Growth and Yield Monitoring Assessments

The Alberta-Pacific Forest Industries Inc. (Al-Pac) kraft pulp mill is primarily dependent on wood fibre from Al-Pac's Forest Management Agreement (FMA) area located in northeastern Alberta. Through the company's FMA, the Government of Alberta grants Al-Pac stewardship of 6.4 million hectares of forest land to sustainably harvest, establish, and grow timber. An important aspect of this stewardship is monitoring the growth and yield of forest stands and trees across the FMA through the use of Permanent Sampling Plots (PSP), Temporary Sample Plots (TSPs) and the Alberta Vegetation Inventory (AVI).
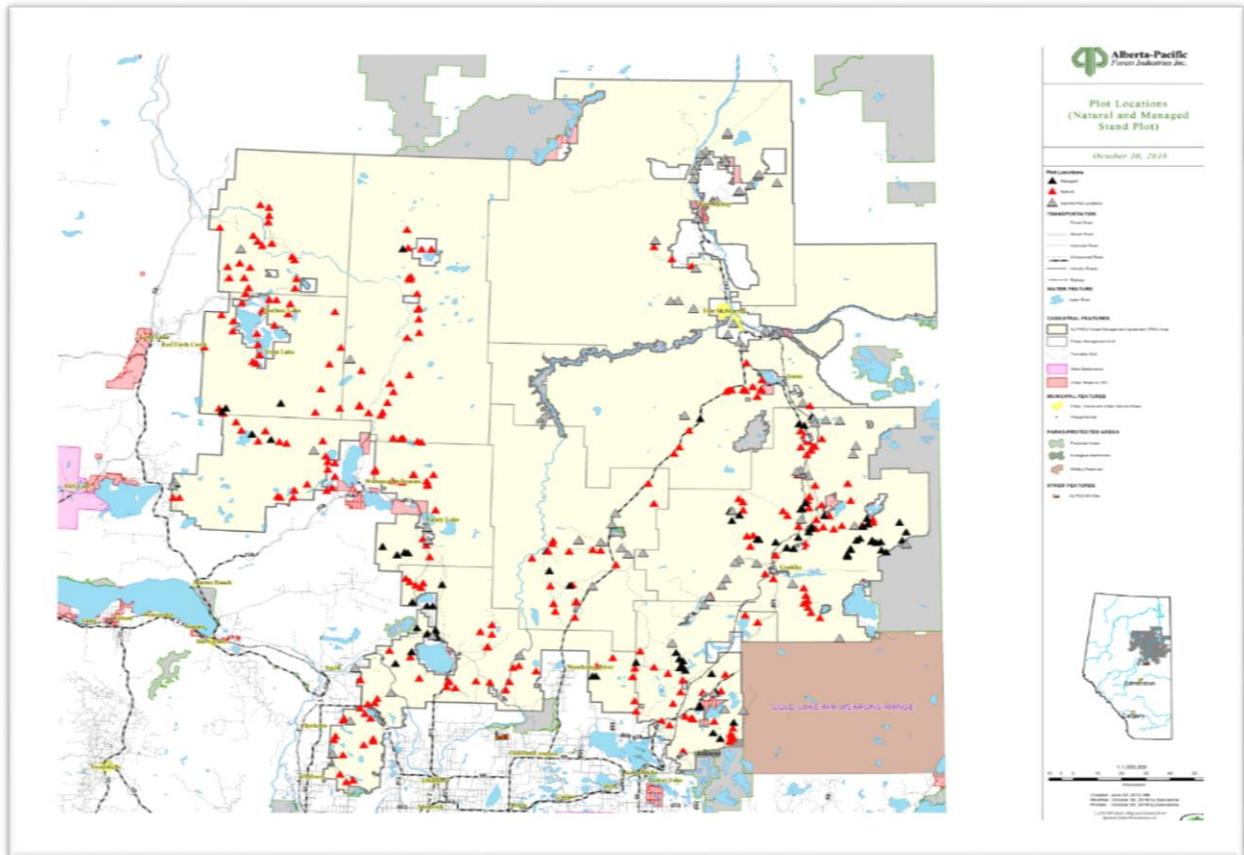

Figure 1. Map of Al-Pac's FMA with approximate PSP locations

In order to sustainably harvest wood fibre from the FMA for the future and meet the demands of the mill, Al-Pac must have a program to measure the growth and yield of the forests on the landbase. In order to do this effectively, Al-Pac must have up to date information on the natural and managed forests on the landbase. Managed forests are stands of trees which have been regenerated from a prior harvest or human disturbance. To create an accurate representation of the amount of harvestable volume on the FMA, Al-Pac uses a combination of PSPs, TSPs and AVI. Forests can be broken down into sub groups, called strata. Strata delineates the type of forest (aspen, white spruce, jack pine, or different mixedwoods) and subregions (Athabasca Plain, Lower Foothills, Boreal Highlands, and Central Mixedwood) which have different climactic and ecological conditions. Information collected through

PSPs, TSPs, and AVI allows Al-Pac to model the growth and yield of the forests on the FMA to plan future harvests and maintain stewardship of forests resources.

Al-Pac has been operating on the landbase since 1993 when the company initiated a sampling program which relied on Temporary Sample Plots (TSPs). In 1994, a PSP program was initiated for natural stands across the FMA area. As can been seen in Figure 1, the program's PSPs are distributed across the FMA area. Due to the fact that only 27% of the landbase is considered part of the harvestable landbase sampling of plots are located through a stratified random sample process instead of a grid-based layout. This was done to achieve a proportional sample of targeted stand types to inform future harvest plans and timber supply modelling. In the years since the beginning of the Al-Pac's Growth and yield program, significant landbase changes have occurred and are being incorporated into future plans for data collection and analysis of forest resources. (See Figure 2 for an illustration of a natural stand PSP)

Figure 2. Typical natural PSP with blue paint marking outer boundary

Al-Pac has established 340 natural stand PSPs since 1994. However, 69 of these PSPs have been lost to natural (wildfire) and man-made disturbances as well as landbase deletions through the TSA process. PSPs are a high risk endeavour in a landscape with many different disturbances like wildfire and energy and utility sector plot eradication. PSPs are put into either natural stands based on Alberta Vegetation Inventory (AVI) information or managed stands (forests altered by Al-Pac) based on silviculture and treatment information. As a guideline, a minimum of 50 trees should be encompassed within a 1,000 m^2 main plot, or increased to 1,500m^2 or 2,000m^2 to meet this amount of trees as required.

Both natural stands and managed stands fall into one of ten yield stratum as seen below in Figure 4. As well, there are currently 80 strip cut understory protection plots (SCUP) that are re-measured on a 5-year cycle. An example of a SCUP forest stand can be seen in Figure 3. The different sampling strata are broken into groupings based on the ecology and growth rate of the forest stand. The objective of the allocation of natural plots is to distribute the plots according to the prevalence of the strata in the landbase and across age-classes.

Figure 3. Al-Pac Understory Protection Harvest Block in FMU L1

Alberta-Pacific Yield Stratum	GoA Yield Stratum	Board Cover Group	Description
Aw	Hw	D	Pure deciduous
AwU	Hw	D	Pure deciduous with a conifer understory
AwSx	HwSx	DC	Deciduous leading mixedwood
SxAw	SxHw	CD	Spruce leading mixedwood
Sw	Sw	C	Pure white spruce
SbG/SbFM	Sb	C	Pure black spruce
PjMx	HwPl, PlHw	DC, CD	Pine aspen mixedwood
Pj	Pl	C	Pure jack pine
AwSw^{UP}		DC	Deciduous leading mixedwood post understory protection strip cut harvest
SwAw^{UP}		CD	White spruce leading mixedwood post understory protection strip cut harvest

Figure 4. Alberta-Pacific's 10 base yield strata

A major part of Al-Pac's current growth and yield program is working in conjunction with the Provincial Growth and Yield Initiative (PGYI) which collects data for TSA and yield model development and standardization within Alberta's other forest industry companies. The objective of PGYI is to obtain data from across the province on tree growth through repeated measurements of PSPs to develop, calibrate and validate growth models for Forest Management Plan (FMP) yielded curve development. The minimum number of plots required for the entire province is 900 for natural stands and 1,200 for managed stands.

Al-Pac's PGYI plan is as follows:

- Contribute 75 natural and 100 managed stands PSPs
- Managed stand PSPs will be installed as required and stratified by PGYI
- No new natural stand PSPs will be installed

Al-Pac has already met the number of natural plots required to be installed before 2019 and aims to install 5 new managed stand PGYI plots every year until completion. As part of PYGI, Al-Pac has dropped several types of PSPs from the program based on their characteristics such as being situated on steep slopes, First Nations areas, non-forest and unproductive, or have been disturbed.

In the partnership with PYGI, Al-Pac will retire the majority of non-PYGI PSPs after 3 measurements have been obtained with future data collection focusing on TSPs rather than PSPs. TSPs are lower risk due to only being present on the landscape for only one measurement versus PSPs which must remain undisturbed for 10+ years.

As well as creating PSPs in specific forest types, the PYGI plot allocation is proportional to the natural sub-regions in the FMA area. This can be seen in Figure 5 below. No plots were allocated into the Athabasca Plain and Lower Foothills due to these sub-regions representing only 4% of the landbase. Based on this information and the sufficient representation of natural stands in the PYGI allocation, Al-Pac will not install any new PSPs in natural stands.

Natural Subregion	Natural Landbase (percent)	PGYI Plots (percent)
Athabasca Plain	3	0
Central Mixedwood	69	81
Boreal Highlands	27	19
Lower Foothills	1	0
Total	100	100

Figure 5. Comparison of percent natural sub-regions in the Al-Pac FMA area and the allocated natural PGYI plots.

A key part of growth and yield measurements in the forest industry is the monitoring of managed stands which have been previously harvested. The accumulation of data from managed stands allows forest companies to predict and monitor the future merchantable volume in the FMA area. Due to Al-Pac starting harvest operations in the FMA area in 1993, all managed stands are younger than 30 years and fall into the same age class. As can be seen in Figure 6, there is a lack of representation of Boreal Highlands PSPs in managed stands. To rectify this lack in coverage of the Boreal Highlands, PSPs will be created to increase the proportion in this sub-region.

Natural Subregion	Managed Landbase (percent)	PGYI Plots (percent)
Athabasca Plain	0	0
Central Mixedwood	83	74
Boreal Highlands	15	24
Lower Foothills	2	2
Total	100	100

Figure 6. Comparison of percent of natural sub-regions in the managed landbase in the Al-Pac FMA area and the allocated managed PGYI plots.

The creation of PSPs is guided by a field manual developed by the Government of Alberta and most recently updated by Al-Pac and PGYI. This manual complies with the PGYI`s minimum standards and recommended best practices with the exception of condition codes of the trees sampled. Al-Pac still retains conditions codes from the previous manual but a system has been created to translate these codes into the codes required by the PYGI database. Conditions codes are used to judge the health and usability of trees in the PSPs. Examples of possible condition codes include healthy and live, broken or dead top, mountain pine beetle, or fire damage.

Another technique to acquire information of the Growth and Yield program is the use of TSPs. Al-Pac has previously used TSPs to sample three strata of interest:

- Pure deciduous (including deciduous with coniferous understorey) with a B, C or D AVI crown closure class;

- Pure black spruce with a timber productivity rating (TPR) of good; and

- Pure pine (no exclusions based on TPR or crown closure).

TSPs are not inputted yearly to sample all the forest strata throughout the FMA area. Approximately 75 TSPs are inputted each year.

TSPs can be used as a sample method to fill in data gaps of strata in the PSP program. They are also a primary data source for future yield curves and yield model calibration. As can be seen in Figure 7, there have been several TSPs created in both natural and managed stands across stratum on the landbase.

a)   b)

Alberta-Pacific Yield Stratum	TSP (#)
Aw	79
AwU	29
AwSx	2
SxAw	2
Sw	1
SbG	51
PjMx	1
Pj	141
Total	306

Alberta-Pacific Yield Stratum	TSP (#)
Aw	20
AwSx	8
SxAw	13
Sw	2
Sb	0
PjMx	7
Pj	7
Total	57

Figure 7. Number of TSPs by stratum in natural (a) and managed (b) stands

A mixedwood type of forest that exists on Al-Pac's FMA are mature deciduous stands with a distinct immature conifer understory. These stand types get managed with a Strip Cut Understory Protection (SCUP) treatment. There currently exist 5 understory protection PSPs using the old protocols that will be re-measured. Al-Pac also has 86 "SCUP" plots to assist in a mixedwood model validation. Additonal SCUP PSPs are to be established bi-yearly. The goal is to have over 100 understory protection PSPs throughout the FMA area by 2025.

Data collected from PSPs and TSPs is collected for the Growth and Yield plan which in turn assists in developing yield model, promotes forest stand monitoring and validation of the FMP yield estimates in natural and post-harvest regenerated stands (harvest blocks). Growth models are essentially statistical models to help quantify changes in forest attributes over time and estimate a forests future yield Knowing how the forest is changing allows forest companies to both understand and utilize the timber resources better.

As technology changes, Al-Pac is adapting to better measure, analyze, and record forest data. For example, the use of Android tablets and special PLOTS software is key to storing and measuring PSP data and then feeding that data direct into the PYGI system. An example of software utilized to trach PSP information can be seen in Figure 8. Al-Pac is also using a LiDAR-based prediction method in association with plot data and the AVI, to create merchantable volume estimates for the General Development Plan (GSP). LiDAR can be used to accurately measure the merchantable volume of a forest remotely.

Figure 8. Al-Pac PSP database application – main interface

To effectively manage forest resources, Al-Pac must monitor and understand forest stand dynamics over time. As part of this program, Al-Pac has implemented various PSP, SCUP and TSP programs to better understand the landbase and the forests. In conjunction with PYGI, Al-Pac is changing and modernizing its growth and yield program to be more cost effective and representative.