CFI funded SmartForests project in 2019 and 2020) will provide valuable information on the impacts of climate change, and its interactions with aspen and spruce densities on tree and stand responses. The study also provides long term tree level data needed for the development and testing of growth models like MGM.

For additional information on the WESBOGY LTS please contact Phil Comeau (phil.comeau@ualberta.ca) or Mike Bokalo (mike.bokalo@ualberta.ca).

Mixedwood Growth Model

The Mixedwood Growth Model (MGM) is a deterministic, distance-independent, individual tree growth model developed by the University of Alberta for the western Canadian boreal forest. MGM simulates the growth of five major boreal species (white spruce, lodgepole pine, trembling aspen, black spruce, and jack pine) in pure or mixed stands. The model starts with a tree list or stand summary data. MGM then uses growth and survival functions to project the list of trees into the future. Outputs include yield tables and charts portraying averages and totals for the conifer and hardwood components including estimates of above ground tree biomass. The Stand Visualization System can also be used to provide visual snapshots of stand structure at specific points in time.

MGM is well suited for modelling both natural and managed stands including simple, even-aged stands, mixed species stands, as well as more complex (multi-age, multi-cohort, vertically structured) stands created through partial harvesting practices such as understory protection or other tending practices.

Development of MGM has been supported by industry, provincial and federal governments, and FRIAA. This work has focused on several key needs:

- yield estimation in support of forest management plan development (both natural origin and managed stands)
- estimation of mean annual increment (MAI) from performance survey data
- developing and evaluating response curves for understory protection and other tending practices
- rationalizing and understanding the effects of silviculture on managed stand yields

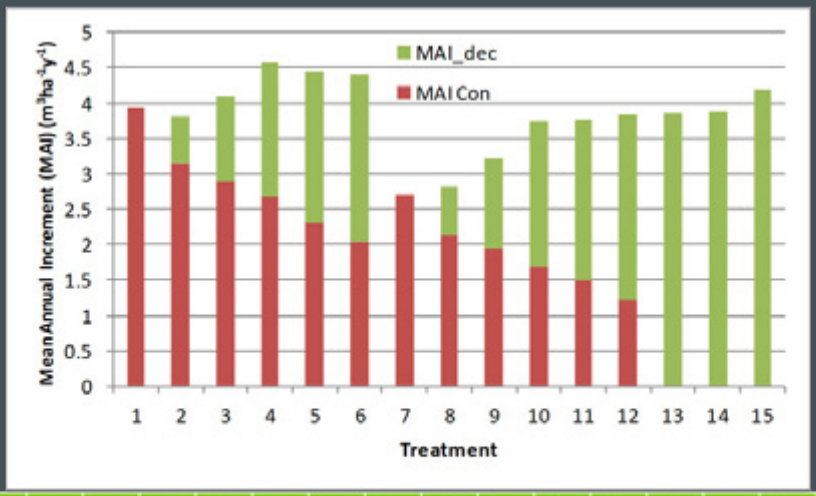
Refining and improving MGM has been an ongoing focus of the MGM Development Team at the University of Alberta. The current version of MGM, released in July 2019, represents a substantial update that includes new climate-sensitive tree survival functions, implementation of the Growth and Yield Projection System (GYPSY) site index curves for Alberta, and support for additional species (i.e. jack pine and black spruce). This release has undergone extensive validation and behavioural testing and is currently undergoing a formal review by the Government of Alberta.

Current model development includes enhancement to model tree improvement, validation and/or re-calibration of the tree list generator, inclusion of a white spruce release response function, and an update to the maximum size-density functions.

In addition to model development, user support and training in the form of user workshops has been offered.

The model is publicly available; information on downloading and installing MGM, along with model documentation can be found on the MGM website at http://www.mgm.ualberta.ca.

For further information please contact: Mike Bokalo (email:mike.bokalo@ualberta.ca).



T	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Aw	0	200	500	1500	4000	un	0	200	500	1500	4000	un	1500	4000	un
Sw	1000						500						0		

Figure 1: Conifer and deciduous mean annual increments (MAIs) at age 90 based on MGM simulations for 299 WESBOGY long term study plots grouped by aspen and spruce treatment densities.

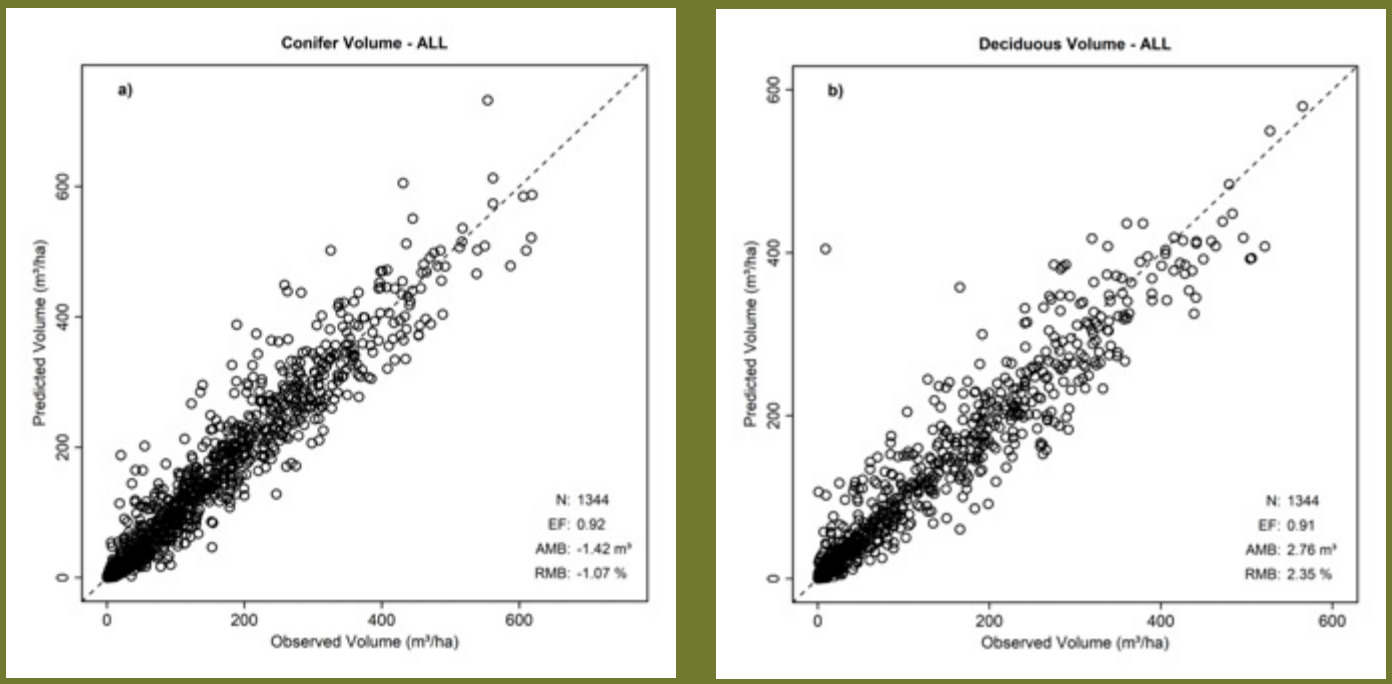


Figure 2. Scatterplots of MGM predictions against observed stand volume (m3) for the full Alberta PGYI dataset show that MGM is validating well against data from measured permanent sample plots

Regenerated Lodgepole Pine Trial

In the late 1990s some forward-thinking foresters working in the foothills of Alberta realized there was a need for better information about how lodgepole pine regenerates and grows after harvest. They recognized that stand dynamics of managed stands could be quite different from fire origin ones and that juvenile stand development is affected by the site's characteristics and any silviculture treatments applied. This interest in juvenile lodgepole pine stand dynamics led to the formation of the Foothills Growth and Yield Association (FGYA) and to the establishment of the Regenerated Lodgepole Pine (RLP) trial beginning in 2000.

The RLP trial uses a replicated split-plot design consisting of 102 one-hectare permanent sample plots, each with four sub-plots, distributed throughout the upper and lower foothills natural sub-regions. After clearcutting and either drag scarification, mounding or no further site preparation, the plots were planted at a range of densities from zero to 4444 trees per hectare. Two of the four sub-plots in each main plot were weeded, and two were later thinned, resulting in four treatment combinations: control, weed only, thin only, and weed and thin. Weeding involved either chemical or mechanical reduction of hardwood, shrub and herbaceous competition during the first six years following planting. Thinning, which included removing both conifer and deciduous trees to target pine densities, was undertaken between 2012 and 2014.

As the RLP approaches 20 years old, the result of the years of effort that have gone into the trial are paying off and have provided information to support silviculture decision making. Analysis of measurement data for 17 growing seasons after planting have provided an understanding of the impacts of herbicide and thinning on stand development, and their interactions, as well as insight into the outcomes of planting at different densities. The analysis also shows relationships between site quality and stand development and illustrates the effects of site on pine growth and hardwood competition. Publication of these results is expected in 2020.

The trial data has also been used to develop a regeneration model called the Foothills Reforestation Interactive Planning System (FRIPSY). The model is intended to assist users with:

- Planning at the stratum level
- Assessing trends at the stratum level
- Helping to define or refine functional groups
- Possibly helping to determine planting densities on different site types
- Helping to identify high risk areas/ types
- Educating staff and improving link between silviculture and yield.

FRIPSY is built on an Excel platform and predicts stand development to performance age (12 to 14 years after harvest). Projections are based on user supplied harvest, planting, site, and treatment information; these can be supplemented with establishment survey information. FRIPSY links directly to the Growth and Yield Projection System (GYPSY) to project the impacts of alternative silvicultural prescriptions on mean annual increment (MAI). The current version of FRIPSY models only pine and aspen, but inclusion of other species such as spruce and fir planned for a future release. Other planned enhancements to FRIPSY include extending the regeneration forecast and time of handoff to GYPSY to 18 years after harvest and addition of pre-commercial thinning response.

Nearly 20 years of measurements leading to a solid understanding of regenerated lodgepole pine treatment response.

Realized Gain Trials: where to from here?

Background

In Alberta, one of the significant challenges with determination of genetic gain in breeding programs, called Controlled Parentage Programs (CPPs), is the lack of realized gain trials (RGT). Genetic gain, in Alberta, is currently calculated on the basis of height gain as measured through controlled progeny trials at experimental test sites. Progeny trials are established on uniform sites, at regular inter-tree spacing, and are controlled for vegetative competition and natural ingress. These types of trials are generally considered adequate for comparing and ranking the families included in the program, however they do not adequately assess performance of genetic stock under normal, operational reforestation conditions. As a result, the link between height gain and volume gain per area of deployment is poorly understood. Realized gain trials are necessary in order to know how much the improved stock increases growth and volume yield.

FRIAA Grant Project Finalized

Through a grant agreement (FFI-15-011) with FRIAA, six Alberta forestry companies collaborated with the University of Alberta (U of A), Isabella Point Forestry, and Alberta Agriculture and Forestry (AAF) to carry out this project.

The RGTs established though this project were designed to quantify the volume gain from improved stock instead of wild seed sources. These trials will have substantial value in the monitoring and validation of genetic gain assumptions in current Forest Management Plans, while also providing critical data for the development of growth models that are better able to project yield increases resulting from deployment of improved stock.

Through this project, 150 unique site and seedlot combinations were established that included a mixture of paired-plots (53), tri-plots (12) and quad-plots (2) shared among the participating companies. In addition to the RGT sites, a total of 130 Permanent Sample Plots were installed to allow monitoring of these trials. A master's student from the U of A measured and assessed paired plots in 2018 to address questions associated with early growth and survival.

As part of the knowledge transfer for this project, on July 16, 2019 a field tour was hosted by West Fraser – Blue Ridge Lumber for project partners, AAF, and the U of A to visit RGT installations in order to have discussions focused on site selection, reforestation challenges, and ongoing maintenance.

Operational Tree Improvement Monitoring Subcommittee

A shared interest to define monitoring expectations and data requirements in operational deployment of improved material was identified at the outset of the Realized Gain Trial FRIAA project. At the Tree Improvement Alberta 2017 fall business meeting, members agreed that to move forward with this, a subcommittee should be convened to discuss and compile recommendations on program objectives and specifications, data collection, and installation best practices. As a result, the Operational Tree Improvement Monitoring (OTIM) Subcommittee was established in March 2018 and included representatives of TIA member companies, the U of A and AAF.

The mandate for the OTIM Subcommittee was to develop recommendations on how the RGT program could be expanded to satisfy most, or all, Tree Improvement–related data needs associated with forest management planning growth and yield programs.

The mandate helps FGrOW and the TIA Project Team meet several of their goals:

FGrOW Goals	Facilitate discussion among members on forest management practices related to growth and yield policy and provide input on growth and yield policy.	Coordinate collaborative solutions in forest growth data collection and management.
FGrOW Tactics	Strike working groups to develop recommendations for addressing areas of concern identified by members.	Enable collection of data suitable for growth model validation, development and enhancement and allow members to achieve cost-savings in their growth and yield programs through collaborative data collection.
TIA Project Team Goals	To provide an avenue for constructive dialogue between companies involved in tree improvement and the Alberta Government.	To promote and facilitate communication among Forest Genetics, Growth and Yield, and Silviculture practitioners on all forest genetics related matters.

OTIM Draft Report and Next Steps

The OTIM Subcommittee recommendations report, "Guidelines for Operational Growth & Yield Monitoring of Improved Seed Deployment & Forest Management Plan Yield Projections" (DRAFT, Version 1.0, January 31, 2020) has been provided to TIA members and other FGrOW members that may have interest in it. The report outlines what a collaborative Realized Gain Trial provincial program should look like from the broad sample design, site selection, and installation establishment, to plot establishment and associated measurement protocols.

The next step in this process is for interested companies to work together on determining how to implement a provincial RGT program, and allocation of program plot requirements. To begin these discussions, TIA will host a 1-day workshop in spring 2020.

Empirical Post-Harvest Stand Assessment Project

Background

Effective and reliable reforestation in post-harvest stands is essential to sustaining Alberta's timber supply, among the many ecosystem services provided by provincial forests. Over time, as more of the landscape has been harvested, there has been an increasing emphasis on collecting data in post-harvest stands to assess regeneration. These data serve operational needs, such as meeting obligations under the Reforestation Standard of Alberta (RSA). Many permanent sample plots (PSPs) have also been established in post-harvest stands and incorporated into the Provincial Growth and yield Initiative (PGYI) database. These provide a time series of observations useful for assessing regenerating stand condition relative to treatment and site condition, and for evaluating and improving forest growth and yield models. Gathering data and assessing post-harvest stand development is the goal of the Empirical Post Harvest (EPH) Stand Assessment Project.

Overview

The project has had two phases, the first of which was completed in 2013 and focused on gathering and compiling data into a project database. Data came from recent (2009 onwards) reforestation performance surveys and historical surveys of openings dating back as far as 1985 that used similar protocols. In addition, 58 of these historical openings were re-measured to create a time series of stand condition.

This, the second project phase, began in 2017. The master database was expanded by adding more performance survey data, re-measuring the historical openings sampled in the first phase, and re-sampling an additional 23 openings that were included in the performance data from the first phase. These additional openings added coverage of stand types that were not well-represented. The database now contains more than 6,000 unique performance surveys and 1,500 historical surveys, of which 84 have been re-measured one or two times. The database is paired with PGYI data for post-harvest stands.

The basic question to be answered in EPH analysis is how post-harvest stands are developing. This has been approached from three directions. First, the condition of post-harvest stands is evaluated relative to intent by comparing the realized Broad Cover Group (BCG) against the declaration recorded in ARIS.

Second, how might we describe stand condition at performance age? Here, the emphasis is on evaluating RSA performance survey data to identify relationships between density, stocking, and stratum, and silvicultural history.

Third, are there characteristic patterns in post-harvest stand development, and can they be related to intent, site condition, or silviculture? For this question, re-measured openings, and PSPs in particular, are the focus.

Results

Overall, the data suggest there is a substantially larger deciduous component in post-harvest stands at age 12–14 than might be expected from the initial declaration to one of four Broad Cover Groups. Sampling units declared to conifer met the criteria for pure conifer (>80% by density) at performance age on 40% of the land area, but for units declared to conifer-leading mixedwood only 25% of the declared area met the criteria. While these results present a snapshot of early stand development, they represent only a single point, at performance age of 12–14 years, and only examine density, not yield. Therefore, they must be interpreted in the context of other analyses.

Declaration	Opening Area (ha)				Total Declared (ha)	%OK
	Data-Based Stratum					
	D	DC	CD	C		
D	2,105	131	-	-	2,236	94%
DC	2,965	3,201	717	112	6,995	46%
CD	2,557	7,087	3,548	932	14,124	25%
C	2,328	10,111	10,928	15,350	38,717	40%
Area Achieved	9,955	20,530	15,193	16,394	62,072	39%

In Alberta, BCG is purposefully broad to make concise summaries possible. But much variation exists among individual stands within strata, across natural sub-regions, and is influenced by pre-harvest composition, ecology, and silvicultural intent. Models, principally GYPSY, are used to link regenerated stand conditions at the stratum level to growth and yield. Re-measured EPH data have been used to compare model predictions to stand development outcomes, revealing situations where model assumptions are more or less strong and the degree to which stand development matches expectations. An example is shown for the pine species group, revealing that GYPSY projections tend to over-estimate density and top height, at least in the sample of openings selected for measurement in the EPH project. These results also reveal some sharp reductions in density and stocking due to a mortality event between the two most recent measurements.

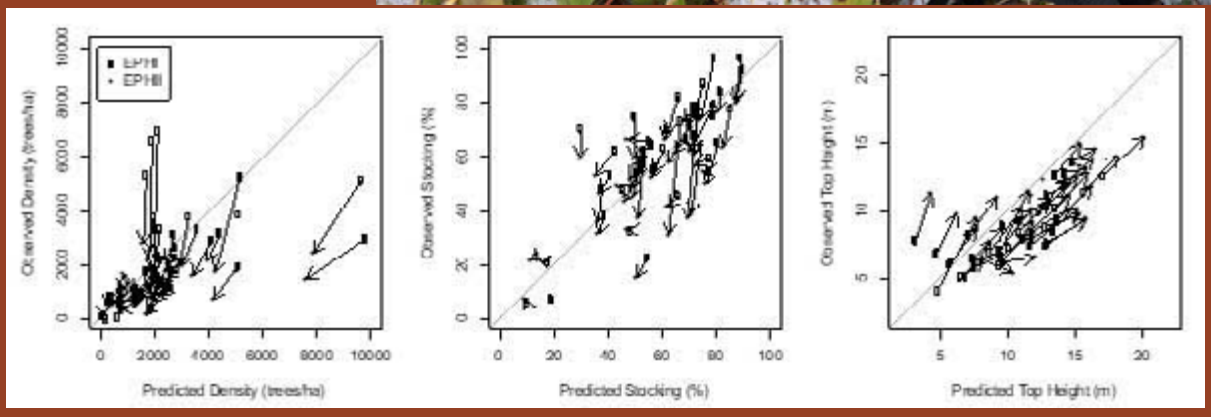


Figure 1. Comparison of observed stand attributes to those projected using the GYPSY model, for the pine species group in the EPH data. Arrows illustrate how results for individual stands have changed between EPH Phase 1 and Phase 2 re-measurements, about seven years apart.

Next Steps

The EPH project analysis is ongoing but will be completed in the first half of 2020. The results will be compiled in a final report that includes recommendations of the most promising and useful data types, and data gaps to prioritize for future measurements and analyses. The project will also create an analysis code-base and improved data set for use in subsequent projects.

Stand Dynamics after Mountain Pine Beetle Attack

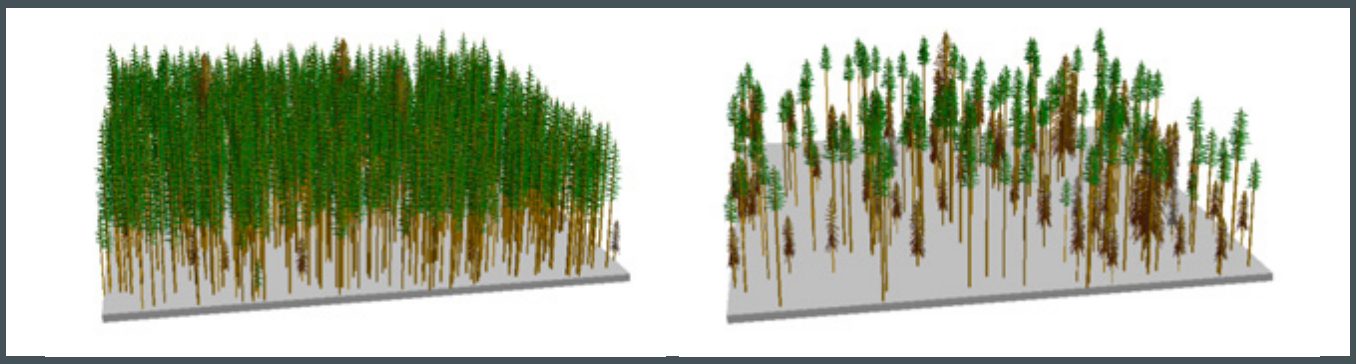
Members of FGrOW were among the first in Alberta to realize the importance of understanding how forests will respond to attack by MPB. A push to begin quantifying development in stands attacked by MPB was inspired by a 2007 field tour organized by the FGYA in parts of British Columbia that were heavily impacted by MPB.

Working with the fRI Research Mountain Pine Beetle Ecology Program, the first step was to protect a network of 240 existing pine permanent sample plots from harvesting and other human interventions. This was seen as an ideal opportunity to capitalize on existing information about pre-attack conditions and to continue monitoring these plots in the event of attack by MPB.

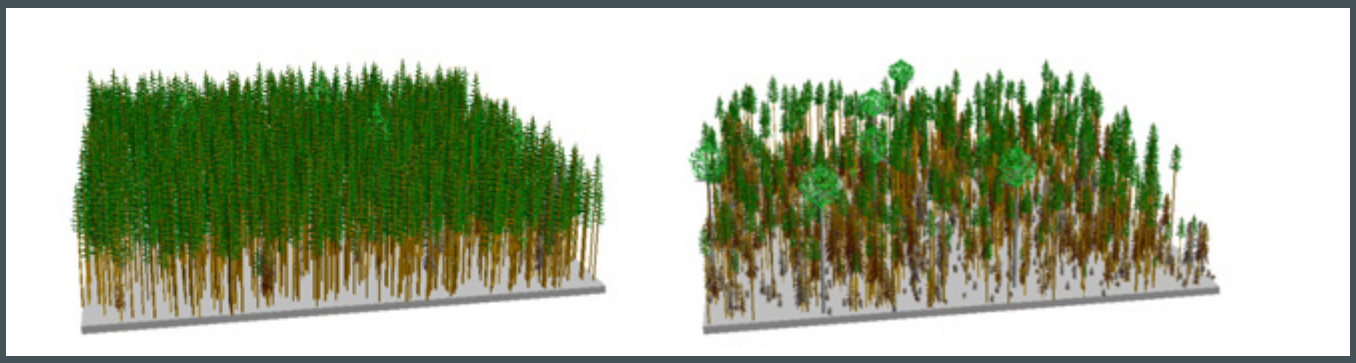
A recent analysis focussed on 65 of these plot located in 17 stands in the lower foothills natural subregion. All were attacked by mountain pine beetle before 2010 and had available plot measurements for conditions prior to and after attack, including information on intensity of attack.

There was a large range in attack severity between stands, with 11 stands having high levels of disturbance (70% or more lodgepole pine trees attacked), 6 stands with low levels (less than 15% of pine trees attacked), and two stands with intermediate levels. There was also a large variation in the presence of non-pine tree species and the amount of ingress between the stands.

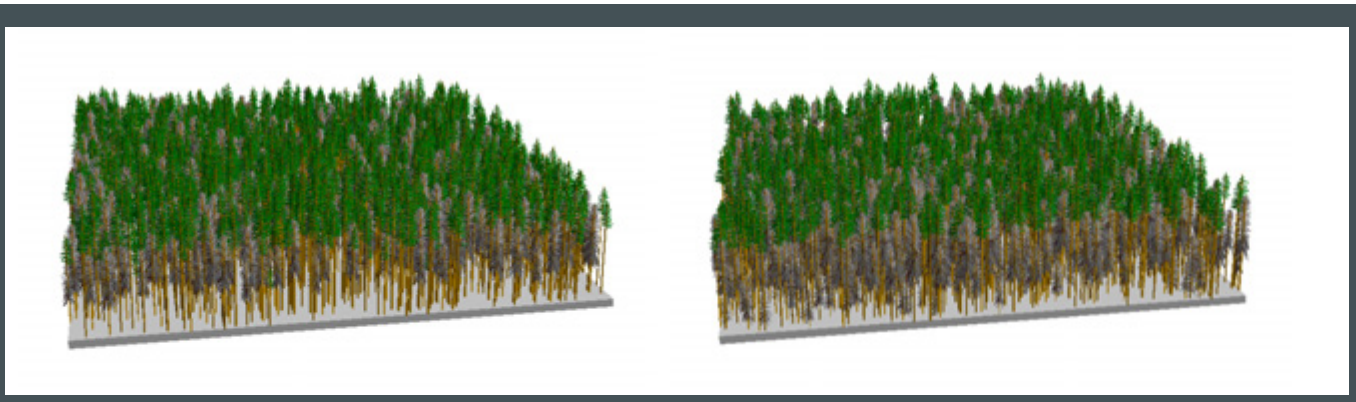
The plot measurement data were used to project future stand conditions using the Mixedwood Growth Model. Visualizations produced by the Stand Vegetation Simulator show the range of possible future stand conditions. The images below illustrate the range of post-attack stand conditions and associated projected future conditions. In each pair, the first image is pre-attack conditions and the second is projected conditions 30 years after attack.



Stand with high MPB attack severity and low levels of regeneration

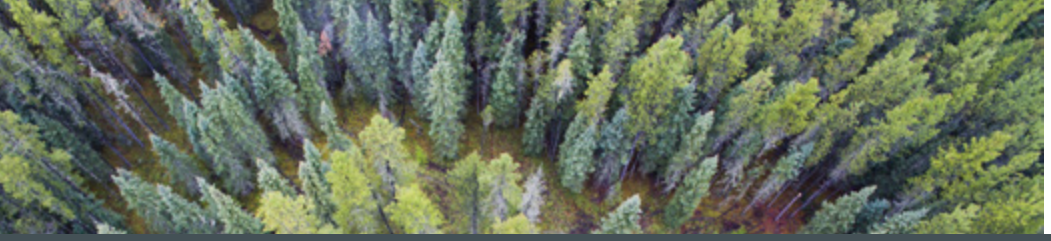


Stand with high MPB attack severity and high regeneration levels

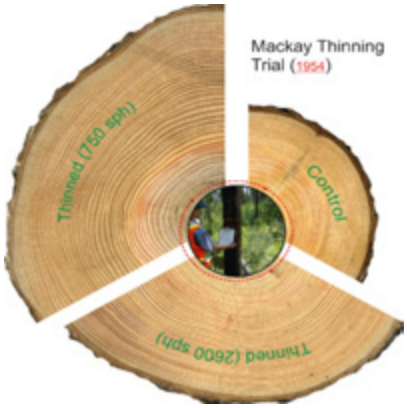


Stand with low MPB attack severity and significant non-pine regeneration

As illustrated above, stands attacked by mountain pine beetle in the lower foothills of Alberta will have a wide range of growth and yield over the coming decades. Attack levels and presence of non-pine advanced growth and regeneration are the main factors driving the different outcomes. They will be important considerations in planning salvage operations to minimize losses of timber yield and other forest values.



Alberta Network of Long-term Lodgepole Pine Silviculture Trials



Early in the 20th century, Alberta was a new province, still being settled and its resources still being explored. Forestry was the responsibility of the Forestry Branch of the federal Department of the Interior, and mostly focussed on inventory and protection. As the extent of harvesting began to increase, so did concerns about how those forests would be regenerated. Once the responsibility for managing the Crown forests devolved to the province in 1930, the federal forest service focussed on research, including developing silviculture practices based on local species and conditions, in particular lodgepole pine in the foothills of the Rocky Mountains. Much of this research was undertaken at the Kananaskis Forest Experiment Station (KFES), established in 1934. A number of research trials were installed at KFES in the 1930s and 1940s under the direction of Research Forester H. A. Parker, most with labour from the camp located there, created initially for an unemployment relief program, and ultimately for prisoners-of-war.

In the 1950s, the silviculture research program had expanded beyond KFES to other regions of the province and incorporated more rigorous experimental designs and treatments. In addition to stand regeneration, the experimental focus was on stand density management and fertilization to improve yield. Detailed documentation and durable field markings were conscious efforts to give these installations a long lifespan and allow measurements over the course of a rotation. Some of these installations still exist and remain valuable for monitoring long-term effects. The earliest remaining trial is K-57, established at KFES in 1949 by J. Quaite to investigate thinning effects in mature pine. The lack of knowledge about appropriate silvicultural practices prompted D. I. Crossley in 1951 to establish near Strachan a complex trial to determine the most suitable methods for harvesting, regenerating and thinning lodgepole pine. While the growth and yield value of this trial is diminishing, it remains an important demonstration site for school classes as well as forestry professionals. The MacKay trial near Nojack was established in 1954 by L. A. Smithers in a young pine stand to test different spacing treatments for their effect on yield and wood quality, including treatments of both an original spacing and later mid-rotation thinning, the latest occurring in 2014. This replicated and controlled experiment is frequently a subject of field tours.

The 1960s saw a flurry of trial establishment. In 1963, an experiment was established by Bob Ackerman in the 1956 Gregg River burn south of Hinton to test five levels of spacing across three levels of site productivity. Four years later, F. Marsh replicated the same thinning treatment design on three sites of different slope aspect at Teepee Pole Creek west of Sundre. Fertilization was also the subject of field trials in sites west of Caroline; initially a small trial established by Imre Bella near Ricinus in 1965, and a larger experiment established by Joe Soos (Alberta Forest Service) and Bella in 1968 on a thinned stand near Clearwater Ranger Station. The latter tested both composition and amount of different fertilizer mixes.

The only major long-term trial established in the following decade was the Swan Lake trial of mechanical thinning methods in high-density pine regeneration, which was established in 1976 by Imre Bella in the same area as the previous fertilization trials. Field trials were set up south of Hinton in 1971 by Richard Yang to test the effects of NPS fertilization on young and mature pine stands on two soil types; however, subsequent disturbance and loss of field marking rendered these unsuitable for long-term study.

The 1980s were again an active decade for silviculture trial establishment. A follow-up to the 1960s spacing trials was

established in the Gregg River burn in 1984 by V. S. Kolabinski and Stan Lux. This trial used the same design as the earlier Gregg River and Teepee Pole trials, but with a different set of thinning intensities. Also in 1984, Richard Yang followed up his earlier fertilization trial by establishing a highly-replicated factorial experiment on the McCardell Creek Road site to test different levels of nitrogen fertilization on thinned and un-thinned plots. Sam Takyi of the Alberta Forest Service also established two trials on low and medium productivity sites south of Edson 1980 to examine the effects of thinning and/or fertilization on overstocked lodgepole pine.

There followed a long hiatus in the establishment of thinning and fertilization field trial, accompanied by a general flagging of interest in silviculture. In the late 1990s, Dave Presslee of Weldwood was interested in applying these tools to Weldwood's forest management and became aware of the long-term trials established by CFS. He contacted Stan Lux at the Northern Forestry Centre (NoFC) to find out whether the field sites and data still existed. Lux recovered the data from various sources at NoFC, and together they visited the field sites to assess their status. This resulted in a series of field tours of the sites in 1999–2001 to showcase their results and continuing value.

At the same time, the companies operating in the foothills pine landbase were developing a research co-operative, the Foothills Growth and Yield Association (FGYA), which continues today as the Foothills Pine Project Team of FGrOW. As the continuation of these field installations was deemed to be of value to a range of stakeholders a framework for cooperative protection, measurement and evaluation was developed by Dick Dempster and Hugh Lougheed (FGYA), Dave Morgan (Alberta Sustainable Resource Development Lands and Forests Division (ASRD)) and Jim Stewart (CFS). This resulted in the signing of a co-management Memorandum of Agreement by ASRD, CFS and FGYA in 2002, renewed in 2007 and 2013. The field sites continue to be monitored for disturbance annually, re-measured periodically and have their markings renewed as required. The database of the complete time series of data from these trials is updated, compiled and archived at NoFC by Stewart.

In addition to use of the growth and mortality data by the co-op members, the data has also been given to other organizations for research purposes and development and/or testing of growth and yield models including GYPSY, MGM and TASS. In the past decade, some of these field installations have been used in a number of wood quality and remote sensing studies by Jim Stewart and a host of collaborators. While we have been fortunate that plots have avoided Mountain Pine Beetle attacks for many years, in the past two years we have documented attacks at the Gregg River, Mackay and McCardell sites. The co-management group plans to repurpose attacked plots to evaluate how the different stand conditions manifested in the different treatments affect MPB attack incidence and severity.

Most of the studies were established independently of each other, by different researchers, for different purposes. However, collectively they have generated substantial information on the range of response of lodgepole pine stands to density management and fertilization. Examining these long-term results

has enhanced our understanding of the responses of lodgepole pine to silvicultural treatments and aided in developing silvicultural practices that are most appropriate for this region and species. They represent a valuable and indispensable legacy of long-term results that continue to be useful in informing management decisions regarding lodgepole pine on the eastern slopes of the Rocky Mountains.

For more information on the trials or the publications arising from them, please contact Jim Stewart at 825-510-1202 or Jim.D.Stewart@canada.ca.

Provincial Growth and Yield Initiative

The Provincial Growth and Yield Initiative arose out of the desire to better understand managed stand dynamics and the need for growth models to predict future growth. PGYI, affectionately know as "piggy," is a cooperative data collection and management program that supports the development, validation, and calibration of growth models. It is the first undertaking of its kind in Alberta, and possibly in Canada. By joining forces and pooling their collective permanent sample plot (PSP) data, the province's forestry industry has created a one-of-a-kind dataset to support researchers developing growth and yield models.

Working with Alberta Agriculture and Forestry, FGrOW has developed standards for collecting PSP data and each of the participating organizations has committed to the number of plots it must maintain based on the company's annual allowable cut. Companies must target specific numbers of plots based on stand type (natural vs. managed), natural subregion and forest cover type.

PGYI data resides in a database maintained by FORCORP Solutions. Most of the participating organizations have now submitted measurement data, including historical measurements that extend as far back as 1960. In addition to the 3,225 natural stand and 1,329 managed stand plots supplied by participants, the database houses measurement data from FGrOW's Historic Pine Research Trials and its network of post-MPB attacked plots.

Although PGYI was only established in 2014, the data are already proving to be an invaluable resource. The Empirical Post Harvest Stand Assessment project is using the data to evaluate the relationship between early stand conditions, silviculture and future stand conditions. The Herbicide Quantification project will also rely on PGYI data for a comparison of stand development with and without herbicide treatments. Data cleaning and compilation work is currently underway that will lead to use of the data in development and enhancement of the GYPSY model, and PGYI data have already been used for MGM model validation.

A review of the PGYI data is currently underway to determine how well individual targets are being met and whether any changes are needed to enhance the program.

Site Preparation Project

A combination of roadside processing and drag scarification is most likely to minimize mortality of planted trees and maximize timber yield.

Site preparation is an important tool in the silviculturist's toolbox and understanding how it interacts with other treatments and site conditions is important for rationalising silviculture investments and predicting long-term outcomes. Results of the regenerated lodgepole pine trial suggested that mechanical site preparation improved health and survival of pine regeneration 12 years after planting. The trial was not designed to control for the effect of site prep, so another trial or other information to confirm this observation was of interest to Foothills Pine Project Team members.

Just such a trial was established by Sundance Forest Industries in 2001. It was designed by Simon Landhäusser to investigate the effects of slash removal and site preparation techniques, and their interactions, on natural and planted lodgepole pine. The site preparation techniques were drag scarification, mounding, and no mechanical site prep. The slash removal treatment was intended to simulate whole-tree harvesting with roadside processing. Slash retention mimicked conditions created by cut to length harvesting.

A remeasurement of the trial in 2017 was funded by FRIAA and sponsored by Hinton Wood Products. Analysis of the measurement data indicated that the combination of roadside processing followed by mounding or drag scarification is most likely to maximize timber yield and minimize mortality of planted trees. Stump-side processing (slash retention) results in higher costs, more death of planted trees and, possibly, in lower yields.

Drag scarification is the best treatment for promoting natural regeneration of pine. However, high densities achieved in some situations may suppress future timber yield, but to what degree is uncertain.

Although not doing site preparation saves money and time, at least initially, it may result in reduced timber yields and increased mortality. This may lead to fill-in planting costs and regeneration delays. Slash removal and site preparation are particularly important where survival of planted trees is a priority, such as for tree improved stock, or if Armillaria or other root disease is a concern.

The results of the study are expected to be published in 2020 and will contain more details and further insights.

Quantification of Herbicide Impacts on Timber and Non-timber Values

Introduction

Herbicide use for stand tending of reforested lands is one of the more controversial aspects of forest management. This controversy has been exacerbated by recent media coverage of the potential carcinogenicity of the glyphosate which is the most used herbicide for forest management. Recent concerns have also been raised by some academics and activists as to the use of herbicides resulting in forests more susceptible to risk factors such as fire and climate change.

In the face of these concerns, FGrOW is seeking to quantify the long-term effects of herbicide use for stand tending on both the composition and growth of forests. In particular, this project seeks to evaluate the impact 25 years or more post-treatment on plant community composition, general biodiversity, and growth of tree species.

Methods

There are numerous studies which document the impact of herbicide use in a boreal environment on tree growth and plant biodiversity; however, most of these studies were conducted within the first 10 years after herbicide use. As this project examines herbicide impact over a much longer period, it enables evaluation of herbicide impact on a maturing forest.

The study evaluates a number of older herbicide trials established to monitor the effects of herbicide use which had an untreated control included in the trial. The control is a critical component for assessing long-term effects of herbicide use as it provides a reference case for what would have happened without herbicide use.

The nine study sites for the FGrOW project were established over a 10-year period immediately prior to, and during, the adoption of herbicides for operational use in Alberta (1986–1996). Each site includes an untreated "control" area. All sites were assessed in 2003 and response to herbicide treatment reported in a 2004 paper in The Forestry Chronicle[1] . The initial assessment focused entirely on tree composition and growth.

The current study addresses plant community composition and plant biodiversity, through an assessment of species present and occurrence of species typical to the ecosites on which the treated cutblocks occur. This is in addition to an assessment of density, height and diameter of trees present. The study is able to assess the impact of herbicide use on both fibre volume produced by the forest and on production of an array of other ecosystem services.

Deliverables

In addition to analysis of the plant community and tree data, the project will produce:

- Low level, high resolution color images taken by unmanned aerial vehicles for all sites.
- Projections of tree growth to 80 years post-harvest using GYPSY.
- A series of information bulletins to share outcomes with interested members of the public.
- A tour package, including highlights of results and maps showing access, will be prepared to enable FGrOW members to use these sites to facilitate discussion of herbicides with interested parties.

The photos show a stand 22 years after herbicide application in areas that were untreated (left) and treated (right).

Quantifying long-term impacts of herbicide on stand development

1 Pitt, D.G., M. Mihajlovich and L.M. Proudfoot. 2004. Juvenile stand responses and potential outcomes of conifer release treatments on Alberta's spruce – aspen mixedwoods site. Forestry Chronicle, 2004, 80 – 5: 583-597.

Mixedwood Silviculture Guide

Developed by the Mixedwood Management Association in 2007, The Alberta Silviculture Guide was intended for use by field and management foresters, allowing them to interpret field data and identify risks and opportunities. The Guide used information from the published literature and other sources, and integrated this knowledge to predict future stand characteristic such as volume; species composition; gross stand structural attributes; fibre quality; and economic return as a function of initial species composition, ecosite types, and management interventions. The Guide was intended to outline a range of silvicultural opportunities and strategies with their associated risks, and the likely resulting stand trajectories of these management activities.

The original Guide was a computer-based tool developed for use with MS

A guide consisting of flowcharts and decision support tools to be used in developing silviculture prescriptions for spruce and aspen mixedwood stands

Excel 2000/2003 and MS Windows XP. As it was not compatible with the newer versions of MS Windows or MS Excel, the FGrOW Mixedwood Project Team (MPT) commissioned revisions of the Mixedwood Silviculture Guide. The intent was to replace the electronic processes with text and flowcharts, thereby making the Guide more approachable and user-friendly. It was also updated to reflect the latest silviculture research.

"The Alberta Silviculture Guide: Boreal Mixedwood and Lower Foothills Natural Subregions. Version II," brings together our understanding of silviculture systems, practices, and planning with forest ecology in a practical guide. It integrates this knowledge and understanding into a series of site and objective-based flowcharts that can be used to facilitate developing silvicultural prescriptions for establishing and managing forest stands of mixed aspen and spruce composition.

The current version of the Guide integrates flowcharts, text, and decision support tools (electronic and conceptual) to assist the forest manager in prescribing an integrated suite of treatments to achieve specific mixedwood silviculture objectives.

The Guide is available for download on the fRI Research website: https://fgrow.friresearch.ca/resource/fgrow-alberta-silviculture-guide-boreal-mixedwood-and-lower-foothills-natural-subregions

Growth and Yield Summit

In the spring of 2021, FGrOW will host a two-day conference and one-day field tour to discuss innovations in growth and yield. This event, the Canadian Growth and Yield Summit, is expected to attract participants from across the country. The summit will showcase ground breaking research and highlight approaches to growth and yield throughout the country. Representatives of agencies from across Canada will be invited to speak about their work underway in growth and yield and the strengths and weaknesses of their approaches. International speakers from jurisdictions with strong growth and yield sectors will be invited to share their experiences.

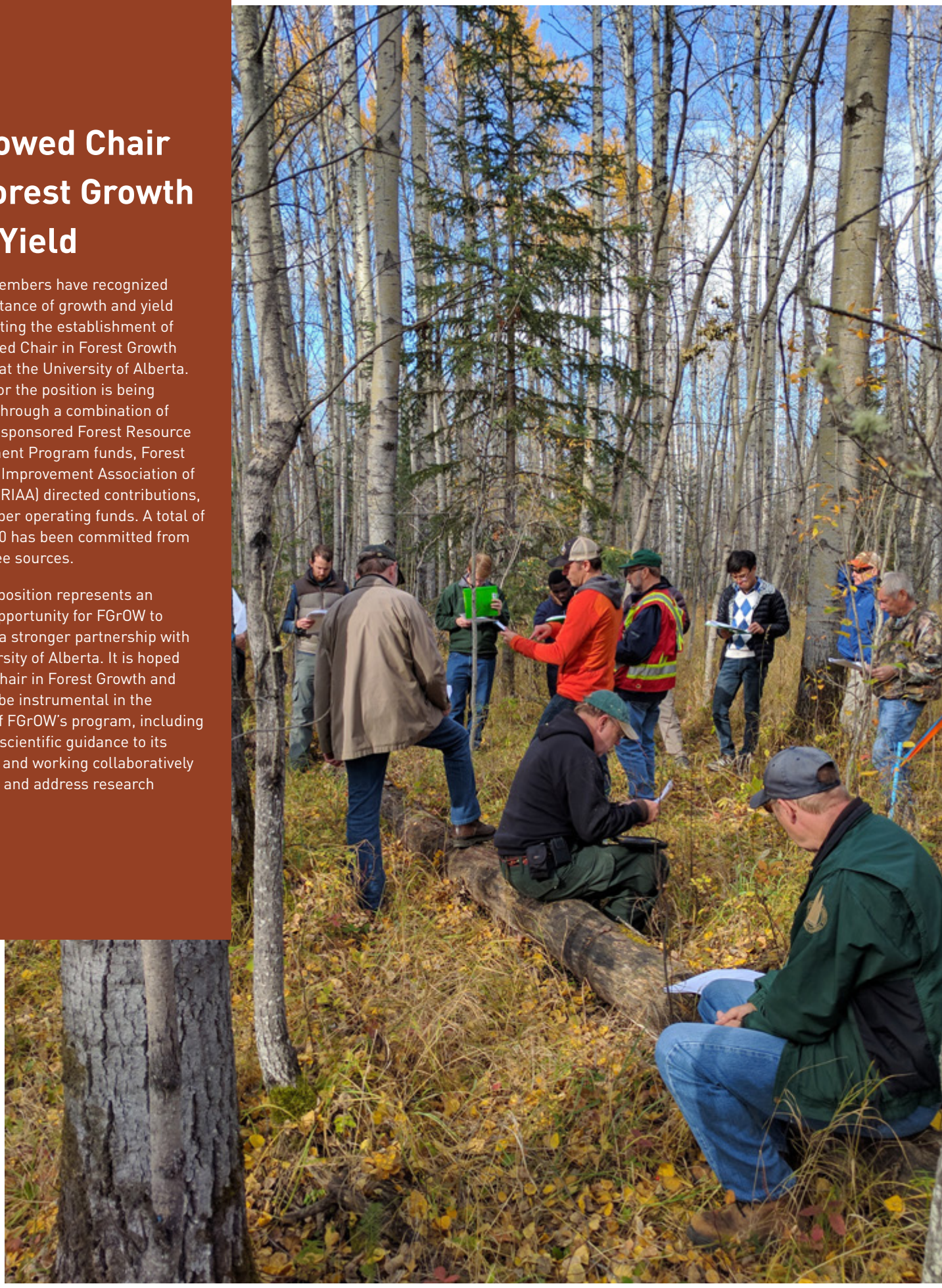
The objective of the summit is to support development and maintenance of a robust growth and yield sector and to address the erosion of growth and yield expertise and the associated dwindling research capability at universities across the country. The summit will provide a venue for knowledge sharing around innovations in growth and yield research and practice, and identify ways to build capacity of researchers, skilled analysts, and knowledgeable practitioners. This will be accomplished by:

- learning about innovations in growth and yield research and practice
- discussing successes and challenges in regions across the country
- learning about new technology that can help address skilled labour shortages
- hearing from other jurisdictions with robust growth and yield sectors

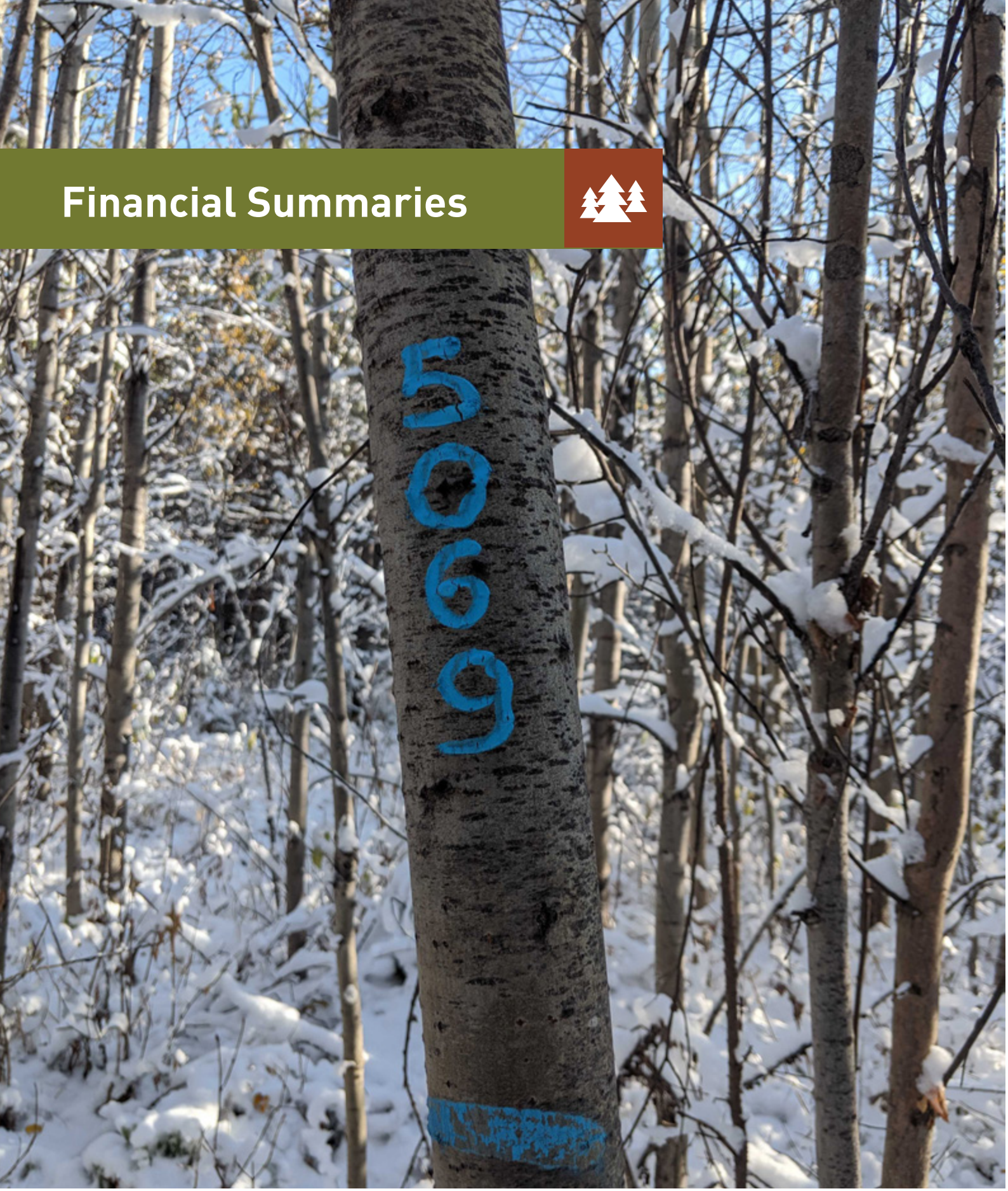
Endowed Chair in Forest Growth and Yield

FGrOW members have recognized the importance of growth and yield by supporting the establishment of an Endowed Chair in Forest Growth and Yield at the University of Alberta. Funding for the position is being provided through a combination of company-sponsored Forest Resource Improvement Program funds, Forest Resource Improvement Association of Alberta (FRIAA) directed contributions, and member operating funds. A total of $4,125,000 has been committed from these three sources.

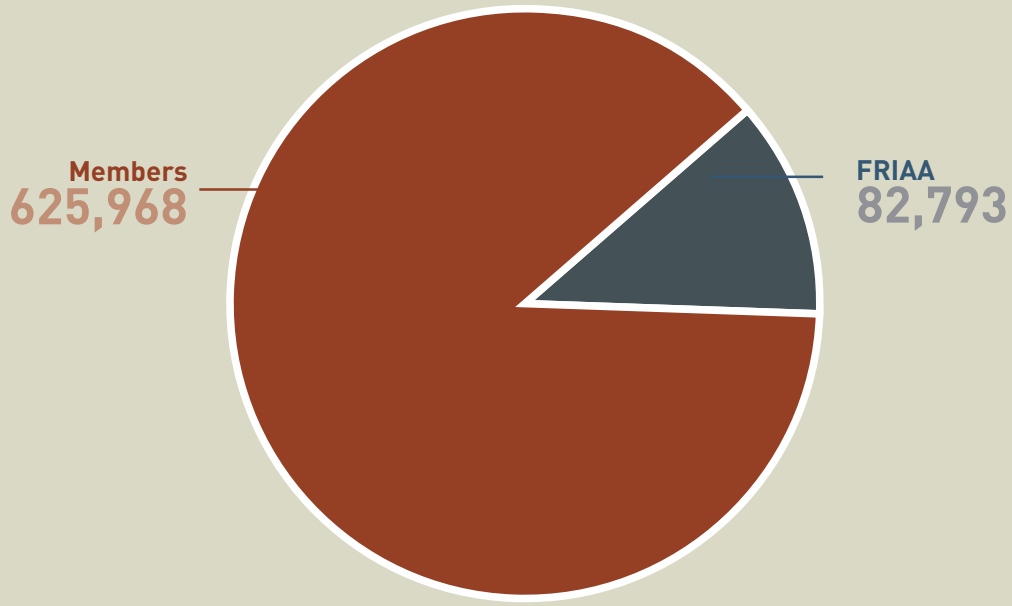
This new position represents an exciting opportunity for FGrOW to establish a stronger partnership with the University of Alberta. It is hoped that the Chair in Forest Growth and Yield will be instrumental in the delivery of FGrOW's program, including providing scientific guidance to its members and working collaboratively to identify and address research priorities.



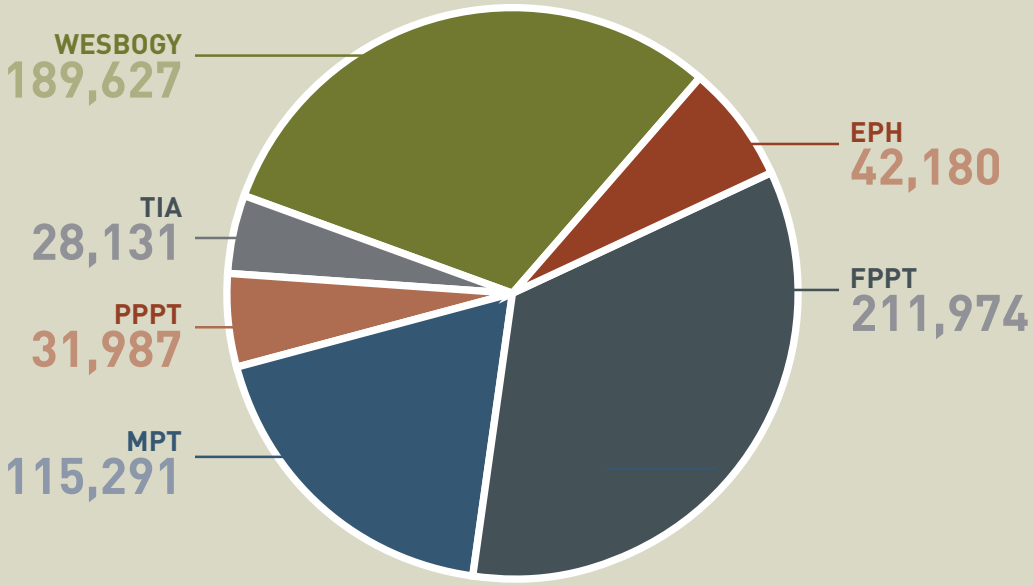
Financial Summaries



Income by Source



Project Team Expenditures



FGrOW is an association of fRI Research

Please contact us at:

1176 Switzer Drive, Hinton, Alberta, Canada, T7V 1V3
Tel: 780.865.8330 | https://fgrow.friresearch.ca/

FOREST GROWTH
ORGANIZATION OF WESTERN CANADA