Alberta-Pacific FMA Area Growth and Yield Plan

September 15, 2010

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1. Overview

1.1 Introduction

A Growth and Yield plan is needed to meet the Forest Companies' requirements within the Alberta-Pacific Forest Industries Inc. (Alberta-Pacific) Forest Management Agreement (FMA) area Forest Management Plan (FMP)[1]. Within the program, the following issues must be addressed:

1. Local yield curves have been created and approved for natural stands in the Alberta-Pacific FMA area.
2. Alternative Reforestation Standards requirements mean that the Forest Companies must provide a linkage between regeneration standards and predicted yields for managed stands.
3. Data are required to contribute to model development efforts, at both an individual tree and stand level.
4. Since predictions are based on models, the Forest Companies also need to provide a framework for monitoring and validating model performance, and either verifying or revising assumptions.
5. The Forest Companies will require a basis for predicting stand development and silvicultural treatment response for partial harvest and post-harvest stands.
6. Data are required to "roll up" forecasting and monitoring to a landscape level.

1.2 Growth and Yield Planning Needs

Stands can be divided into three types based on their disturbance history: natural (*i.e.*, fire origin) stands, post-harvest (*i.e.*, managed or salvage harvest), and partial harvest (*e.g.*, understory protection) stands. Natural stands in the Alberta-Pacific FMA area have been intensively sampled using temporary sample plot (TSP) and permanent sample plot (PSP) data, which have in turn been used to create empirical yield curves. To date, partial harvest and post-harvest stands a) have less intensive sampling, and b) generally are not available across

[1] Forest Companies operating within the FMA area include Alberta-Pacific Forest Industries, coniferous Quota Holders (Millar Western Forest Products, Northland Forest Products, Alberta Plywood, Vanderwell Contractors, St. Jean Lumber, Bobocel Lumber, S11 Logging and Spruceland Millworks) and companies operating under the Alberta Sustainable Resource Development Commercial Timber Permit (CTP) and Miscellaneous Timber Use (MTU) programs.

the range of ages and stand types of interest. As such, models based primarily on natural stand data have been and will be used as a proxy to bridge the gap between early stand performance and future productivity until sufficient managed stand data are available.

There are two main focal areas for growth and yield planning: 1) forecasting growth and yield and 2) monitoring of stand development for comparison with forecasted growth and yield, and for improvement of forecasts.

In the Alberta-Pacific FMA area, forecasting for management planning purposes has, in the past, been achieved using empirical yield curves. Yield curve forecasts are generally used to predict merchantable volume/ha or measures of average tree size (*e.g.*, m^3/tree by species). Yield curves have been stratified by broad cover group, leading species and/or site class, with other stratification, such as north/south geographic splits, applied on a stratum-specific basis.

Growth models (*e.g.*, the Mixedwood Growth Model (MGM), Growth and Yield Projection System (GYPSY)) provide a means for forecasting growth responses to various activities within stands, and can provide a more sophisticated prediction of response. This type of forecasting can often provide more detailed outputs, such as tree lists and individual tree attributes. Detailed information on stand succession and growth is required for the development of such models.

Monitoring is required to examine assumptions underlying models used for forecasting and to improve predictions. In particular, monitoring of early stand establishment and subsequent performance is needed to create a linkage between juvenile stand conditions and timber volume production at maturity.

TSPs have, in the past, provided data suitable for empirical yield curve modelling. As Alberta-Pacific's growth and yield program has expanded, data suitable for model calibration and monitoring model performance are now available for many stand types.

For the assessment of managed stands, a nested approach consisting of Alberta Regeneration Standards (ARS) performance survey plots, "re-measured TSPs" and PSPs has been developed (ARS Transitioning to PSPs – ATP Program). The goal of this approach to growth and yield sampling is to continue sampling using ARS based protocols and transition to a TSP program that is semi-permanent. This program should provide good stand level data over time to validate model trajectories and yield curves. It will be supplemented by fewer traditional PSPs to provide individual tree trajectories, species interactions as well as data on ingress and mortality for model functions. This approach enables the Forest Companies to establish more samples[2], which can more easily be replaced if destroyed by other landuses or fire.

[2] The term samples is used to refer to either plots, such as PSPs or TSPs, or to stand-level measurements comprised of a number of plots, such as ARS surveys.

1.3 Guiding Principles

The foundation of the Alberta-Pacific FMA area growth and yield plan will be its guiding principles. These principles reflect the philosophy of the plan, and its intent and purpose. The Eight Guiding Principles of the growth and yield plan will be:

1. ***The growth and yield program will be based on three key elements:***
   - ***The use of growth models for predictions;***
   - ***An emphasis on repeated measurements as the main data source; and***
   - ***The use of temporary sample plots to fill data gaps on an ad-hoc basis.***

   ✓ Future yield curves will be built using growth and yield models (*e.g.*, MGM and GYPSY).

   ✓ Emphasis will be on repeated measures data collection for use in growth models. These data will provide information to support the continued development and validation of models.

   ✓ TSPs are recognized as the best quick solution to data needs. New TSP data will be collected to fill data gaps in specific strata for validating yield predictions, and to address ad-hoc questions. Recently collected (2001-2008) AVI-based TSPs from pine and black spruce stands will be included with these data. TSPs will also be used to help operationalize the spatial harvest sequence, to determine the merchantability of certain AVI stand types, for volume and piece size estimates, and to test models and anchor model outputs. Existing Phase III-based TSP data will be used for growth and yield-related analyses, but will not be used for developing yield predictions.

2. ***In natural stands, the existing PSP-based approach will be maintained.***

   ✓ Existing permanent sample plots in natural stands will be maintained, with measurements taken according to ASRD permanent sample plot protocols.

   ✓ Over time, the number of natural stand PSPs will be reduced for certain oversampled strata / age classes to allow reallocation of effort to undersampled strata / age classes and to managed stands.

3. ***For managed stands, a nested sampling approach (ATP; ARS Transitioning to PSPs) will be used to collect data at a variety of scales.***

   ✓ Sampling units (SU) in performance age stands will be selected for repeated measures. Each selected sampling unit will have repeated regeneration surveys, as well as repeated measurements in 100 m^2 plots, to obtain stand-level trajectories in managed stands. These data will be the foundation for yield curve development, model testing and validation/calibration.

   ✓ A subsample of the selected SUs will also have 400 m^2 individual tree PSPs to collect information primarily for individual tree model development, validation, testing and calibration.

4. ***All samples will be established using stratified random sampling.***

   ✓ All PSP and TSP programs are already well-established within the FMA area, with upwards of 400 PSPs (established by both Alberta-Pacific and ASRD) and several thousand TSPs established on a stratified (non-grid) basis.

✓ The FMA area is very large, with a high proportion of nonproductive or nonforested areas (approximately 50% or roughly 2,900,000 ha). Stratified sampling is required in order to achieve a balanced sample of target stand types and age classes.

✓ Grid-based sampling would require large numbers of samples outside the realm of the Forest Companies' interest. The uneven distribution of age classes across the landbase would result in most samples ending up in mature stands, with few samples in managed, juvenile or complex mixedwood stands due to underrepresentation on the landbase.

✓ Therefore, these new ATPs (and TSPs if required) will be established using a selection matrix based on stratum, age class and/or geographic location. Any FMA-wide estimates that are required will be provided using area-weighted values and/or growth models.

5. ***Stratification for sampling will be based on plans for future model development, rather than redevelopment of existing yield curves.***

✓ The strata that will be used are: Aw, Aw/Sw, AwSw, SwAw, Sw, PjMix, Pj and Sb (good TPR only). These are described further in Section 3. Understory protection strata may also be included, or monitored using local plots.

✓ Variance analysis will identify variables with a statistically significant effect on volume. These results will be used to develop a sampling matrix and/or identify priorities for sampling. Professional knowledge from members of the Forest Companies will be used to supplement this information.

6. ***The number of samples will be allocated to each stratum of interest as follows:***

✓ For modelling, the range of stands and variables of interest must be sampled, with a balanced sample to allow model development. Certain strata are not well represented on the landbase, but a minimum target number of samples (5 PSPs or ATP400 plots, see Section 4.3.2) is required for modelling purposes, regardless of the area they comprise.

✓ Sample size will be adjusted to account for proportion of AAC and landbase, such that more prevalent stand types are sampled more extensively.

✓ For the reasons listed here, final numbers of samples per stratum in this plan will not be equal.

✓ Samples will only be placed within the productive landbase.

7. ***Alternative Reforestation Standards linkages will be an integral component of the Growth and Yield program.***

✓ As stated, there will be a focus on establishment of samples in juvenile stands. This will primarily be addressed through the ATP program in performance age stands, creating an explicit linkage between juvenile conditions and those at maturity.

✓ Other ground-based regeneration surveys will be used as TSPs for the purposes of filling data gaps in juvenile stands.

✓ The Forest Companies will also consider experimental approaches to examining the competitive interactions of aspen and pine in regenerating stands, but this will not be explicitly addressed in this growth and yield plan.

8. ***Access considerations will be integral to the development a cost-efficient program,***

✓ The Forest Companies have an extensive road network throughout the FMA area, but some areas are simply not accessible. Fly-in access will not be considered.

✓ Where access to sampled stands is altered or destroyed, samples may be deactivated and reestablished elsewhere.

2. Growth and Yield Programs

2.1 Historic Growth and Yield

Alberta-Pacific has been collecting TSP and PSP data within the Alberta-Pacific FMA area since 1991. Alberta-Pacific has been involved with the Western Boreal Growth and Yield Cooperative (WESBOGY) since 1993, and maintains two WESBOGY research installations within the FMA area. The company has also been an active participant in the Alberta Mixedwood Management Association (MWMA) since its inception in 2001.

The following section is mainly derived from the approved Alberta-Pacific FMA area Forest Management Plan (Revised by Alberta-Pacific in 2007) and describes the intent and extent of each of these programs.

2.2 Volume and Growth Programs

The volume and growth programs provide tree and stand volume information for planning current harvesting operations, and growth information required to calculate sustainable annual allowable cuts. Four programs are currently in place:

1. Permanent Sample Plot program (PSP)
2. Temporary Sample Plot program (TSP)
3. Western Boreal Growth and Yield Co-operative (WESBOGY)
4. Growth and yield initiatives with the Alberta Mixedwood Management Association (MWMA)

2.2.1 Permanent Sample Plot Program

The objective of establishing PSPs on the FMA area is to monitor and measure the growth and succession of representative forest types over time. As the PSPs are re-measured, the changes observed with respect to plant

species, tree growth, stand development, stand structure and tree mortality contribute to the understanding of the dynamics of the forest. Re-measured data provide needed information for predicting the growth and succession of forest types through time. By 2005, Alberta-Pacific had established 386 PSPs[4] and re-measured the 39 Alberta Sustainable Resource Development (ASRD) PSPs within the FMA area. In 2008, Alberta-Pacific added 9 new PSPs in managed stands under the new Juvenile Stand PSP protocols[5].

Table 1 summarizes the total number of PSPs currently either managed by Alberta-Pacific or located within the Alberta-Pacific FMA area. This includes 395 Alberta-Pacific PSPs, some of which are located in FMU S14 (outside of the FMA area), and 39 Land and Forest Service PSPs (LFS, now Sustainable Resource Development) located in the Alberta-Pacific FMA area, which were once measured by Alberta-Pacific (36 are now inactive and 3 are closed). Of the 395 Alberta-Pacific PSPs, an additional 23 PSPs have been burnt or destroyed by oil and gas exploration, leaving a total of 372 active PSPs, 321 of which are in fire origin (natural) stands and 51 of which are in managed (clearcut, salvage or understory protection) types[6].

Table 1. Total number of PSPs by stratum and PSP type/status.

	PSP Type/Status							
Stratum	Burnt/ Destroyed	Inactive (LFS PSP)	Fire Origin	Harvest Clearcut	Harvest Salvage	Harvest Underst. Prot	Total PSPs	Total Open PSPs
Aw	3	9	118	17		6	153	141
Aw/Sw	5		18				23	18
AwSw	3	5	42	7			57	49
SwAw	1	2	37	6	1		47	44
Sw	9	2	33	5			49	38
Pj	2	14	35	6			57	41
PjMix		2	25	2			29	27
Sb_FM	1	1	9				11	9
Sb_G			4	1			5	5
Lt		1					1	0
Blank	2						2	0
Total	26	36	321	44	1	6	434	372

Comments regarding Table 1:

1. PSPs in young fire-origin stands are a priority for Alberta-Pacific and existing PSPs which have been closed after fire have generally been closed for good reasons (*e.g.*, damage makes it difficult to relocate the PSP; fire suppression and/or salvage activities have damaged the site).

2. There are 6 understory protection PSPs located in understory protection harvest areas within the Alberta-Pacific FMA area. These were established under the same sampling protocols as all other PSPs (ASRD PSP protocols), and are not to be confused with Mixedwood Management Association understory protection PSPs. Since understory protection are sampled under the new Mixedwood Management Association sampling protocol, no additional understory protection PSPs will be established under Alberta Government PSP protocols.

The biological response of mixedwood forests to alternative silvicultural treatments in targeted stands is poorly documented throughout the Western Canadian boreal forest. Alberta-Pacific has established and will continue to re-measure PSPs in natural stands. The Forest Companies will build upon the data by installing new repeated

[4] PSP sampling protocols follow the Alberta Sustainable Resource Development PSP protocols.
[5] Note that these protocols are being replaced by the new ATP program.
[6] Tables updated and effective September 15, 2010.

measures samples in managed stands. These data will address a variety of growth and yield needs, including the calibration of growth and yield models and providing data for the Tree List Generator.

Establishment of new samples is dependent on accessibility and operational considerations. Ground access-only plots are planned. The Forest Companies will continue to expand the geographic range of the coverage to provide representative coverage over the entire FMA area, and will build upon the current 434-PSP[7] database by establishing new samples in target strata. In general, these plots will be established within managed stands.

2.2.2 Temporary Sample Plot Program

The primary purposes of the TSP program are to provide a "snap-shot" of stand composition, volume and piece size data for operational planning and/or yield curves, to provide data for the Tree List Generator (TLG) and to supplement data used for calibration of growth models. The Forest Companies will continue to establish temporary sample plots as needed to fill growth and yield information gaps.

2.2.3 Western Boreal Growth and Yield Co-operative

The Western Boreal Growth and Yield Co-operative (WESBOGY[8]) is a Western Canadian industry-sponsored organization managed by the University of Alberta. The co-operative is involved in addressing forest growth and yield issues in Western Canada's boreal forest. The co-operative facilitates co-ordinated research and development efforts in boreal forest growth and yield, data sharing and also provides a forum for communications. The main objectives of WESBOGY and its members are to:

1. Encourage the continued monitoring of standardized PSPs;
2. Assist in quantifying the effects of intensive forest management practices, and co-ordinate the acquisition of high priority growth and yield data;
3. Further the knowledge and understanding of the growth and yield of boreal forests;
4. Expedite the development of managed-stand yield models for the major commercial tree species in the region; for example a mixedwood growth model is a major priority project; and
5. Fund a full-time researcher at the University of Alberta to pursue growth and yield priorities as set by the co-operative.

The Forest Companies currently participate in the WESBOGY program and maintain two WESBOGY research installations within the Alberta-Pacific FMA area.

2.2.4 Alberta Mixedwood Management Association

Starting in 2001, the Forest Companies assisted in defining and establishing a mixedwood management co-operative. Ten forest companies within Alberta are signatories of an agreement to participate in a co-operative program, known as the Mixedwood Management Association, for the following purposes:

1. The forecasting and validation of managed stand growth and yield, particularly of aspen/white spruce complexes;

[7] Please note that 26 out of the 434 plots within the database have been destroyed by fire or oil and gas activity and 36 plots are currently inactive.
[8] Wesbogy – http://www.rr.ualberta.ca/wesbogy/

2. The establishment of research needs and priorities; facilitating the completion of research projects, and ensuring that the results of the research are disseminated. Where possible, co-ordinate with other research groups. Where high priorities cannot be addressed by existing research groups, the association will carry out its own research;

3. Facilitate discussion and understanding within the forestry community of mixedwood management issues; and

4. Develop standardized research and data-collection protocols considering the long-term need for reliable data in forest management decision making.

To date, the association has been involved in a number of activities including the development of a Strip Shelterwood Understory Protection Permanent Sample Plot program (The Forestry Corp. 2003). Sampling began in 2005, with the establishment of six understory protection PSPs in each of five selected blocks, four of which are within the Alberta-Pacific FMA area. There are also an additional 6 PSPs established in understory protection stands under Alberta Government PSP protocols.

Other projects include funding of studies relating to mixedwood management activities, and supporting continued development of the MGM model.

2.3 Regeneration Surveys

Data gathered during regeneration surveys are recognized as an important source of juvenile data for growth and yield purposes. Since regeneration surveys are required on a large proportion of all harvested blocks, this is also an abundant source of data. Current performance standards were developed specifically to build linkages between juvenile stand conditions and yield at maturity. As such, these surveys and protocols have had an important influence on Alberta-Pacific's growth and yield program.

3. Sampling Stratification Scheme

3.1 Preliminary Stratification

Stratification is required as a basis for guiding placement of new samples for the growth and yield program. A starting point for the stratification scheme will be the strata identified in the document "Yield Curves for Mixedwood Management" (The Forestry Corp 2002). These yield strata (hereafter referred to as simply "strata") are defined in Table 2.

Note that there is only one approved yield curve for the pine mixedwood stratum. This stratum represents approximately 2.5% of the FMA area, and as such has not been split into separate DC and CD strata. The intent is to allocate growth and yield sampling effort proportionally by sampling stratum; creation of two PjMix strata would detract from sampling of strata that represent a larger proportion of the landbase.

Table 2. Growth and yield plan strata based on mixedwood management yield curve definitions.

Stratum	Description	Broad Cover	Leading Conifer	Percent Crown Closure	
				Decidouus	Coniferous
Aw	Pure Deciduous without "Valid" Conifer Understory	D	n/a	80-100	0-20
Aw/Sw	Pure Deciduous with Valid Coniferous Understory (Sw > 600 sph)	D(U)	Sw	80-100	0-20
AwSw	Aspen-Spruce Mixedwood	DC	Sw, Sb	51-79	21-49
SwAw	Spruce-Aspen Mixedwood	CD	Sw, Sb	21-50	50-79
Sw	Pure White Spruce	C	Sw	0-20	80-100
Pj	Pure Pine	C	Pj	0-20	80-100
PjMix	Aspen-Pine or Pine-Aspen Mixedwood	DC/CD	Pj	21-79	21-79
Sb_G	Pure Black Spruce Good	C	Sb	0-20	80-100

3.2 Geographic Variability

Because of the extent of the Alberta-Pacific FMA area, geography may influence stand composition and growth. An examination of geographic variability was undertaken to determine whether geography should be considered as part of stratification, and if so, which geographic strata would be most important to sampling.

3.2.1 Landbase Distribution

The productive landbase was summarized by stratum and geographic location (N/S, E/W), which was determined based upon the FMU as follows (Table 3):

Table 3. Geographic location based on FMU.

Geographic Location	FMU
North	A14, A15, S11, S22
South	L1, L2, L3, L8, L11, S7, S18
East	A14, A15, L1, L3, L8, L11
West	L2, S7, S11, S18, S22

The total productive landbase area by stratum and geographic location is presented in Table 4. Overall, mixedwood strata (AwSw, SwAw, and PjMix) comprise relatively little area within the landbase.

Table 4. Productive landbase (area in ha) by stratum and geographic location.

	Latitude				
	North		South		
Stratum	Area (ha)	%	Area (ha)	%	Total
Aw	314485	44.8	386989	55.2	701475
Aw/Sw	296878	71.7	117106	28.3	413984
AwSw	45256	48.9	47284	51.1	92540
SwAw	39891	42.3	54399	57.7	94291
Sw	122943	50.4	121077	49.6	244019
Pj	229005	62.7	136055	37.3	365060
PjMix	33409	63.8	18967	36.2	52377
Sb_G	43565	43.4	56893	56.6	100457
Total	1125432	54.5	938770	45.5	2064202
	Longitude				
	East		West		
Stratum	Area (ha)	%	Area (ha)	%	Total
Aw	381676	54.4	319798	45.6	701475
Aw/Sw	252671	61.0	161314	39.0	413984
AwSw	53910	58.3	38630	41.7	92540
SwAw	53786	57.1	40505	42.9	94291
Sw	164471	67.4	79549	32.6	244019
Pj	280311	76.8	84749	23.2	365060
PjMix	33505	64.0	18871	36.0	52377
Sb_G	73994	73.7	26463	26.3	100457
Total	1294324	62.7	769879	37.3	2064202

Note that slightly over ½ of the landbase area is located in northern regions, with slightly less in southern regions. However, the geographic distribution by stratum varies considerably. Highlighted in blue are strata with a distribution that varies 10% or more from the total landbase proportion. For example, 55% of the landbase (all strata combined) is in the north and 45% of the landbase is in the south, however 72% of the Aw/Sw stratum area is located in the north, with only 28% located in the south (more Aw/Sw is present in the north relative to the proportional representation in the landbase).

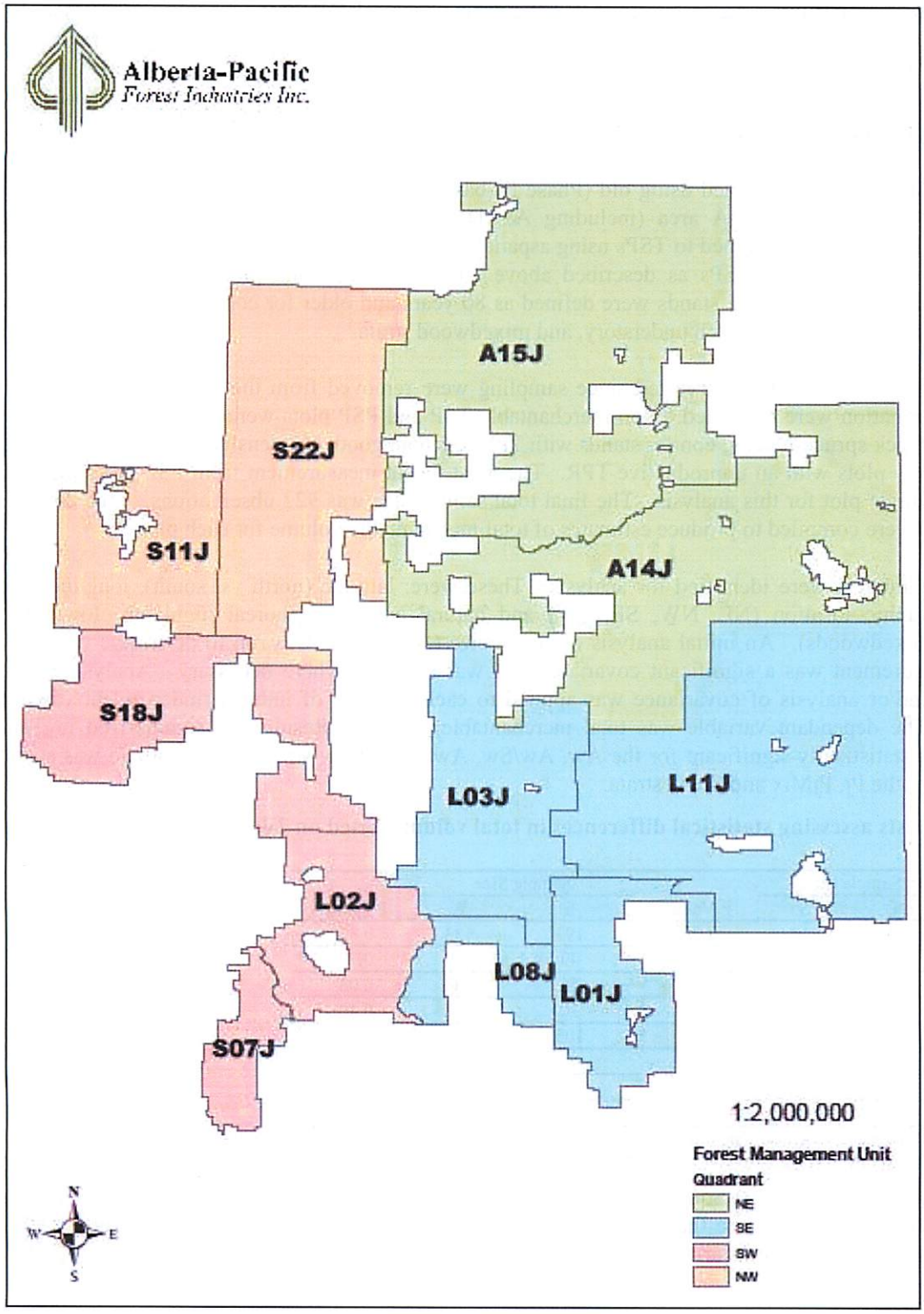

Figure 1. Quadrant layout, Alberta-Pacific FMA area.

Just over 60% of the landbase is within the eastern portion of the FMA area, with just under 40% of the landbase within the western portion. Again, strata that differ from those relative proportions by more than 10% are highlighted in blue (in this case, pure Pj and Sb_G). These differences may be an indication that geographic location may have an effect on suitability for certain species types.

3.2.2 Variance Analysis

Variance analyses were conducted using old (Phase III-based) TSP data and PSP data collected prior to 2004 within the Alberta-Pacific FMA area (including ASRD PSPs measured by Alberta-Pacific). Geographic location and stratum were assigned to TSPs using aspatial linkages with the landbase based on polygon number. Attributes were assigned to PSPs as described above. Only mature stand plots from natural stands were included in the sample. Mature stands were defined as 80 years and older for conifer strata, and 60 years and older for deciduous, deciduous with understory, and mixedwood strata.

TSPs that had been burned or harvested since sampling were removed from the sample. PSP plots missing required information were discarded. Non-merchantable TSP and PSP plots were also removed; this included any plots in black spruce-leading conifer stands with TPR less than good, 'A' density deciduous and mixedwood stands, and any plots with an unproductive TPR. The most recent measurement from PSP plots was used as a temporary sample plot for this analysis. The final total sample size was 922 observations. Tree data from the eligible plots were compiled to produce estimates of total merchantable volume for each plot.

Attributes of interest were identified for analysis. These were: latitude (north vs. south), longitude (east vs. west), geographic location (NE, NW, SE, SW) and natural subregion (boreal highlands, lower foothills, central/dry mixedwoods). An initial analysis of covariance (ANCOVA) was run to determine whether age at year of measurement was a significant covariate[9], and was included where necessary. Analysis of variance (ANOVA) and/or analysis of covariance was applied to each attribute of interest (independent variables) by stratum[10]. The dependant variable was total merchantable volume. Results are summarized in Table 5[11]. Latitude was statistically significant for the Aw, Aw/Sw, AwSw and Sw strata, and longitude was statistically significant for the Pj, PjMix and Sb_G strata.

Table 5. T-tests assessing statistical differences in total volume based on 2-level geographic variables.

	Sample Size				Sample Size			
Stratum	N	S	P Value		E	W	P Value	
Aw	114	212	0.03		193	133	0.83	
Aw/Sw	50	33	0.05	*	49	34	0.79	*
AwSw	42	59	<0.01	*	55	46	0.08	
SwAw	32	25	0.12	*	30	27	0.40	
Sw	73	105	0.01	*	105	73	0.57	*
Pj	22	47	0.72		46	23	<0.01	
PjMix	16	24	0.52		25	15	0.01	
Sb_G	14	54	0.83		33	35	0.01	

Note: shaded cells indicates statistically significant values at α=0.05.
Note: stars indicate results where Analysis of Covariance was used rather than T-tests, to adjust results based on measured age as a covariate.

ANOVA/ANCOVA with Least Squares Means was used to assess whether there is a relationship between total volume and variables with more than two levels. Geographic location (NE, NW, SE, and SW) was assessed using these methods, and results are presented in Table 6.

[9] Use of a covariate in ANCOVA controls for the effects of measurement age on total volume.
[10] Note that when ANOVA is applied to an attribute with two levels, results are the same as applying a two-tailed T-test.
[11] Note that Type III sums of squares is used here to assess significance since it is appropriate for unbalanced designs (*e.g.* where there is not the same number of observations in each group).

Although there were many statistically significant differences based on geographic location, there were no clear patterns that could be generalized.

Table 6. Results of least squares means to determine statistical differences between 4-level geographic location variables.

Stratum	Total	n		Different From...				
				NE	NW	SE	SW	
Aw	326	46	NE	-	0.39	0.65	0.08	
		68	NW		-	0.10	<0.01	
		147	SE			-	0.08	
		65	SW				-	
				NE	NW	SE	SW	
Aw/Sw	83	38	NE	-	0.52	<0.01	0.30	*
		12	NW		-	0.09	0.84	
		11	SE			-	0.10	
		22	SW				-	
				NE	NW	SE	SW	
AwSw	101	29	NE	-	0.81	<0.01	<0.01	*
		13	NW		-	0.05	<0.01	
		26	SE			-	0.38	
		33	SW				-	
				NE	NW	SE	SW	
SwAw	57	15	NE	-	0.37	0.08	0.22	*
		17	NW		-	0.41	0.60	
		15	SE			-	0.83	
		10	SW				-	
				NE	NW	SE	SW	
Sw	178	29	NE	-	0.21	0.03	<0.01	*
		44	NW		-	0.28	0.12	
		76	SE			-	0.43	
		29	SW				-	
				NE	NW	SE	SW	
Pj	69	17	NE	-	0.03	0.79	0.12	
		5	NW		-	0.02	0.26	
		29	SE			-	0.04	
		18	SW				-	
				NE	NW	SE	SW	
PjMix	40	8	NE	-	0.01	0.51	0.15	
		8	NW		-	0.03	0.32	
		17	SE			-	0.30	
		7	SW				-	
				NE	NW	SE	SW	
Sb G	68	4	NE	-	0.05	0.25	0.03	
		10	NW		-	0.15	0.89	
		29	SE			-	0.03	
		25	SW				-	

Note: shaded cells indicates statistically significant values at α=0.05.
Note: stars indicate results where Analysis of Covariance was used rather than T-tests, to adjust results based on measured age as a covariate.

This process was also applied to examine the natural subregions within the Alberta-Pacific FMA area. There are three levels of natural subregion (BH, CM/DM, LF) (Table 7). There was no evident relationship between natural subregion and total volume, with the exception of a few statistically significant differences, which were between the Boreal Highlands and other natural subregions (CM, LF).

Table 7. Results of least squares means to determine statistical differences between 4-level natural subregion variables.

Stratum	Total	n		Different From...			
				BH	LF	CM/DM	
Aw	326	51	BH	-	0.01	<0.01	
		13	LF		-	0.23	
		262	CM/DM			-	
				BH	LF	CM/DM	
Aw/Sw	83	8	BH	-	0.51	0.60	*
		11	LF		-	0.12	
		64	CM/DM			-	
				BH	LF	CM/DM	
AwSw	101	10	BH	-	0.10	0.19	*
		12	LF		-	0.38	
		79	CM/DM			-	
				BH	LF	CM/DM	
SwAw	57	12	BH	-	0.32	0.09	
		1	LF		-	0.63	
		44	CM/DM			-	
				BH	LF	CM/DM	
Sw	178	30	BH	-	0.87	0.99	*
		7	LF		-	0.86	
		141	CM/DM			-	
				BH	LF	CM/DM	
Pj	69	8	BH	-	n/a	0.79	
		0	LF		-	n/a	
		61	CM/DM			-	
				BH	LF	CM/DM	
PjMix	40	6	BH	-	n/a	<0.01	
		0	LF		-	n/a	
		34	CM/DM			-	
				BH	LF	CM/DM	
Sb_G	68	8	BH	-	0.67	0.44	
		6	LF		-	0.89	
		54	CM/DM			-	

Note: shaded cells indicates statistically significant values at α=0.05.
Note: stars indicate results where Analysis of Covariance was used rather than T-tests, to adjust results based on measured age as a covariate.

3.2.3 Results

The is an indication that differences in volume may occur in a north-south split for aspen, spruce, and mixes thereof, and an east-west split for pine and pine mixes. However, it is evident that obtaining a good overall geographic distribution is important for ensuring that the full range of conditions is sampled. Geographic location will be incorporated into the stratification scheme as follows: 1) splits by latitude for the Aw, Aw/Sw, AwSw, SwAw and Sw strata will be used to ensure both north and south locations are sufficiently sampled; 2) splits by longitude for the Pj, PjMix and Sb-G strata will be used to ensure both east and west locations are represented in sampling.

4. Plan for Continued Data Collection

4.1 Sampling Stratification

Based on the variance analysis results and knowledge of the Alberta-Pacific FMA area, the stratification scheme for sampling will be comprised of the initial strata combined with geographic location variables that vary by stratum. These will be referred to as Sampling Strata. The stratification scheme for sampling is identified in Table 8. Note that this is stratification for sampling only; individual yield curves will not necessarily be developed based on Sampling Strata. The Aw/Sw stratum is not a managed stand stratum but is included for completeness (*e.g.* in case additional natural stand TSPs are required at a later date).

Table 8. Stratification scheme for sampling.

	Percent Crown Cover		Geog.	Sampling
Stratum	Aw% + Pb%	Conifer %	Split	Stratum
Aw	80-100	0-20	N	Aw-N
			S	Aw-S
Aw/Sw	80-100	0-20	N	Aw/Sw-N
			S	Aw/Sw-S
AwSw	51-79	21-49	N	AwSw-N
			S	AwSw-S
SwAw	21-50	50-79	N	SwAw-N
			S	SwAw-S
Sw	0-20	80-100	N	Sw-N
			S	Sw-S
Pj	0-20	80-100	E	Pj-E
			W	Pj-W
PjMix	21-79	21-79	E	PjMix-E
			W	PjMix-W
Sb_G	0-20	80-100	E	Sb_G-E
			W	Sb_G-W

The stratification scheme will be used for determining the number of additional samples to establish. It will also help determine TSP needs during future sampling exercises, in order to fill data gaps. Until such time as there are sufficient data in managed stands to complete a similar variance analysis, this sampling scheme will be used when selecting potential locations for sampling in managed stands.

4.2 Temporary Sample Plots

TSP data will be collected to fill data gaps in specific strata and to address ad-hoc questions. TSPs are recognized as the best quick solution to data needs. TSPs may also be necessary to validate growing stock for standing timber yield curves. TSPs will be sampled on an as-needed basis to:

1. Operationalize the spatial harvest sequence;
2. Determine merchantability of certain AVI stand types;
3. Develop volume and piece size estimates;
4. Provide supplemental data for model development in lower priority areas (*e.g.* black spruce, medium Pj); and/or
5. Model validation.

There will be no commitment to additional numbers of plots, since needs will determine what data must be collected and at what intensity. The need for additional TSPs will be assessed prior to the next FMP; TSP sampling programs will be submitted to SRD for review and approval prior to implementation.

TSPs may be used to help validate growth and yield models, and growth and yield models will be used to develop standing timber and regenerating yield curves.

4.3 Natural Stand Program

All existing PSPs in natural stands have been established using ASRD PSP protocols, either by Alberta-Pacific or by the government (LFS PSPs). These PSPs provide important information on the growth dynamics of natural stands and will continue to be an important growth and yield data source.

4.3.1 Sampling Design

All PSPs will be re-measured according to the existing ASRD PSP manual (ASRD 2005). Based on current protocols, plots consist of a series of nested plots, with a 1000 m^2 main plot for sampling trees $\geq$ 9.1 cm DBH, a 250 m^2 sapling plot for measuring trees $\geq$ 1.3 m tall, and a 62 m^2 regeneration plot for tallying seedlings 0.1-1.29 m tall by height class. Note that plot sizes actually vary based on density at establishment; for example, in the Alberta-Pacific FMA area, the main plot size ranges from 62 m^2 to 2000 m^2.

Within the main and sapling plots, all eligible trees are tagged and measured for height, diameter, height to live crown, crown class and condition codes. Age information is collected in the plot buffer on a minimum of three

dominant/codominant trees of each major species found in the plot, including collection of the same mensurational data collected on main plot trees.

Plots are measured every 10 years from age 80-130 for coniferous stands and 60-100 for deciduous stands; for older or younger stands, re-measurements occur at a 5-year measurement interval.

The following changes will be made to the current protocols:

1. All PSPs in stands older than 40 years of age will be re-measured every 10 years; PSPs in young stands will be measured at 5-year intervals.

2. New rules will be developed for collecting site index data by species group, and will be collected for each plot at next measurement[12]. For juvenile plots, site index will be collected twice: once when the majority of trees are older than 10 years of age, and once when the majority of trees are approximately 50 years of age.

3. Ecosite will be assessed at the same time as site index (unless already collected within the last five years).

4. Vegetation plots will no longer be measured except during ecosite assessment.

5. Small main plots (*e.g.* 62 m^2) will be increased to 400 m^2 at next measurement.

An addendum will be created for the SRD PSP manual describing the components listed above.

4.3.2 Sample Size

Alberta-Pacific will continue to re-measure all existing PSPs in natural stands (Table 9).

Table 9. Number of natural stand PSPs in Alberta-Pacific growth and yield program.

Stratum	Number of PSPs
Aw	118
Aw/Sw	18
AwSw	42
SwAw	37
Sw	33
Pj	35
PjMix	25
Sb_FM	9
Sb_G	4
Total	321

Currently, PSPs are protected from harvest: while stands are eligible for scheduling under the spatial harvest sequence, PSPs within stands are buffered and left unharvested.

[12] New rules for site index sampling will include addition of a top height plot (rather than sampling in the PSP buffer), selection of one top height tree per 100 m^2 by species, and measurement of top height and breast height age (or total age in younger stands).

4.4 Managed Stand Program

The emphasis in this growth and yield plan is placed on managed stands. All existing PSPs in managed stands will be maintained. These include 35 PSPs established using SRD protocols and 9 PSPs established using JPSP protocols, which will be re-measured using existing field manuals (The Forestry Corp. 2008, ASRD 2005). New sampling will be undertaken as part of a new ATP program (ARS Transitioning to PSPs), which is described briefly below, and in further detail in Appendix II. An ATP field manual will be developed in 2010.

The ATP program is intended to monitor the assumed linkage between Alberta Regeneration Surveys and future yields, as well as to provide data for managed stand growth and yield needs. Under this program, a subset of ground-sampled "sampling units" (SUs), as defined under the current Alberta Regeneration Standards for performance age stands, will be selected for intensive sampling.

The ATP program will collect data to support:

1. Individual tree and stand level model development and validation.
2. Validation of yield curves based on the current FMP standards.
3. Tracking of top height and potential dominance switching over time.
4. Examination of density and stocking trajectories at a block level.
5. Comparison of the potential for varying plot sizes to represent stand-level growth.

4.4.1 Sampling Design

The sampling design is a nested design of plots of varying sizes, established at varying intensities within existing performance age (12-14 year old) cutblocks. Three types of plots will be sampled:

ATP10 For each selected SU, 40 basic plots (10 m^2) sampled during performance surveys will be permanently marked for re-measurement[13]. Ten of these basic plots will also have been selected for additional detail plot measurements (random heights and diameters within a 10 m^2 area, and measurement of top height by species within a 100 m^2 area). Only top height trees will be tagged. All performance survey protocols will be measured every five years to age 40, and then every 10 years until age 60[14].

ATP100 Three of the 100 m^2 detail plots will be selected for additional sampling. Inside these plots, all trees will be measured for height and DBH[15]. No additional trees will be tagged. In high density stands, only ½ the plot will be sampled. Plots will be measured every five years to age 40, then every 10 years thereafter.

ATP400 A 400 m^2 individual tree PSP will be established in approximately 1/3 of ATP stands. The main plot will be centered around one of the ATP100 plots and will measure all trees with a diameter of 9.1 cm[16] or greater. Plots will be measured every five years to age 40, then every 10 years thereafter.

[13] Including measurement of optional heights and diameters as per the performance survey protocols.
[14] ATP10 plots will be re-measured until at least year 60, at which time they will be evaluated to determine whether there is value in continuing re-measurements.
[15] Conifers ≥ 30 cm and deciduous ≥ 130 cm in height.
[16] Minimum diameter for measurement may change based on field trials and examination of existing data.

The sampling design will be similar to the design for natural stand PSPs in that:

1. Stands will be measured every 5 years until age 40, after which a 10-year re-measurements schedule will be employed (with the exception of the ATP10 component, which is sampled only to age 60).

2. For ATP400 plots, site index will be collected twice: once when the majority of trees are older than 10 years of age (likely at performance age), and once when the majority of trees are approximately 50 years of age. Site index will be collected at each measurement within ATP10 top height plots.

3. Ecosite will be assessed at the same time as site index collection in the ATP400 plot.

4. Vegetation plots only be measured during ecosite assessment.

These rules will also be applied to the existing PSPs (sampled using ASRD and JPSP protocols).

This sampling design will allow Alberta-Pacific to collect more data relative to the cost of establishing individual PSPs in selected stands, and tailors data collection efforts more closely to the companies' varying growth and yield needs.

The sampling design will also enable Al-Pac to mitigate the impact of losing PSPs to oil and gas activity. For example, up to 25% of ATP10 plots may be disturbed before the block will be considered for replacement; if one of the ATP100 plots is disturbed, it can be replaced by one of the remaining 100 m^2 plots (top height plots) on the ATP10 grid.

4.4.2 Sample Size

The existing and planned number of samples is outlined in Table 10. Based on the number of existing and planned samples, the managed stand program will provide:

- 104 individual tree permanent sample plots (44 existing PSP + 60 ATP400)
- 570 repeatedly measured stand-level permanent sample plots (ATP100)
- 190 repeatedly measured block-level permanent sample stands (ATP10)

Note that the higher number of samples in Aw stands reflects the relative importance of this stand type to the AAC.

Table 10. Planned number of managed stand samples.

	Percent	Existing PSPs		Planned ATP		Total			
Stratum	AAC	SRD	JPSP	Basic	w/ATP400	PSP	ATP400	ATP100	ATP10[1]
Aw	53	10	7	38	12	17	12	150	50
AwSw	5	7	0	20	10	7	10	90	30
SwAw	5	5	1	20	10	6	10	90	30
Sw	18	5	0	20	10	5	10	90	30
Pj	14	5	1	20	10	6	10	90	30
PjMix	1	2	0	6	4	2	4	30	10
Sb	4	1	0	6	4	1	4	30	10
Total	100	35	9	130	60	44	60	570	190

[1] Number of ATP 10 samples represents number of stands, not number of 10 m^2 plots.

For the mixedwoods, pure Pj and pure Sw strata, a minimum of 30 new ATP samples will be established, although this is proportionally higher than the current AAC. This sample size will provide 10 new ATP400 PSPs for individual tree modelling, plus samples from 20 additional stands, which will in turn supply enough data to create N/S or E/W splits for model development and validation if required (90 ATP100 plots would provide a sufficient number of "static" points for model validation based on current FMP requirements).

The PjMix and Sb strata represent a very low proportion of both the AAC and the landbase; however, 10 ATP samples will still be established in these stand types (where available). The sample will provide 4 new ATP400 plots for individual tree modelling, plus samples from an additional 6 stands, which supplies enough data for model development and validation if required (30 ATP100 plots would provide a sufficient number of "static" points for model validation based on current FMP requirements).

Geographic splits (N/S, E/W) will be used to ensure that the number of samples are established in proportion to the landbase areas.

4.5 High-Effort Strip Cut Understory Protection Program

High-effort understory protection PSPs will be addressed through the establishment of understory protection PSPs in cooperation with the Mixedwood Management Association (MWMA). The six existing understory protection PSPs established using the ASRD PSP protocols will be evaluated to either 1) determine whether these plots can be converted to the MWMA design, or 2) map plot areas to assign portions of the plots to understory protection strata and continue re-measurements using the ASRD manual (ASRD 2005).

4.5.1 Sampling Design

MWMA sampling protocols are described in The Forestry Corp. (2003) and ASRD sampling protocols are described in ASRD manual.

4.5.2 Sample Size

Target sampling intensity is shown in Table 11 (numbers from The Forestry Corp. 2003). Target sampling intensity represents the number of blocks to be sampled. Five PSPs will be established in each selected block. Across all Mixedwood Management association members, the total sample size will be between 45 and 90 PSPs. Note that target pre-harvest understory densities may change to reflect Alberta-Pacific TSA assumptions.

Table 11. Target sampling intensity (number of blocks to be sampled) for Alberta Mixedwood Management Association understory protection PSPs.

	Pre-Harvest Understory Density		
Natural Subregion	300-600 sph	600-1000 sph	>1000 sph
Central Mixedwood	5-10	5-10	5-10
Dry Mixedwood	5-10	5-10	5-10
Other	5-10	5-10	5-10

5. Planning and Scheduling

5.1 Planned Development

The following activities are planned in support of this growth and yield plan:

1. Create an addendum to the SRD PSP manual regarding modified data collection protocols: survey timing, vegetation and ecosite data collection, and site index sampling.

2. Update the Juvenile PSP (JPSP) manual to align with existing PSP manuals.

3. Create a field manual for the ARS Transitioning to PSP (ATP) program.

Field manual development and testing will be undertaken in 2010.

Alberta-Pacific is also creating a new database as a repository for repeated measures. This database will include enhanced content to facilitate data entry and cleaning, re-measurements scheduling and data compilation.

5.2 Scheduling

The total number of planned measurements is summarized in Table 12. Re-measurements of existing PSPs includes existing natural PSPs as well as managed stand and understory protection PSPs sampled using ASRD and JPSP protocols.

Note that the total number of PSP re-measurements can vary considerably by year, and the PSPs to be re-measured in any given year can be widely distributed geographically. As such, Alberta-Pacific intends to review the scheduled re-measurements and adjust them as follows:

1. Examine PSPs to be re-measured by year and geographic location.

2. Shift the planned re-measurements for a given PSP by up to two, but preferably only one, years in order to group PSPs geographically, and to even out the number of PSPs being re-measured by year.

Table 12. Number of planned measurements by plot type over the next 30 years.

	Basic ATP[1]						ATP with ATP400[1]						Total ATP			Remeas. of Existing PSPs[3,4,5]								Total
Year	E	R1	R2	R3	R4	R5	E	R1	R2	R3	R4	R5	400	100	10[2]	R1	R2	R3	R4	R5	R6	R7	R8	PSP
2010	10													30	10	12	27							39
2011	10						5						5	45	15	12	31							43
2012	10						5						5	45	15		27	1						28
2013	10						5						5	45	15	6	37							43
2014	10						5						5	45	15	3	37	4						44
2015	10	10					5						5	75	25		10	35						45
2016	10	10					5	5					10	90	30		2	43						45
2017	10	10					5	5					10	90	30		16	21	1					38
2018	10	10					5	5					10	90	30		28	17						45
2019	10	10					5	5					10	90	30		13	17	15					45
2020	10	10	10				5	5					10	120	40		12	8	24					44
2021	10	10	10				5	5	5				15	135	45		12	7	24					43
2022	10	10	10				5	5	5				15	135	45			25	2					27
2023		10	10					5	5				10	90	30		6	35	2					43
2024		10	10					5	5				10	90	30		3	37	2					42
2025		10	10	10				5	5				10	120	40			10	11	20				41
2026		10	10	10				5	5	5			15	135	45			2	19	21				42
2027		10	10	10				5	5	5			15	135	45			16	19	3				38
2028			10	10					5	5			10	90	30			28	14	1				43
2029			10	10					5	5			10	90	30			13	17	15				45
2030			10	10	10				5	5			10	120	40			12	8	4	20			44
2031			10	10	10				5	5	5		15	135	45			12	7	3	21			43
2032			10	10	10				5	5	5		15	135	45				25		2			27
2033				10	10					5	5		10	90	30			6	35	1	1			43
2034				10	10					5	5		10	90	30			3	37	2				42
2035				10	10	10				5	5		10	120	40				10	10		20		40
2036				10	10	10				5	5	5	15	135	45				2	18		14		34
2037				10	10	10				5	5	5	15	135	45				16	17	1			34
2038					10	10					5	5	10	90	30				28	10		1		39
2039					10	10					5	5	10	90	30				13	17	15			45
Total	130	130	130	130	100	50	60	60	60	60	45	20	305	2925	975	33	261	352	331	142	60	35	0	1214

[1] Establishment at age 12-14; remeasurements every 5 years thereafter.

[2] Number of ATP 10 samples represents number of stands, not number of 10 m^2 plots.

[3] Includes Al-Pac PSPs surveyed using both SRD and JPSP protocols but excludes existing LFS PSPs in Al-Pac's FMA area.

[4] Remeasurements occur at 5 or 10-year intervals depending on age of stand and PSP type.

[5] Remeasurement schedule may be modified slightly to create sampling efficiencies and even flow costs.

6. Ongoing Development

The Forest Companies' growth and yield program for the Alberta-Pacific FMA area is expected to develop in an iterative manner over time. Improved knowledge, changes in information needs, feedback from incoming data, and a variety of other factors will affect the evolution of the plan.

The Forest Companies are committed to continuing to develop a growth and yield knowledge base that incorporates a number of different types of data and levels of data acquisition, from simple regeneration survey data to detailed PSP protocols.

It is important to note that PSPs and ATPs are and will be continually threatened by increasing oil and gas activity in the Alberta-Pacific FMA area. Of specific concern are PSPs where only one measurement is obtained prior to destruction by the energy sector. Under current protocols, there is a significant investment in establishment costs that may not be necessarily realized in long-term data acquisition. The Forest Companies are discussing alternatives to reduce the cost of growth and yield sampling, particularly with respect to establishment costs. The new Alberta-Pacific ATP protocols may allow an increase in the number of samples and reduce the financial impact of PSP losses due to oil and gas activities.

The growth and yield plan will be reassessed prior to subsequent Forest Management Plans and/or where major changes to the growth and yield program are anticipated. Changes will be made as appropriate to reflect the current philosophy and intended execution of the plan and will be discussed with ASRD prior to implementation.

7. References

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Province of Alberta. 1998. Forests Act Forest Management Agreement OC 193/98. Available online at: http://www3.gov.ab.ca/srd/forests/managing/fma/pubs/FMA_ALPAC.pdf

Appendix I. Proposed ATP Design

The goal of this approach to growth and yield sampling is to continue sampling of ARS based protocols and transition to a PSP program and to test varying levels of sampling relative to growth and yield needs and efficiency. This program should provide good stand level data over time to validate model trajectories and yield curves. It will be supplemented by fewer traditional PSPs (in the form of ATP400 plots) to provide individual tree trajectories, species interactions as well as data on ingress and mortality for model functions. Field protocols based on this design will be developed in 2010.

The goal of this design is to provide data for a variety of uses, including:

1. Model validation
2. Model calibration
3. Stand dynamics
4. Yield curve development
5. Yield curve validation (FMP requirements)
6. Landscape monitoring

For objectives 1-3, trajectories of change over time are needed, including:

Stand Level:

- Stocking
- Density
- Top Height
- Basal area
- Volume
- Height and Diameter (mean, standard deviation, *etc.*).

Tree Level:

- Height
- Diameter
- Mortality
- Ingress

For objectives 4-6, static (point in time) information is necessary to:

- Provide data to initiate models: stocking, density, top height, etc.
- Provide data to validate predicted volumes.

The design proposed here has been discussed with MGM model developers at the University of Alberta and staff at Alberta Sustainable Resource Development (SRD), who are familiar with GYPSY modelling needs.

Types of Data and Source

Stand Level:

Density and Stocking (**ATP10**)
- 10 m^2 plots across the stand
- Tally all trees ≥ 30 cm for conifers and ≥ 130 cm for deciduous
- Measure at performance and every 5 years to age 40, then 10 years to age 60

Height and Diameter (**ATP10**)
- Every 4th 10 m^2 plot across the stand
- Measure DBH on three trees ≥ 130 cm by species
- Measure height on three trees ≥ 30 cm (conifer) and ≥ 130 cm (deciduous) by species group
- Measure at performance and every 5 years to age 40, then 10 years to age 60

Top Height (**ATP10**)
- At every 4th plot, establish a 100 m^2 plot centered around the 10 m^2 plot
- Tag top height tree only (no advance growth)
- Measure total age and height (rules of when to change to breast height age TBA)
- Measure at performance and every 5 years to age 40, then 10 years onwards

Density, Height, Diameter, [BA, volume] (**ATP100**)
- Subsample of 100 m^2 plots across stand (3 out of 10 top height plots)
- Measure all trees ≥ 30 cm for conifers and ≥ 130 cm for deciduous
- Reduce plot size for high density stands by ½ (sample north half of plot and tally remainder of plot)
- Sample advance growth separately (measurements and/or tallies)
- Measure at performance and every 5 years to age 40, then 10 years onwards

Tree Level:

Individual Tree height, Diameter, Mortality and Ingress (**ATP400**)
- 400 m^2 plot centered around one of the ATP100 plots
- Measure height and DBH of all trees ≥ 9.1 cm DBH
- Measure height and DBH of all planted conifers ≥ 30 cm in height
- All trees in ATP100 and ATP400 tagged and measured
- Sample advance growth separately (measurements and/or tallies)
- Measure at performance and every 5 years to age 40, then 10 years onwards

Sampling Design

Number of Plots by Type (see sample plot layout in Figure 2):

- 40 regen plots (ATP10 – ARS basic plots)
- 10 top height plots (ATP10 – ARS detail plots)
- 3 100 m^2 plots (ATP100 – repeated measures TSPs)
- 1 400 m^2 plot (ATP400 – individual tree PSP)

- Select SUs from each year's sample population by stratum, weighted by comp_wt
- Must have a minimum of 40 10 m^2 plots
- All selected SUs have ATP10 and ATP 100 sampling
- Establish ATP400 in a subsample of selected SUs (approximately 30%)

- ATP400 will be placed in one SU randomly selected using probability proportional to area[17]

ATP10 For each selected SU, 40 basic plots (10 m^2) sampled during performance surveys will be permanently marked for re-measurement[18]. Ten of these basic plots will also have been selected for additional detail plot measurements (random heights and diameters within a 10 m^2 area, and measurement of top height by species within a 100 m^2 area). Only top height trees will be tagged. All performance survey protocols will be measured every five years to age 40, and then every 10 years until age 60[19].

ATP100 Three of the 100 m^2 detail plots will be selected for additional sampling. Inside these plots, all trees will be measured for height and DBH[20]. No additional trees will be tagged. In high density stands[21], only ½ the plot will be sampled. Plots will be measured every five years to age 40, then every 10 years thereafter.

ATP400 A 400 m^2 individual tree PSP will be established in approximately 1/3 of ATP stands. The main plot will be centered around one of the ATP100 plots (randomly selected from available ATP100 plots within the SU) and will measure all trees with a diameter of 9.1 cm[22] or greater. Plots will be measured every five years to age 40, then every 10 years thereafter.

Additional Measurements:

The following additional data will be collected:

- Site Index
  - Additional site index sampling to be compatible with existing PSP plots
  - Site index assessment to occur at performance age and age 50 for all ATP400 only
  - Site index assessment methods to follow protocols in the existing JPSP manual (within 300 m^2)
  - Sample total age and height by species group at performance age, and breast height age and height at age 50
- Ecosite
  - No vegetation plot data collection except at time of ecosite assessment
  - Ecosite assessment to occur at performance age and age 50 for all ATP stands
  - Ecosite assessment to occur in ATP400 plot if present; else at one of the three ATP100 plots
- Vegetation
  - Assess within each small plot (for ecosite assignment)
    - Percent cover by vegetation class: grasses, forbs, low shrubs, high shrubs
    - Average height of high shrubs (SRD definition of high shrub)
- Samples will not be protected from harvesting; when the block is harvested, the entire ATP will be harvested at the same time. However, no blocks with ATPs located within their boundaries will be scheduled for harvesting until at least three measurements have been obtained.
- ATPs will be protected from landuse wherever possible. However, an ISP will only be placed on the ATP400 plot. Up to 25% of ATP10 plots may be destroyed before the block is reevaluated. If one of the ATP100 plots is disturbed, it may be replaced by one of the other ATP10 top height plots.

[17] Assuming that initial selection of SUs for ATP10/100 uses probability proportional to the comp_wt, the resulting selection should have been corrected for initial selection bias; as such, subsequent selection for the ATP 400 plot will use probability proportional to SU area.
[18] Including measurement of optional heights and diameters as per the performance survey protocols.
[19] ATP10 plots will be re-measured until at least year 60, at which time they will be evaluated to determine whether there is value in continuing re-measurements.
[20] Conifers ≥ 30 cm and deciduous ≥ 130 cm in height.
[21] A high density stand is defined as 10,000 sph or greater.
[22] Minimum diameter for measurement may change based on field trials and examination of existing data.

Use of the Data

ATP10

- Use to verify model trajectories predicted by GYPSY and MGM
- Data also suitable for GYPSY model development (stand level model)
- Landbase monitoring

ATP100

- Trajectories as from ATP10, with the exception of stocking
- Better height and diameter information (larger sample)
- Data suitable for validating yield curves (volume/age trajectories) – as per current FMP requirements
- Three observations for 300 m^2 of sampling effort, considerably cheaper than 1 PSP measurement
- Use to test plot vs. stand level – are the estimates different?
- Track switch in top height dominance over time
- Landbase monitoring

ATP400

- All uses similar to SPSP data
- Key use is data for individual tree trajectories – suitable for MGM model development – and information on species interactions as well as mortality/ingress modeling

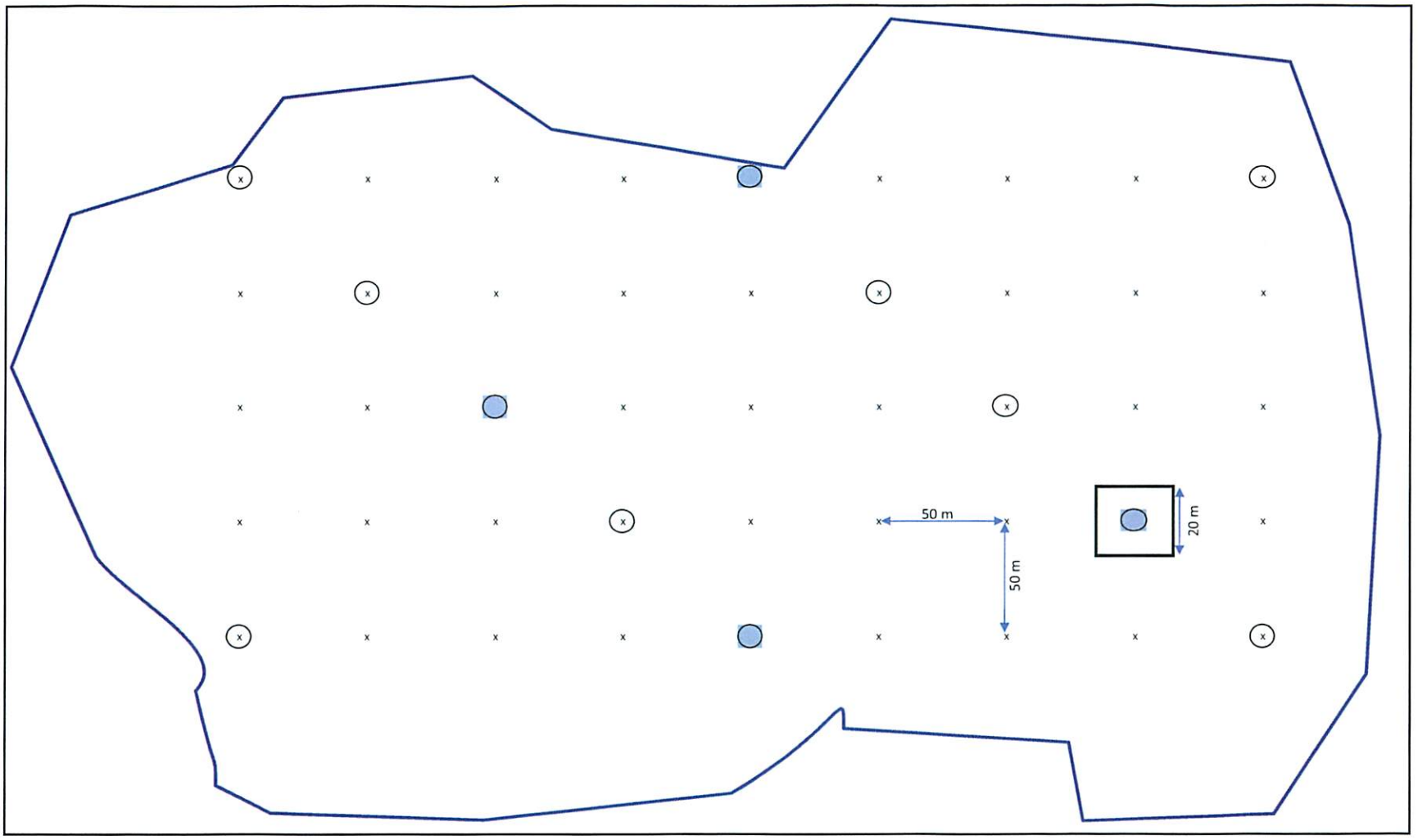

Figure 2. Sample layout of an ATP block.

x = ATP10 plots; circle = ATP10 top height plots; blue circle = ATP100 plots; square = ATP400 plot.