Growth and Yield Monitoring Plan for the Edson and Drayton Valley Forest Management Agreement Areas

Prepared for

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Project: WCG–010

October 6, 2005

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Executive Summary

As part of their Detailed Forest Management Plan process Weyerhaeuser Company Limited (Weyerhaeuser) must develop a growth & yield monitoring plan (GYMP) to measure actual growth on natural and managed stands. Weyerhaeuser proposed to the Alberta Forest Management Branch of the Department of Sustainable Resource Development (ASRD) that a joint program be developed for the Drayton Valley and Edson Forest Management Agreement (FMA) areas. This GYMP establishes Weyerhaeuser's growth & yield monitoring objectives for the fire-origin and post harvest regenerated (PHR) stands on the two FMA's.

The primary goal of the GYMP is to provide data to check growth & yield (G&Y) predictions. The intent is that the GYMP will be robust and provide data to check the different yield projection systems that are developed over time. The specific objectives are to:

1. Monitor change in volume, species composition, stand top height, site height, and site index in fire-origin stands on the two FMA areas.
2. Provide data on fire-origin stand growth that can be used as a subset of the data to develop new G&Y models and calibrate or validate existing models.[1]
3. Monitor change in volume, species composition, stand top height, site height, and site index (growth intercept) in PHR stands on the two FMA areas.
4. Provide data on competition and succession in PHR stands that can be used to link early stand performance to late stand conditions, especially in succession-based mixedwood stands.
5. Provide data on stand height and volume growth as well as seedling mortality and ingress that can be used as a subset of the data to develop new G&Y models or calibrate existing ones for PHR stands.
6. Provide data that could be used to develop relationships between ecological classification and stand development.

Weyerhaeuser's existing permanent sample plots (PSPs) will be used to meet objectives 1, 2, and 6 in fire-origin stands. A gap analysis showed that the 389 PSPs are well distributed across the fire-origin stands on the productive forest land base of the combined FMA areas. They proportionately represent the natural subregions, broad cover groups, site productivity, and crown closure classes. There are an additional 29 PSPs in the Drayton Valley FMA that are currently outside the productive forest land base. These PSPs will also continue to be re-measured as the definition of the productive forest land base may change over time.

To meet objectives 3, 4, 5, and 6 Weyerhaeuser will initially establish approximately 86 new growth and yield monitoring (GYM) plots on a 3.33 km grid in PHR stands. This grid will be created by dividing the National Forest Inventory 20 km grid[2] by six. This will allow each GYM plot established on the 20 km grid to also serve as a PSP in the provincial and federal inventory and monitoring programs. Initial

[1] Note that this program is not intended to develop new G&Y models, or calibrate and validate existing models. It is not expected that this program will provide all the data required to do this. Rather the data collected could be a subset of the total pool of data used.

[2] http://nfi.cfs.nrcan.gc.ca/nfi_e.html

establishment will include cut blocks from 1960 onwards. New GYM plots will be established over time as the target population of PHR stands expands. GYM plots will be established following reforestation of the block and re-measured at years 5, 10, 15, 20, 25, 30, 40, 50, etc. By 2018 there should be 122 GYM plots established. The 3.33 km grid size results in approximately 30 plots on 5% of the combined FMA areas.

Complete graphical and statistical analyses of the fire-origin PSPs and GYM plots will be completed on a five-year cycle. Analyses will address objectives 1 and 3 by comparing actual volumes, species composition, and site indices to those assumed in timber supply analyses.

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1. INTRODUCTION

1.1 Background

As part of developing their Detailed Forest Management Plan (DFMP), Weyerhaeuser must develop a growth and yield monitoring program (GYMP) to measure actual growth on natural and managed stands. Weyerhaeuser proposed to the Alberta Forest Management Branch of the Department of Sustainable Resource Development (ASRD) that a joint GYMP be developed for the Drayton Valley and Edson Forest Management Agreement (FMA) areas.

1.2 Growth & Yield Monitoring Defined

Growth and yield (G&Y) monitoring is the process of comparing observed growth and yield attributes of the forest, yield stratum, or a stand to predicted G&Y attributes to assess the risk and uncertainty of these predictions.[3]

Measurement data derived from the GYMP will be compared with G&Y models and assumptions used in timber supply analysis. If this analysis shows practically different[4] values from the assumptions used in timber supply analysis, then the GYMP data can be used to evaluate the impact and make appropriate adjustments.

A GYMP is a key component of adaptive management; it provides an independent and statistically-based sample of a forest area that can confirm the G&Y information used in timber supply. This is especially significant for post-harvest regenerated (PHR) stands where there is less certainty around productivity and yield predictions.

1.3 Project Goals & Objectives

The overall goal of this project is to develop a GYMP that is cost effective and meets both Weyerhaeuser and ASRD objectives.

The specific objectives of this project are to:

1. Clearly define the GYMP goals and objectives, including identifying G&Y activities that will not be part of the GYMP.
2. Determine the suitability of existing natural stand permanent sample plots (PSPs) for meeting the GYMP objectives and determine whether improvements are required.
3. Develop a sample design to meet the GYMP objectives for PHR stands.
4. Update field procedures.
5. Define future analysis and reporting procedures.
6. Establish a timeline for implementing the GYMP.

A database to store and manage all GYMP data (including existing PSPs and new GYMP plots) will be developed as part of a separate project.

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[3] McWilliams, E.R.G. and Thrower, J.S. 1994. A review of operational growth and yield monitoring in British Columbia. Contract Rep. BC MOF Inventory Branch, Minor Services Contract 19525.

[4] "practically different" is defined as differences that will change management decisions.

1.4 Terms of Reference

This project was completed by J.S. Thrower & Associates Ltd. (JST) for Greg Behuniak, *RPFT* of Weyerhaeuser, Grande Prairie, Alberta. The JST project team was Eleanor McWilliams, *MSc RPF* (project manager), Gyula Gulyas, *MScF* (technical advisor), Carlos Pinillos, *MSc* (GIS data analyst), and Hamish Robertson, *RPF BC* (technical reviewer).

1.5 Document Structure

Section 2 describes the guiding principles used to develop the GYMP along with program goals, objectives and scope. Sections 3 and 4 focus on the two main target populations of the GYMP. Section 3 deals with fire-origin stands, and Section 4 deals with PHR stands. Both sections are further divided into four sub-sections that include an overview and definition of the target population, a review of existing G&Y programs, and the specifics of the proposed G&Y data collection and monitoring program. Section 5 outlines the steps required to implement the GYMP.

2. GYMP OVERVIEW

2.1 Guiding Principles

The following general principles were used to guide the development of the GYMP:

1. One GYMP will be implemented for both the Edson and Drayton Valley FMA areas. We will evaluate if subdivision of the GYMP is necessary due to ecological or other factors affecting growth.
2. The GYMP will address G&Y monitoring (i.e., checking observed G&Y values against predicted G&Y variables and assumptions) in the short- and medium-term (10-20 years). G&Y monitoring will be carried out at the broad cover group (C/CD/DC/D) and natural subregion basis.
3. The importance of linking the GYMP to stratum specific regeneration standards (SSRS) and silviculture survey design is recognized. The proposed sampling design for the GYMP in regenerated stands will accommodate the linkage of early stand performance and other G&Y objectives.
4. Weyerhaeuser will utilize on-going existing data collection programs (e.g., Western Boreal G&Y Cooperative) to compliment data collected in the GYMP.
5. The GYMP will utilize the 20 km ASRD master grid for allocating sample plots to allow for potential integration and data sharing with government and other licensees.
6. Weyerhaeuser will acquire ownership of the PSP information for plots established by Sunpine Forest Products Ltd. in the R2U Forest Management Unit (FMU).
7. The data collected in the GYMP will be analyzed and the results submitted in the appropriate format five years after DFMP approval as part of the Forest Stewardship Plan.

2.2 Goal and Objectives

The primary goal of the GYMP is to provide data to check G&Y assumptions and predictions used in timber supply analysis. The specific objectives are to:

1. Monitor change in volume, species composition, stand top height, and site index in fire-origin stands on the two FMA areas. This data will be compared with predicted values of the same attributes used in timber supply analysis to provide a level-of-comfort that predictions are accurate. These comparisons will be made at the broad cover group (C/CD/DC/D) and natural subregion basis.
2. Provide data on fire-origin stand growth that can be used as a subset of the data to develop new G&Y models and calibrate or validate existing models.
3. Monitor change in volume, species composition, stand top height, site height and site index (growth intercept) in PHR stands on the two FMA areas. This data will be compared with predicted values of the same attributes and regeneration assumptions used in the timber supply analyses to provide a check that predictions are accurate. These comparisons will be made at the broad cover group (C/CD/DC/D) and natural subregion basis.
4. Provide data on competition and succession in PHR stands that can be used to link early stand performance to late stand conditions, especially in succession-based mixedwood stands.
5. Provide data on stand height, volume growth, seedling mortality, and ingress that can be used as a subset of the data to develop new G&Y models or calibrate existing ones for PHR stands.

6. Provide data that could be used to develop relationships between ecological classification and stand development.

2.3 Scope

The primary goal of the GYMP is to provide data to check G&Y predictions. The intent is that the GYMP will be robust and provide data to check the different yield projection systems that are developed over time. We consider the development of new yield curves or models a separate program and one that will evolve over time from the development of empirical yield curves to the development of more sophisticated G&Y models. It is recognized that additional data may need to be collected for the development of new yield curves or models. Data from the GYMP will be used to check the information used in timber supply analysis, regardless of whether it comes from empirical yield curves or G&Y models. The GYMP is designed to be a trigger mechanism (i.e., raise the red flag) if problems are detected. If this is the case, more in-depth studies can be undertaken to determine the cause(s) of the problem.

Checks of yield predictions will not occur for each individual stand type as it is not necessary and this requires an unreasonably high number of plots (and expense). A sufficient number of plots will be established to ensure that on average stands within each natural subregion and broad cover group (covering at least five percent of the combined land bases) are producing the expected yields. This is all that is required to meet the goal of checking yield predictions used in timber supply analysis. If analyses show that a more narrowly defined stratum (with a small number of plots) appears to be consistently over or under-estimated, additional temporary plots may be established to investigate further. This would only be necessary however, if timber supply sensitivity analyses showed that AAC determinations were sensitive to the yield projections for the strata in question.

Monitoring plots will be established across all regenerated stands on the two FMAs using a grid-based design. The grid-based design will ensure that stands are sampled proportional to their occurrence on the landscape, and furthermore that natural variation (age classes, densities, and site classes) is sampled proportional to its occurrence. Stratification will be done post-sampling. The target population of stands to sample will continually change over time making pre-stratification very complex. The design will be a simple system that will remain robust over time.

In the process of meeting the goal to provide data to check yield projections used in timber supply analysis, the GYMP will produce data that could be used as a subset of the data for future development of more sophisticated G&Y models. Ideally, independent datasets would be used to develop and check G&Y models. However, the costs of maintaining two independent sets of plots is likely prohibitively expensive and is not necessary. Most sophisticated G&Y models are developed using data from a wide range of areas and stand conditions. Consequently, the risk of a model projection being largely influenced by the data from any given management unit is low. However, it is prudent to examine the degree to which monitoring data from a given area contributed to a model before using the same data to check the model projections.

The primary goal of the GYMP is not to provide data for localization - it is to check that model outputs are as predicted for the specified target population. The term "localization" can be interpreted several different ways. For simple models, localization can be re-fitting functions to local data. For models that are more complex localization may simply be insuring the correct input values and adjustment factors for outputs as opposed to re-fitting equations. If problems are detected in the G&Y monitoring analysis, data from the GYMP could be used to make interim adjustments to yield projections, but this is not a primary goal of the program.

3. FIRE-ORIGIN STANDS

3.1 DEFINITION & LAND BASE SUMMARY

Natural stands are the dominant forest type in the Edson and Drayton Valley FMA areas. These stands regenerated naturally following wildfire and have relatively homogeneous species composition. The importance of natural stands will decline as the proportion of managed stands increases. The following key points describe the status and ideas on monitoring G&Y in these stands.

3.2 YIELD GROUPS

Thirty (30) and 35 yield groups were established during the planning process for the Edson and Drayton Valley FMA's, respectively (Table 1, Table 2). The yield groups were defined based on natural subregion, SiteLogix ecosite based productivity groups and AVI 2.1 stand attributes of crown closure and overstorey and understorey species composition.

Table 1. Yield Groups in the Weyerhaeuser Edson FMA area[a].

#	Nat Subrgn	Site Class	Crown Closure	#	Nat Subrgn	Site Class	Crown Closure
Coniferous dominated stands				*Deciduous dominated stands*			
1	LF	G	A	1	LF	G	A
2	LF	G	B	2	LF	G	B
3	LF	G	C	3	LF	G	C
4	LF	G	D	4	LF	G	D
5	LF	M	A	5	UF	G	A
6	LF	M	B	6	UF	G	B
7	LF	M	C	7	UF	G	C
8	LF	M	D	8	UF	G	D
9	LF	P	All	9	LF/UF	P	All
10	UF	G	A				
11	UF	G	B				
12	UF	G	C				
13	UF	G	D				
14	UF	M	A	*Coniferous dominated switch[b] stands*			
15	UF	M	B				
16	UF	M	C	19	LF/UF	G	All
17	UF	M	D	20	LF/UF	M	All
18	UF	P	All	21	LF/UF	P	All

[a] LF=Lower Foothills; UF=Upper Foothills; G=good; M=medium; P=poor
[b]Switch stands are based on the understory AVI attributes. Across the entire Edson FMA stands were assigned to the understory AVI attributes when a polygon had a pure deciduous "A" crown closure overstory with an understory crown closure greater than "A". For the W6 (Section 3.4.1) only, understory AVI attributes were used when non-horizontal polygons had a pure deciduous overstory with a coniferous or mixedwood understory of greater than "A".

Table 2. Yield Groups in Weyerhaeuser Drayton Valley FMA Area[a].

#	Nat Subrgn	Site Class	Crown Closure	#	Nat Subrgn	Site Class	Crown Closure
Coniferous dominated stands				*Deciduous dominated stands*			
1	LF	G	A	1	LF	G	A
2	LF	G	B	2	LF	G	B
3	LF	G	C	3	LF	G	C
4	LF	G	D	4	LF	G	D
5	LF	M	A	5	UF	G	A
6	LF	M	B	6	UF	G	B
7	LF	M	C	7	UF	G	C
8	LF	M	D	8	UF	G	D
9	LF	P	All	9	LF/UF	P	All
10	UF	G	A				
11	UF	G	B				
12	UF	G	C				
13	UF	G	D				
14	UF	M	A				
15	UF	M	B				
16	UF	M	C				
17	UF	M	D				
18	UF	P	All				
19	SA	G	A	*Coniferous dominated switch stands*			
20	SA	G	B				
21	SA	G	C	24	LF/UF/SA	G	All
22	SA	G	D	25	LF/UF/SA	M	All
23	SA	P	All	26	LF/UF/SA	P	All

3.3 Existing PSP Program

The PSP program started in Drayton Valley in 1994 with the goal of establishing 200 PSPs in predominantly standing timber. The plot design utilized stratified sampling based on the Phase 3 forest inventory classification. Plots were located randomly in stands selected randomly within each stratum. In 1998, with the completion of AVI in the FMA, stratification was re-examined. Strata were defined based on stand density, species composition, and origin.

The Edson FMA PSP program started in 1999 with the intent of establishing 210 PSPs across the land base. Plots were first established in FMU W6 because this was the only FMU having an approved AVI. Plots have since been established across the entire FMA. Stratification was based on AVI stand density, species composition, and origin. The plot configuration and random plot location process was the same as used in Weyerhaeuser's Drayton Valley and Slave Lake programs.

The programs in both FMAs were designed with the intent of acquiring data for regional analysis of growth and yield, rather than as stand alone programs. The data have been used for timber supply analyses, ecological mapping, and provided to SRD for development of regional stand volume tables.

3.3.1 PSPs

There are 418 permanent sample plots (PSP) in the combined FMA areas (Figure 1).[5] The PSPs were used in conjunction with temporary sample plots to develop the yield curves used in the 2000 timber supply analysis. This analysis was not approved and is being replaced by an analysis which employs yield curves developed solely from temporary sample plots. As a result, the PSPs are an independent data set the can be used for G&Y monitoring.

[5] There are 238 PSPs in Drayton Valley and 180 plots in Edson.

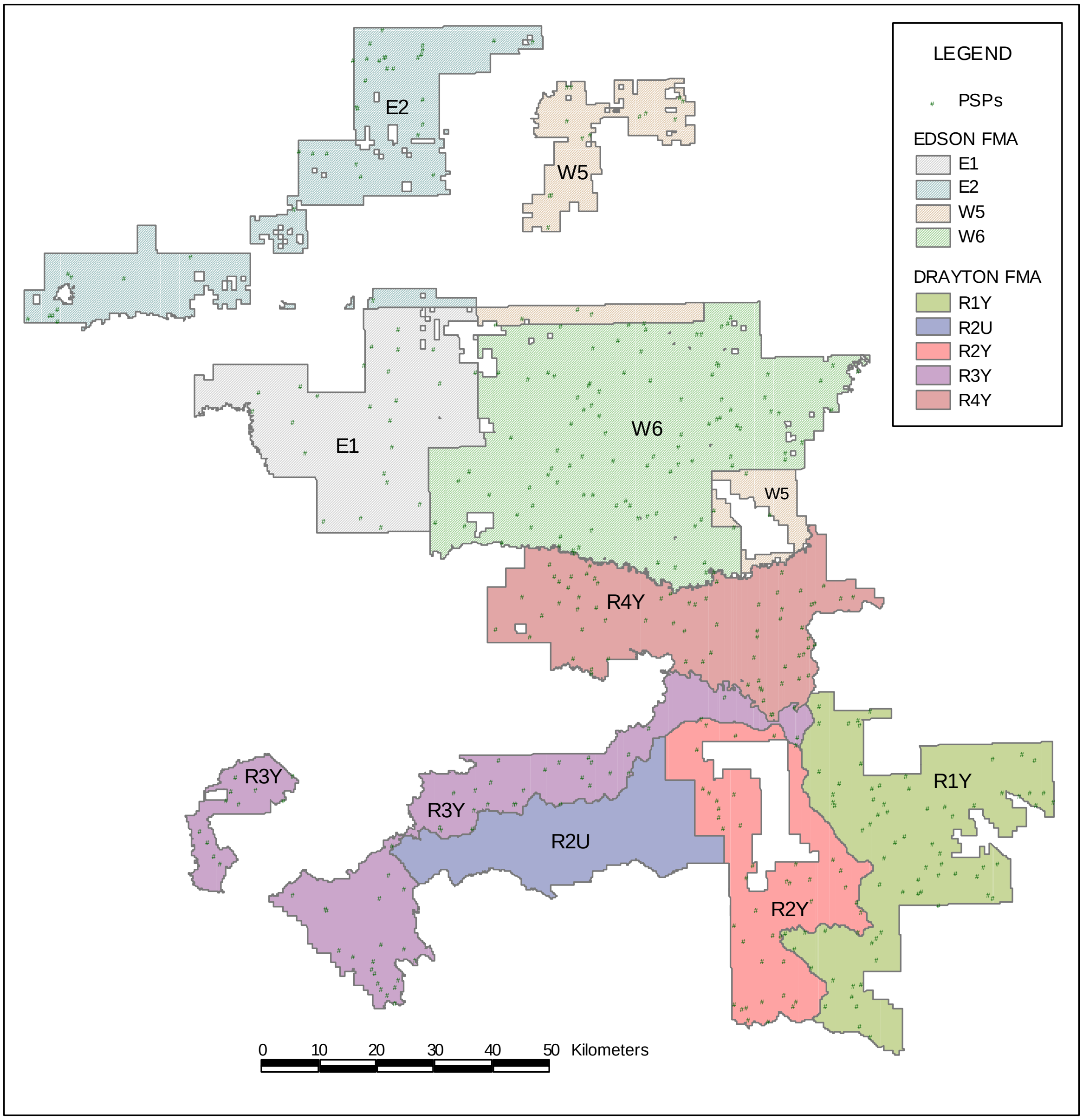

Figure 1. PSP distribution in the Edson and Drayton Valley FMAs.

3.4 Gap Analysis

A gap analysis was done to evaluate how well the existing PSPs represent the current distribution of fire-origin stands.

3.4.1 Edson FMA

The four FMUs comprising the Edson FMA are identified by the codes E1F, E2F, W5F, and W6F. There are 180 PSPs proportionately distributed across the natural subregions and broad cover groups (Table 3). In addition, the Edson fire-origin PSPs are reasonably well distributed across site productivity and density classes within the natural subregions and broad cover groups (Table 4, Table 5).

Table 3. Fire-origin PSP distribution in the Edson FMA by natural subregion and broad cover group.

Natural Subregion	Broad Cover Group	Area (ha)	Plots N	Area (%)	Plots (%)
Lower Foothills	unknown		1		1%
	C	95,614	67	41%	37%
	CD	23,361	28	10%	16%
	D	70,694	44	30%	24%
	DC	23,835	24	10%	13%
	Subtotal	*213,504*	*164*	*92%*	*91%*
Upper Foothills	C	12,458	8	5%	4%
	CD	2,278	2	1%	1%
	D	2,765	4	1%	2%
	DC	2,283	2	1%	1%
	Subtotal	*19,783*	*16*	*8%*	*9%*
	Total	*233,288*	*180*	*100%*	*100%*

Table 4. PSP distribution in the Edson FMA Lower Foothills by broad cover group, timber productivity rating, and density class.

Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)	Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)
C	G	A	6,995	6	3%	4%	D	G	A	1,733	3	1%	2%
	G	B	12,390	13	6%	8%		G	B	12,314	14	6%	9%
	G	C	14,256	9	7%	5%		G	C	43,798	19	21%	12%
	G	D	4,462	2	2%	1%		G	D	12,792	8	6%	5%
	M	A	3,897	2	2%	1%		M	A	0	0	0%	0%
	M	B	7,342	7	3%	4%		M	B	0	0	0%	0%
	M	C	28,008	10	13%	6%		M	C	0	0	0%	0%
	M	D	8,449	7	4%	4%		M	D	0	0	0%	0%
	P	A	6,341	9	3%	5%		P	A	0	0	0%	0%
	P	B	1,689	1	1%	1%		P	B	0	0	0%	0%
	P	C	1,430	1	1%	1%		P	C	58	0	0%	0%
	P	D	355	0	0%	0%		P	D	0	0	0%	0%
CD	G	A	2,685	5	1%	3%	DC	G	A	3,330	0	2%	0%
	G	B	4,597	4	2%	2%		G	B	5,474	6	3%	4%
	G	C	9,937	18	5%	11%		G	C	13,510	16	6%	10%
	G	D	1,377	1	1%	1%		G	D	1,209	2	1%	1%
	M	A	613	0	0%	0%		M	A	0	0	0%	0%
	M	B	1,033	0	0%	0%		M	B	0	0	0%	0%
	M	C	2,001	0	1%	0%		M	C	0	0	0%	0%
	M	D	167	0	0%	0%		M	D	0	0	0%	0%
	P	A	633	0	0%	0%		P	A	165	0	0%	0%
	P	B	139	0	0%	0%		P	B	66	0	0%	0%
	P	C	133	0	0%	0%		P	C	80	0	0%	0%
	P	D	46	0	0%	0%		P	D	0	0	0%	0%
								Unknown			1		1%
								Overall Totals		*213,504*	*164*	*100%*	*100%*

Table 5. PSP distribution in the Edson FMA Upper Foothills by broad cover group, timber productivity rating, and density class.

Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)	Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)
C	G	A	584	0	3%	0%	D	G	A	235	1	1%	6%
	G	B	1,676	1	8%	6%		G	B	432	0	2%	0%
	G	C	6,672	3	34%	19%		G	C	1,832	2	9%	13%
	G	D	2,121	0	11%	0%		G	D	238	1	1%	6%
	M	A	595	3	3%	19%		M	A	0	0	0%	0%
	M	B	100	0	1%	0%		M	B	0	0	0%	0%
	M	C	495	0	3%	0%		M	C	0	0	0%	0%
	M	D	84	0	0%	0%		M	D	0	0	0%	0%
	P	A	3	0	0%	0%		P	A	0	0	0%	0%
	P	B	6	0	0%	0%		P	B	0	0	0%	0%
	P	C	110	1	1%	6%		P	C	29	0	0%	0%
	P	D	11	0	0%	0%		P	D	0	0	0%	0%
CD	G	A	134	1	1%	6%	DC	G	A	186	0	1%	0%
	G	B	414	0	2%	0%		G	B	572	1	3%	6%
	G	C	1,368	1	7%	6%		G	C	1,359	1	7%	6%
	G	D	219	0	1%	0%		G	D	136	0	1%	0%
	M	A	11	0	0%	0%		M	A	0	0	0%	0%
	M	B	17	0	0%	0%		M	B	0	0	0%	0%
	M	C	97	0	0%	0%		M	C	0	0	0%	0%
	M	D	3	0	0%	0%		M	D	0	0	0%	0%
	P	A	1	0	0%	0%		P	A	14	0	0%	0%
	P	B	1	0	0%	0%		P	B	1	0	0%	0%
	P	C	12	0	0%	0%		P	C	15	0	0%	0%
	P	D	0	0	0%	0%		P	D	0	0	0%	0%
									Overall Totals	*19,783*	*16*	*100%*	*100%*

3.4.2 Drayton Valley FMA

The Drayton Valley FMA is comprised of five FMUs identified by the codes R1Y, R2Y, R3Y, R4Y, and R2U.

In 2000, Weyerhaeuser approached Sunpine Forests Products Ltd. with the opportunity to amend the boundary of the R2U management unit so that Weyerhaeuser could access its conifer quota within its own Drayton Valley FMA boundary. Negotiations occurred to fine-tune the boundary and in 2001, an agreed-upon area was identified, and the boundaries to each FMA were amended. The amended area was sufficient to provide Weyerhaeuser with a conifer annual allowable cut sufficient to meet the previous quota commitment.

Weyerhaeuser will acquire Sunpine's PSP's in the R2U FMU. The following summaries include the area of the R2U FMU, but not the Sunpine PSP's, as these have not yet been acquired.

Weyerhaeuser has 238 fire-origin PSPs in the R1Y, R2Y, R3Y and R4Y FMUs. Of these, 29 are outside the productive forest land base (PFLB) and therefore outside the target population for G&Y monitoring. These 29 plots will be re-measured and maintained as the definition of the PFLB could change over time. The distribution of the remaining 209 PSPs is shown relative to the entire FMA PFLB in the (Table 6).

Table 6 shows that even without PSPs from FMU R2U, the current PSPs are proportionately distributed across the natural subregions and broad cover groups. In addition, Table 7, Table 8, and Table 9 show that the Drayton fire-origin PSPs are reasonably well distributed across site productivity and density classes within the natural subregions and broad cover groups.

Table 6. Fire-origin PSP distribution in the Drayton Valley FMA by natural subregion and broad cover group.

Nat Subrgn	Broad Cover Group	Area (ha)	Plots N	Area (%)	Plots (%)
LF	C	81,752	72	31%	34%
	CD	18,787	18	7%	9%
	D	63,476	61	24%	29%
	DC	20,508	18	8%	9%
	Subtotal	*184,523*	*169*	*70%*	*81%*
SA	C	4,803	4	2%	2%
	Subtotal	*4,803*	*4*	*2%*	*2%*
UF	C	68,833	33	26%	16%
	CD	1,690	0	1%	0%
	D	1,127	2	0%	1%
	DC	1,582	1	1%	0%
	Subtotal	*73,233*	*36*	*28%*	*17%*
Overall Totals		*262,559*	*209*	*100%*	*100%*

Table 7. PSP distribution in the Drayton Valley FMA Lower Foothills by broad cover group, timber productivity rating, and density class.

Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)	Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)
C	G	A	6,971	5	4%	3%	D	G	A	1,617	1	1%	1%
	G	B	8,928	13	5%	8%		G	B	12,304	8	7%	5%
	G	C	20,048	15	11%	9%		G	C	37,230	32	20%	19%
	G	D	6,110	7	3%	4%		G	D	12,281	20	7%	12%
	M	A	5,030	7	3%	4%		M	A	0	0	0%	0%
	M	B	6,169	4	3%	2%		M	B	0	0	0%	0%
	M	C	15,516	9	8%	5%		M	C	0	0	0%	0%
	M	D	6,683	9	4%	5%		M	D	0	0	0%	0%
	P	A	2,053	1	1%	1%		P	A	1	0	0%	0%
	P	B	1,154	1	1%	1%		P	B	11	0	0%	0%
	P	C	1,901	1	1%	1%		P	C	29	0	0%	0%
	P	D	1,189	0	1%	0%		P	D	4	0	0%	0%
CD	G	A	3,010	2	2%	1%	DC	G	A	2,554	2	1%	1%
	G	B	3,964	4	2%	2%		G	B	4,253	3	2%	2%
	G	C	8,356	10	5%	6%		G	C	11,322	9	6%	5%
	G	D	1,822	0	1%	0%		G	D	2,255	4	1%	2%
	M	A	458	1	0%	1%		M	A	0	0	0%	0%
	M	B	365	1	0%	1%		M	B	0	0	0%	0%
	M	C	62	0	0%	0%		M	C	0	0	0%	0%
	M	D	10	0	0%	0%		M	D	0	0	0%	0%
	P	A	314	0	0%	0%		P	A	88	0	0%	0%
	P	B	215	0	0%	0%		P	B	30	0	0%	0%
	P	C	129	0	0%	0%		P	C	4	0	0%	0%
	P	D	82	0	0%	0%		P	D	0	0	0%	0%
							Overall Totals			*184,523*	*169*	*100%*	*100%*

Table 8. PSP distribution in the Drayton Valley FMA Upper Foothills by broad cover group, timber productivity rating, and density class.

Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)	Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)
C	G	A	6,379	0	9%	0%	D	G	A	23	0	0%	0%
	G	B	10,201	5	14%	14%		G	B	123	0	0%	0%
	G	C	30,589	13	42%	36%		G	C	728	2	1%	6%
	G	D	13,823	8	19%	22%		G	D	250	0	0%	0%
	M	A	457	0	1%	0%		M	A	0	0	0%	0%
	M	B	487	1	1%	3%		M	B	0	0	0%	0%
	M	C	2,121	1	3%	3%		M	C	0	0	0%	0%
	M	D	2,885	5	4%	14%		M	D	0	0	0%	0%
	P	A	639	0	1%	0%		P	A	1	0	0%	0%
	P	B	488	0	1%	0%		P	B	2	0	0%	0%
	P	C	579	0	1%	0%		P	C	0	0	0%	0%
	P	D	185	0	0%	0%		P	D	0	0	0%	0%
CD	G	A	133	0	0%	0%	DC	G	A	47	0	0%	0%
	G	B	258	0	0%	0%		G	B	161	0	0%	0%
	G	C	1,045	0	1%	0%		G	C	1,110	1	2%	3%
	G	D	206	0	0%	0%		G	D	177	0	0%	0%
	M	A	14	0	0%	0%		M	A	0	0	0%	0%
	M	B	2	0	0%	0%		M	B	0	0	0%	0%
	M	C	0	0	0%	0%		M	C	0	0	0%	0%
	M	D	0	0	0%	0%		M	D	0	0	0%	0%
	P	A	32	0	0%	0%		P	A	50	0	0%	0%
	P	B	0	0	0%	0%		P	B	38	0	0%	0%
	P	C	0	0	0%	0%		P	C	0	0	0%	0%
	P	D	0	0	0%	0%		P	D	0	0	0%	0%
							Overall Totals			*73,233*	*36*	*100%*	*100%*

Table 9. PSP distribution in Drayton Valley Subalpine by broad cover group, timber productivity rating, and density class.

Broad Cover Group	TPR	CC	Area (ha)	Plots N	Area (%)	Plot (%)
C	G	A	72	0	1%	0%
	G	B	207	0	4%	0%
	G	C	825	0	17%	0%
	G	D	346	0	7%	0%
	M	A	0	0	0%	0%
	M	B	0	0	0%	0%
	M	C	0	0	0%	0%
	M	D	0	0	0%	0%
	P	A	88	0	2%	0%
	P	B	589	2	12%	50%
	P	C	2,168	2	45%	50%
	P	D	508	0	11%	0%
		Totals	*4,803*	*4*	*100%*	*100%*

3.4.3 Edson and Drayton Valley combined

Weyerhaeuser has more than 40 existing fire-origin PSPs in each of the five natural subregion-broad cover group combinations that represents 5% or more of the combined land bases (Table 10). There are 15 PSPs in the remaining 3.6% of the land base.

Table 10. Fire-origin PSP distribution in the combined land bases by natural subregion and broad cover group.

Nat Subrgn	Broad Cover Group	Area (ha)	Plots N	Area (%)	Plots (%)
LF	Unknown		1		0%
	C	181,550	139	34%	36%
	CD	54,291	46	10%	12%
	D	141,868	105	27%	27%
	DC	47,447	42	9%	11%
	Subtotal	*425,156*	*333*	*81%*	*86%*
SA	C	4,978	4	1%	1%
	Subtotal	*4,978*	*4*	*1%*	*1%*
UF	C	83,851	41	16%	11%
	CD	5,692	2	1%	1%
	D	4,227	6	1%	2%
	DC	4,027	3	1%	1%
	Subtotal	*97,797*	*52*	*19%*	*13%*
	Total	*527,931*	*389*	*100%*	*100%*

3.5 Proposed Fire-Origin Stand G&Y Monitoring Program

3.5.1 Overview

The GYMP for fire-origin stands will utilize the existing fire-origin PSPs. A review of the PSP distribution shows that they are proportionately distributed across natural subregions, broad cover groups, productivity and density classes. No new plots will be established. There are 40 or more existing plots for all natural subregion-broad cover group combinations covering more than 5% of the combined land bases.

3.5.2 Objectives

The GYMP objectives (Section 2.2) that apply to fire-origin stands are:

1. Monitor change in volume, species composition, stand top height, site height and site index in fire-origin stands on the two FMA areas. This data will be compared with predicted values of the same attributes used in timber supply analysis to provide a level-of-comfort that predictions are accurate. These comparisons will be made at the broad cover group (C/CD/DC/D) and natural subregion basis.
2. Provide data on fire-origin stand growth that can be used as a subset of the data to develop new G&Y models and calibrate or validate existing models.
3. Provide data that could be used to develop relationships between ecological classification and stand development.

3.5.3 Target Population

The target population consists of all fire-origin stands within the productive forest land base on the Drayton Valley and Edson FMA areas. The target population will decrease over time as stands are harvested and regenerated.

3.5.4 Sample Design

The proposed sample design is to continue to re-measure the existing PSPs as per the Weyerhaeuser PSP program schedule. Appendix I contains the original report describing the PSP program.

3.5.5 Sample Size

Each natural subregion-broad cover group combination covering 5% or more of the combined land bases will contain a minimum of 40 plots. Combinations comprising less than 5% of the fire-origin land base will be amalgamated (Table 10).

3.5.6 Plot Design

PSPs established by Weyerhaeuser area are 0.1 ha circular plots. The main plot, which is used to record the tree information (dbh ≥ 7.1 cm), is established using a 17.84 m radius. All trees in the main plot are tagged. Saplings (1.0 cm < dbh < 7.1 cm) and regeneration (≥ 0.3 m in height and ≤ 1.0 cm dbh) are measured on four 0.001 ha subplots within the main plot. These subplots are established in each of the four cardinal directions (north, east, south, and west). The plots are circular, with a radius of 1.78 m (Figure 2). Appendix II contains the complete PSP field manual.

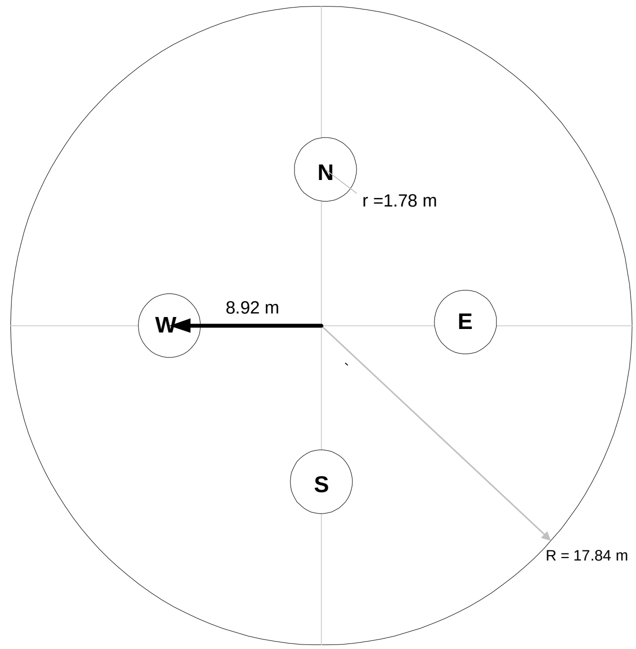

Figure 2. PSP design.

3.5.7 Measurement Schedule

PSPs will be remeasured every five to 10 years based on the anticipated rate of change in the particular stand type. Stands with relatively high rates of change include mature and over mature deciduous leading stands.

3.5.8 Data Management

Weyerhaeuser will build a database to store and manage all the GYMP data (including existing PSPs and new GYMP plots).

3.5.9 Data Analysis and Reporting

The data collected in the GYMP will be analyzed and the results submitted in the appropriate format five years after DFMP approval as part of Weyerhaeuser's Forest Stewardship Plan. A thorough analysis of sample sizes will be conducted as part of the analysis. For further details, refer to Section 4.4.12.

4. REGENERATED STANDS

4.1 Definition & Land Base Summary

PHR stands are those that originate after harvesting and reforestation activities. For the purposes of the GYMP, these stands are further defined as those resulting from harvesting from 1960 onwards. The importance of PHR stands to the annual harvest will increase over time. Currently there are 40,275 ha of PHR stands in the Drayton Valley FMA and 47,770 ha of PHR stands in the Edson FMA for a combined total of 88,045 ha.

4.2 Yield Groups

The fire-origin “C” crown closure yield curves are applied to regenerated stands (Table 1, Table 2).

4.3 Existing Data Collection Programs

There is very little G&Y data for PHR stands in the combined FMA areas for two main reasons:

1. Data collection efforts were focused on natural stand conditions to understand growth and to set current harvest levels.
2. Weyerhaeuser believed that the Northern Interior Vegetation Management Association (NIVMA) data collection programs would provide ample information on the G&Y of PHR stands.

Weyerhaeuser now acknowledges that NIVMA will not provide appropriate G&Y monitoring data and therefore are committed to establishing PSPs in regenerated stands to address G&Y monitoring needs.

4.3.1 NIVMA

NIVMA is a BC and Alberta forest industry co-operative that has been building a database for assessing plantation performance since 1989. NIVMA members use a common monitoring protocol to track plantation and managed stand development and performance. Eight hundred and fifty (850) installations were established using the Unified System of Silvicultural Monitoring (USSM) protocol up to 1995. The Treatment Regime Evaluation - Numerical Decision Support (TRENDS©) protocol was implemented in 1996 to meet the expanding monitoring objectives of the association. Weyerhaeuser Alberta has been an active NIVMA member since 1996 and has established 37 TRENDS plots on the Drayton Valley and Edson FMAs.[6]

The stated objectives for TRENDS are:[7]

1. Monitor years to breast height for timber supply planning purposes.
2. Monitor years to free growing for silviculture policy purposes.
3. Monitor tree performance in relation to the height of competing vegetation as a basis for reviewing the free growing targets.
4. Monitor years to breast height at various levels of site disturbance as a basis for reviewing soil conservation guidelines.
5. Monitor years to green-up height.

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[6] 19 TRENDS plots in Drayton Valley and 18 in Edson.

[7] TRENDS field manual. June 2002. http://www.nivma.bc.ca/

6. Monitor tree performance from operational silviculture regimes to assist in identifying trends in outcomes.
7. Describe changes in plant species communities following disturbance.
8. Monitor forest health in managed stands.

4.3.2 The Foothills Growth and Yield Association (FGYA)

The FGYA was formed in 2000 by nine participating member companies (including Weyerhaeuser) with forest tenures on the eastern slopes of the Rocky Mountains who recognized the value of a collaborative lodgepole pine G&Y research program. The mandate of FGYA[8] is to continually improve the assessment of lodgepole pine G&Y in managed stands by:

1. Forecasting and monitoring responses to silvicultural treatments.
2. Facilitating the scientific development and validation of yield forecasts used by members in managing their tenures.
3. Promoting knowledge, shared responsibility and cost-effective cooperation.

The FGYA studies in PHR lodgepole pine stands should be incorporated in forest management planning, PHR stand G&Y modeling, and silviculture practice in the two FMA areas. These studies are considered complimentary to the GYMP; FGYA plots will not be utilized as part of the GYMP design.

4.3.3 The Western Boreal Growth and Yield Association (WESBOGY)

WESBOGY is a cooperative of 16 agencies involved in forest growth, yield, inventory, and planning in western Canada. Weyerhaeuser has been a member since WESBOGY's inception in 1985. WESBOGY's main research focus is the mixedwood G&Y of boreal spruce and aspen. This program aims to advance the understanding of mixedwood stand dynamics under intensive management from establishment to final harvest.

The main objectives of WESBOGY are:[9]

1. To identify, evaluate, rank, and address areas of research which are: of regional importance, shared mutual interest, and most effectively approached by cooperative rather than individual efforts;
2. To facilitate the dissemination of G&Y information through the development of appropriate procedures, standards, and databases for members' use;
3. To encourage the establishment and continued monitoring of standardized permanent sample plots (PSPs) to quantify the effects of intensive forest management practices, and in general to coordinate the acquisition of high priority G&Y data;
4. To expedite the development of managed stand yield models for the major commercial tree species in the region;
5. To encourage or sponsor research designed to satisfy established needs;
6. To identify, monitor, evaluate, and disseminate to its members, information on trends in G&Y research and to provide a forum for communication;
7. To provide opportunities to members for mutual action to address information needs in forest G&Y.

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[8] Source: www.fmf.ab.ca/pa_FGYA.html

[9] Source: www.wesbogy.rr.ualberta.ca/about.asp

The findings of WESBOGY studies will be incorporated in forest management planning, PHR stand G&Y modeling, and silviculture practice in the two FMA areas. These WESBOGY plots will not be utilized as part of the GYMP design, but will compliment the GYMP.

4.3.4 MixedWood Management Association

The MixedWood Management Association (MWMA) is a partnership of ten Alberta Forest Products Companies and Alberta Sustainable Resource Development. It works to address management issues around sustaining the mixed species characteristics of mixedwood stands. Weyerhaeuser has been of member of the MWMA since its inception in 2000. The goals and objectives of MWMA[10] are:

1. Development of defensible, ecologically-based (e.g. that accounts for the effects of succession), site-specific yield curves for:
    - Naturally-regenerated stands with or without treatments;
    - Post-harvest regenerated stands across a range of potential management interventions (treatments).
2. Development of defensible site-specific crop plans that lead to mixedwood stands in:
    - Naturally regenerated stands with or without treatments.
    - Post-harvest regenerated stands across the range of potential management interventions (treatments).
3. Development and use of a standardized monitoring protocol. Define the characteristics to measure, optimal timing of these measurements, and how to measure them:
    - Monitoring to judge conformity of predicted and realized stand trajectories.
    - Monitoring to assess accuracy of yield projections.
4. Development of stand assessment tools (i.e., attributes needed to be quantified) to:
    - Enable assignment of naturally-occurring understory spruce to appropriate yield trajectories.
    - Assist in the selection of specific understory spruce protection treatments and the determination of associated probabilities of success for mixedwood stands.
    - Select hardwood stands that will allow for the successful establishment and growth of understory spruce.
5. Development of a decision-support tool (model) that will estimate cost versus yield (m3) for a wide range of silvicultural regimes that will aid in the selection of crop plans to be developed (with an understanding of the models limitations with respect to accuracy). (It was understood that such a model would be based on estimated yields, given the lack of data, but that it would be a "first cut" at enabling a structured assessment of the economic merits of numerous silvicultural regimes.)
6. Documentation of the effects of mixedwood management on non-fibre values.
    - Soil nutrient changes from existing and proposed stand trajectories.
    - Biodiversity implications from practicing mixedwood management.
    - Potential to aid in 'fire-proofing' the forest.
    - Aiding in inter-company cooperation.

[10] Source: http://www.mwma.rr.ualberta.ca/about.asp

4.4 Proposed Regenerated Stand G&Y Monitoring Program

4.4.1 Overview

Weyerhaeuser will establish approximately 86 new GYM plots on a 3.33 km grid in PHR stands. This grid will be created by dividing the National Forest Inventory (NFI) 20 km grid by six. This will allow each GYM plot established on the 20 km grid to also serve as a PSP in the provincial and federal inventory and monitoring programs.

Initial establishment will include cut blocks from 1960 onwards. New GYM plots will be established as the target population of PHR stands expands. GYM plots will be established following reforestation of the block and re-measured at years 5, 10, 15, 20, 25, 30, 40, 50, etc. It is expected that by 2018 there will be 122 GYM plots established. The 3.33 km grid size results in approximately 30 plots on 5% of the combined FMA areas.

4.4.2 Objectives

Weyerhaeuser's GYMP will monitor critical G&Y indicators to track progress towards meeting DFMP G&Y targets and validating timber supply assumptions. The GYMP objectives (Section 2.2) that apply to PHR stands are:

1. Monitor change in volume, species composition, stand top height, site height, and site index (growth intercept) in PHR stands in the Drayton Valley and Edson FMA areas. This data will be compared with predicted values of the same attributes and regeneration assumptions used in the DFMP timber supply analysis to check that predictions are accurate and precise.
2. Provide data on competition and succession that can be used to link early stand performance to late stand conditions, especially in succession-based mixedwood stands.
3. Provide data on stand height, volume growth, seedling mortality, and ingress that can be used as a subset of the data to develop new or calibrate existing G&Y models for PHR stands.
4. Provide data that could be used to develop relationships between ecological classification and stand development.

4.4.3 Linkage to Alternative Reforestation Standards (ARS)

Weyerhaeuser is in the early stages of developing ARS for the FMA's. The data provided from the PHR GYM plots will provide valuable data to assist in the development and refinement of new standards over time. The use of a grid based sampling system also allows the possibility of the grid size being intensified (for example to a 1.67 km grid) to collect additional information for ARS development if this is deemed necessary.

Regeneration survey data provides individual block level information that can be used to ensure stands are meeting regeneration standards and that the most accurate inventory and yield curve assignments are made to the block. The GYM program will provide a forest level check on inventory and yield curve assignments as well as projected future volumes, species composition, and site index.

4.4.4 Collection of Site Index Information

Site index is one of the most important variables in G&Y projections. Under estimation of site index at the stand-level can have considerable implications on the allowable annual cut determination at the forest-level by under estimating managed stand yields, increasing rotation ages, and increasing time to green-up.

Site index estimates will be derived from the four largest diameter suitable trees of each species in a 0.04 ha plot. This conforms to the current ASRD recommendation[11] of selecting the equivalent of the 100 largest diameter trees per ha on a plot at least 0.03 ha in size.

At a minimum, every 36th plot (the 20 km master grid points) will be visited prior to harvest to collect site index and parent stand information. This will enable vertical comparison (pre- and post-harvest) of site index. Measurement protocols will follow those used by the FGYA. The proposed sampling design will also enable the ASRD to collect paired plots for the horizontal comparison of site index as proposed by Huang *et al*. 2004.[12]

4.4.5 Target Population

The target population consists of all PHR stands within the Weyerhaeuser Edson and Drayton Valley FMA areas harvested 1960 or later. The target population will expand over time as fire-origin stands are harvested and regenerated. It currently consists of 88,045 ha, or 16% of the combined land bases.

4.4.6 Stratification

Stratification will be done post-sampling by natural subregion and broad cover group. The target population of stands to sample will continually change over time making pre-stratification very complex. As the target population expands, the number of plots will increase allowing additional post-stratification by major species groups.

4.4.7 Sample Plot Locations

The sample plots are located on a 3.33 km square grid created by dividing the 20 km ASRD master grid by six. Approximately one of every 36 plots established will be established on the 20 km ASRD master grid.

4.4.8 Sample Size

Weyerhaeuser will establish approximately 86 new GYM plots on the 3.33 km grid in PHR stands by 2008, and this number should increase to 122 by 2018 (Table 11). This grid size was chosen because it provides approximately 30 plots in an area equivalent to 5% of the combined FMA areas. This means that by the time a natural subregion – broad cover group combination in PHR stands covers 5% of the combined land bases, there will be approximately 30 plots established.

Table 11. Estimated distribution of plots by natural subregion, broad cover group, and cumulative year.

	Cumulative Totals by Year				
NSR BCG	2008	2018	2028	2038	2048
LF C	13	26	39	52	65
LF CD	25	28	32	35	38
LF D	27	36	46	56	65
LF DC	12	15	18	22	25
UF C	6	11	17	23	28
Other	4	5	6	7	9
Total	*86*	*122*	*158*	*194*	*230*

[11] Shongming Huang, personal communication, March 2005.

[12] Shongming Huang, Yuqing Yang and Jack Heidt, 2004. A proposed framework for developing an integrated growth and yield monitoring system for Alberta. The Forestry Chronicle. Vol. 80. No. 1. 114-126.

4.4.9 Plot Design

GYM plots will consist of a 0.04 ha large tree plot (5 cm dbh +), a 0.01 sapling plot (1.3 m in height to 4.99 cm dbh) and a 0.005 ha regen plot (10 cm to 1.3 m height). DBH and height measurements will be recorded for all trees. Site tree data will be collected on the 0.04 ha plot. Trees will be tagged once they reach 1.3 m.

4.4.10 Measurement Schedule

Plots in new cutblocks will be established following harvest and re-measured at years 5, 10, 15, 20, 25, 30, 40, 50, etc. Plots established in existing PHR stands will be measured every five years after establishment until approximately age 30 and then re-measured every ten years after that.

4.4.11 Data Management

Measurements will be keypunched at the end of the field season and imported into a database for validation, error checking, and compilation. New measurements are checked for error and are cross-referenced against previous measurements to identify discrepancies in potentially high or low growth in tree height and/or dbh.

4.4.12 Data Analysis and Reporting

The data collected in the GYMP will be analyzed and the results submitted in the appropriate format five years after DFMP approval as part of the Forest Stewardship Plan.

The first measurement provides yield estimates only, that can be used to audit the projected yield of managed stands. Change is estimated when two or more measurements are available to determine differences between measured and predicted G&Y for the main attributes of interest. Graphical analysis includes plotting actual versus predicted values and plotting differences (actual-predicted) versus stand age or any other chosen variable to examine trends will be completed. The statistical analysis includes the average differences and associated confidence intervals.[13]

The graphical and statistical analysis is intended to examine overall trends in the data. If the analyses suggest over- or under-prediction, then the possible sources of the differences should be identified. For example, when considering volume estimates, factors to consider as sources of error are the differences between the inventory inputs into the model and the actual stand attributes.

The monitoring plot data could be used to adjust yields, but it should not be used to adjust growth projections (yield curves) based on observed growth. Both activities address the symptom of a problem rather than its actual cause. Adjusting current yields for the sampled population is acceptable if data are representative of current yields. Adjusting yield curves to reflect observed growth in one time period is risky because this trend may not continue over time. The more prudent approach is to determine why differences occur. Often they result from incorrect inputs to the models.

[13] J.S. Thrower & Associates Ltd. 2000. Graphical and statistical analysis for monitoring estimates of change at the management-unit level. Version 2.0. Contract report to B.C. Ministry of Forests, Resources Inventory Branch, Victoria, BC. Project MFI-055. Available at http://srmwww.gov.bc.ca/tib/reports/gymonitor/index.html

5. NEXT STEPS

Upon ASRD approval of this GYMP, Weyerhaeuser will develop a detailed work schedule, listing all necessary steps to achieve the GYMP goals and objectives. The following is a preliminary list of the tasks to be completed:

1. Develop a managed stand field manual detailing the establishment and re-measurement protocols and schedules for PHR stand GYM plots by November 2005. (A draft field manual will be written and piloted during the 2005 field season.)
2. Develop field forms for the PHR stand GYM plots by November 2005. (Draft field forms will be developed for the 2005 field season.)
3. Confirm plot locations and produce maps at the appropriate scale showing the location of both the PHR stand GYM plots and harvest blocks where they occur. Small-scale maps will show plot location and access routes. NAD83 UTM coordinates will be provided to enable global positioning system (GPS) navigation to the plot centre. This will be completed in September 2005.
4. Pilot the field procedures for plot establishment and refine procedures as necessary (2005 field season).
5. Develop a database to manage both the fire-origin PSP data and the PHR stand GYM plot data. This will include data entry, error checking, and compilation routines. This is currently under development.
6. Establish PHR GYM plots beginning in 2006.
7. Continue to re-measure existing fire-origin PSPs as per the current Weyerhaeuser schedule.
8. Complete first analysis of GYM data in 2009.

APPENDIX I – FIRE ORIGIN PSP PROGRAM

The Forestry Corp.

Permanent Sample Plot Program

Prepared for Weyerhaeuser Canada Ltd.
Drayton Valley

December 1994

1. Introduction

harvest.

Information on the growth and yield of forest stands is necessary to ensure that forests are managed on a sustainable basis. The information has a wide variety of uses including yield forecasting for harvest scheduling, identifying priorities for sequencing, modelling wildlife habitat and evaluation of silvicultural practices. Weyerhaeuser Canada Ltd. is committed to improving the understanding of forest dynamics in areas managed by the Company.

As part of this commitment Weyerhaeuser has instituted a permanent sample plot program.

Objectives for growth and yield are best achieved through cooperative efforts in data acquisition and modelling. As part of their contribution to satisfy regional growth and yield needs, Weyerhaeuser has initiated a permanent sample plot (PSP) program in their Forest Management Agreement area located in the Rocky-Clearwater Forest.

The PSP program is intended to contribute to the fulfillment of Weyerhaeuser's growth and yield objectives as stated in their current Detailed Management Plan. These objectives are listed below:

1. To obtain direct growth data which can be used to verify estimates of stand development and breakup obtained through other means.
2. To enhance the temporary plot data used in timber supply analyses and the development of stand volume tables, yield relationships, stand tables and stock tables.
3. To obtain tree and stand level data suitable for calibrating and/or using growth and yield models.
4. To enable the potential development of relationships between ~~site~~ ecological classification classification and stand development.

This document describes fundamental aspects of Weyerhaeuser's PSP program design. Specifics of the field procedures are described in Permanent Sample Plot Field Procedures.

want to include density to

<1900
>1900
incorporated

2. Sampling Design

post harvest
managed

A total of 200 plots are planned for the PSP program. Approximately 25 PSPs will be established annually. As Weyerhaeuser has both coniferous and deciduous management responsibilities in the FMA area, the sampling design considered all forested cover types except those subjectively deleted because of poor productivity.

To achieve the objectives of the program, it is important that the range of age classes be sampled including stands regenerating after harvest In the short to medium term the dynamics of the standing forest crop are more important to current management because these stands will be harvested over the current rotation and current growing stock largely controls allowable cuts. Consequently, initial plot establishment was concentrated in unmanaged stands (i.e., stands of natural origin).

Ten percent of the plots were designated to be established in regenerating stands; the remaining 90% of the plots are to be established in unmanaged stands. Stratification using cover type attributes was used as the basis for plot distribution.

Plots will be maintained for a minimum of two measurements, although it is anticipated that some plots will be maintained for substantially longer periods. Following harvest, the plots will be re-established on the same location.

The intent of the PSP design was to ensure that the plots established were representative of stands being sampled. Thus stand and plot selection had to be unbiased. A procedure was developed for the random selection of stands to be sampled and of plot locations within stands.

2.1 Stratification of Unmanaged Stands

Fifty percent of the unmanaged stands plots will be established in stands less than rotation age and the remaining 50% are planned for establishment in stands over rotation age. The allocation of plots by each of these classes was based on the perceived priorities for data acquisition. In the current rotation most stands will be harvested at ages which exceed rotation age. Therefore an understanding of the development of mature and overmature stands is important. Caution is required in the case of overmature deciduous stands because the remaining overmature stands may have followed a relatively narrow range of possible developmental paths. In these stands it may be prudent to begin stand measurements well prior to stand decline to evaluate alternative developmental paths. Evaluation of the growth and yield of stands less than rotation age is equally important as an improved understanding of the complete developmental path is required. These data will be used in forecasting both existing unmanaged immature stands and regenerating stands. As the data from all developmental stages of managed stands will not be available for many years, relationships based on unmanaged stands will be used in the modelling of regenerated stand dynamics.

The forest structure ~~is~~ of the FMA is characterized as being mature to overmature. Over 70% of the stands in the FMA are over rotation age[1]. On a unit area basis, fewer PSPs will be established in stands over rotation age.

The plots will be established using stratified sampling techniques. The stratification is based on broad cover group, species composition and stand origin. Table 1 below (not appropriate.) indicates the stratification, area by stratum and the planned PSP plot distribution.

As can be seen from Table 1, strata occupying less than 1% of the total productive forest area will not sampled. However, slightly more than 96% of the forest cover based on this stratification will be sampled. The distribution of PSPs is weighted by area. Thus the relative importance of strata to the annual allowable cut is represented in the distribution of plots. It is recognized that this approach means that the data for many strata cannot be considered as a statistically adequate sample size. However the PSP program was planned to be a cooperative program where data from other companies and agencies would be pooled to improve regional information on growth and yield. reword

Stratification was based on the Phase 3 vegetation classification. However, the FMA area is currently being inventoried to Alberta Vegetation Inventory (AVI) specifications. Once AVI is completed for the FMA (in 1995), the stratification will be revised to reflect the AVI classification. This may mean that plots will no longer be within the same strata however as the program is in its' early stages of development, use of Phase 3 data in the interim poses no significant problem.

net volumes: how to come with net volumes.

Numbers of other plots

consider establishing samples.

[1] This statistic was based on a 90 year rotation for coniferous dominant stands and a 70 year rotation for deciduous dominant stands.

Table 1. Stratification and PSP Distribution in Unmanaged Stands

						Number of PSPs	
Broad Cover	Species Group	Origin Class	Area (ha)	Area (%)	Area used for PSP	<rotation	>rotation
C	Pl	> 1901	10494.9	7.02	7.0	26	
C	Pl	<1900	7652.2	5.12	5.1		6
				12.14			
C	PlSw, SwPl	>1901	1229.9	0.82			
C	PlSw, SwPl	<1900	4966.2	3.32	3.3		4
				4.15			
C	Sb, SbLt, Lt	>1901	277.7	0.19			
C	Sb, SbLt, Lt	<1900	5200.4	3.48	3.5		4
				3.67			
C	SwSb, SbSw	>1901	546.8	0.37			
C	SwSb, SbSw	<1900	1289.2	0.86			
				1.23			
C	PlSb, SbPl	>1901	6914.4	4.63	4.6	17	
C	PlSb, SbPl	<1900	6863.6	4.59	4.6		6
				9.22			
C	Sw	>1901	911.8	0.61			
C	Sw	<1900	5534.7	3.70	3.7		5
				4.31			
CD	PlA, PlSwA, PSBA	>1900	3027.7	2.03	2.0	8	
CD	PlA, PlSwA, PSBA	<1900	5740.2	3.84	3.8		5
				5.87			
CD	SwA, SbA, SbPlA, SwPlA, SwSbA	>1900	1070.8	0.72			
CD	SwA, SbA, SbPlA, SwPlA, SwSbA	<1900	9326.4	6.24	6.2		8
				6.96			
DC	APl, APlSw	>1921	536.8	0.36			
DC	APl, APlSw	<1920	4799.9	3.21	3.2		4
				3.57			
DC	ASw,ASb, ASwPl, ASwFb	>1921	2003.6	1.34	1.3	5	
DC	ASw,ASb, ASwPl, ASwFb	<1920	11452.3	7.66	7.7		10
				9.00			
D	A	>1920	13710.5	9.17	9.2	34	
D	A	<1920	45894.5	30.71	30.7		38
				39.88			
Total			149,445			90	90

2.2 Stratification for Managed Stands

Stratification for establishment of the 20 plots in managed stands is based on the land base designation and the silvicultural treatment. As only 20 plots will initially be established in managed stands, stratification has been kept relatively simple. The proposed stratification is indicated in Table 2.

Table 2. Stratification for Managed Stands

Land Base Designation	Silvicultural Treatment	Number of Plots
Coniferous	Scarified and naturally seeded	5
	Scarified and planted	5
Deciduous	Left for natural	10

2.3 Stand Selection

more detail for ground crew.

Within each stratum, a list of randomly selected stands was produced. Selection was weighted by stand area, thus stands with more area had a higher probability of selection. This random stand list was reviewed to ensure that the stand selected was suitable for establishing a PSP. Stands were eliminated from consideration if the stand was to be sequenced for harvest within the next 15 to 20 years or if accessibility constraints were severe. In some cases it may be necessary to modify harvest plans to protect PSPs until at least two measurements are recorded.

2.4. Plot Selection

will be laid

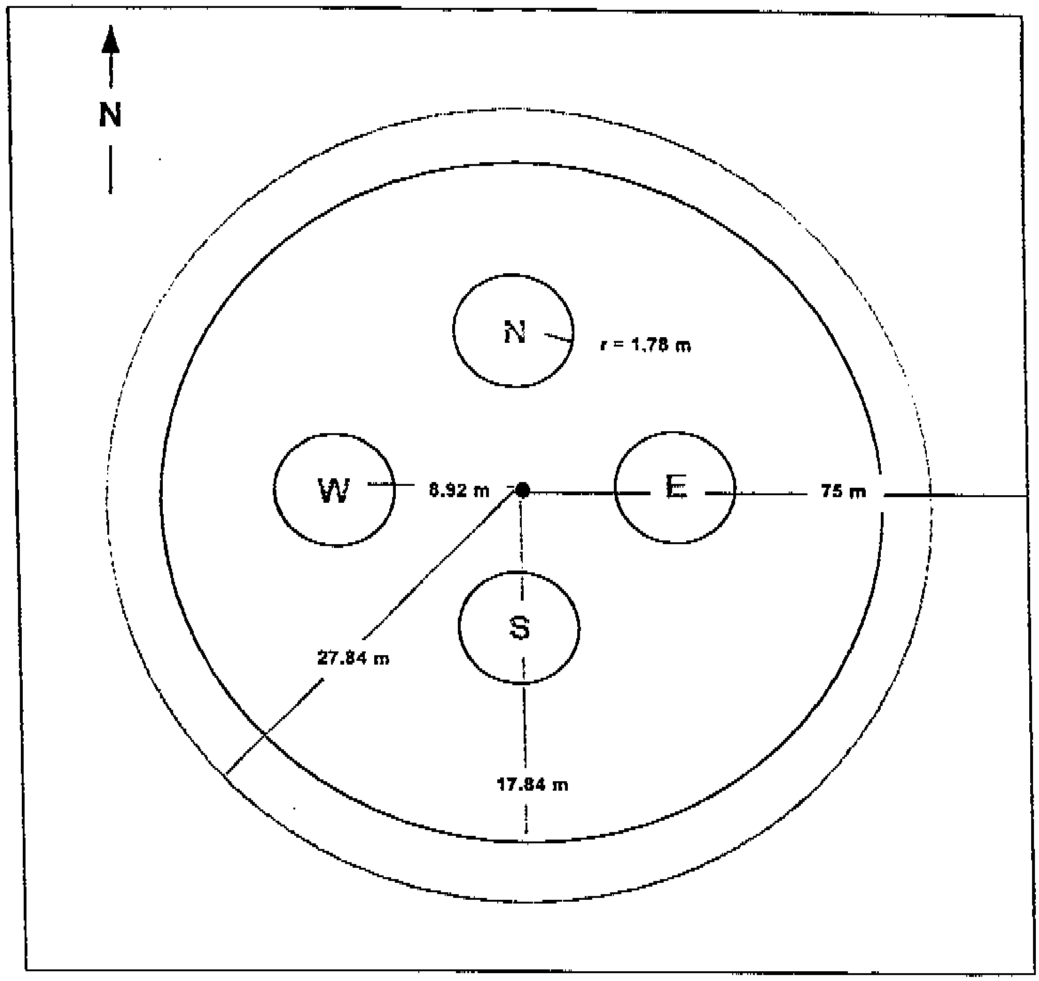
Once a stand has been ~~was~~ selected as being suitable for PSP establishment, a plot location will be randomly chosen. A numbered grid (100 m × 100 m) ~~was~~ laid over a map of the stand and a random number chosen. The corresponding grid intersection was chosen as the plot location. The entire plot and buffer had to be contained within the stand.

Plots which fall on seismic lines or roads which are not mapped as polygons will be moved. The procedures for moving the plot are described in the document Permanent Sample Plot Field Procedures. Other disturbance such as partial cutting are to be noted but are not justification for re-locating plots. Many of the stands in the FMA have been partially cut.

2.5 Plot Configuration

The plot configuration for the PSPs is indicated in Figure 1. A tree plot of 0.1 ha and four sapling/regeneration plots each 0.001 ha will be established.

Figure 1. Plot Configuration



3. Remeasurement Schedule

Remeasurement of PSPs will be based on the anticipated rate of change in the particular stand type. In stands which are changing rapidly plots will be remeasured every five years. All other plots will be remeasured every ten years.

Stands which are likely to have relatively high rates of change include mature/overmature predominantly deciduous stands and young stands of all covertypes. The remeasurement interval for each plot will be decided at each measurement based on stand type, stand age and condition.

APPENDIX II – FIRE ORIGIN PSP FIELD MANUAL

PSP Field Procedures

Weyerhaeuser

August, 1998

1. Introduction

Weyerhaeuser Canada Ltd. has made a commitment to establish a Permanent Sample Plot (PSP) programs for their Drayton Valley, Edson and Slave Lake Forest Management Agreement Areas. Slave Lake Pulp Corporation has also adopted these field procedures with the intent of sharing data. The PSP program represents a long-term commitment on the part of Weyerhaeuser to determine the growth and yield of the forests within the FMAs. The program was initiated in 1994 with the establishment of several PSPs in Drayton Valley. During subsequent years the other locations have commenced PSP plot installation: Slave Lake in 1996, Slave Lake Pulp Corp. in 1997, and Edson in 1998.

The PSP field procedures are based, to some extent, on the Land and Forest Services PSP program. The plot configuration has been changed to simplify establishment and remeasurement. Additional changes to the procedure were also necessary to facilitate measurement of primarily hardwood and/or mixedwood stands.

This manual outlines the procedures used for PSP plot establishment and remeasurement. It is designed to be used by field crews when establishing or remeasuring plots. This manual does not describe the stratification used in allocating plots or the criteria used to establish plot locations within the selected stands.

Tally sheets for the PSP program are provided in Appendix 1.

2. Plot Configuration

PSPs established by Weyerhaeuser area are 0.1 ha circular plots contained within a 2.25 ha buffer (150 metres by 150 metres). Figure 1 indicates the basic configuration for the plot, including the location of subplots used to record information on regeneration.

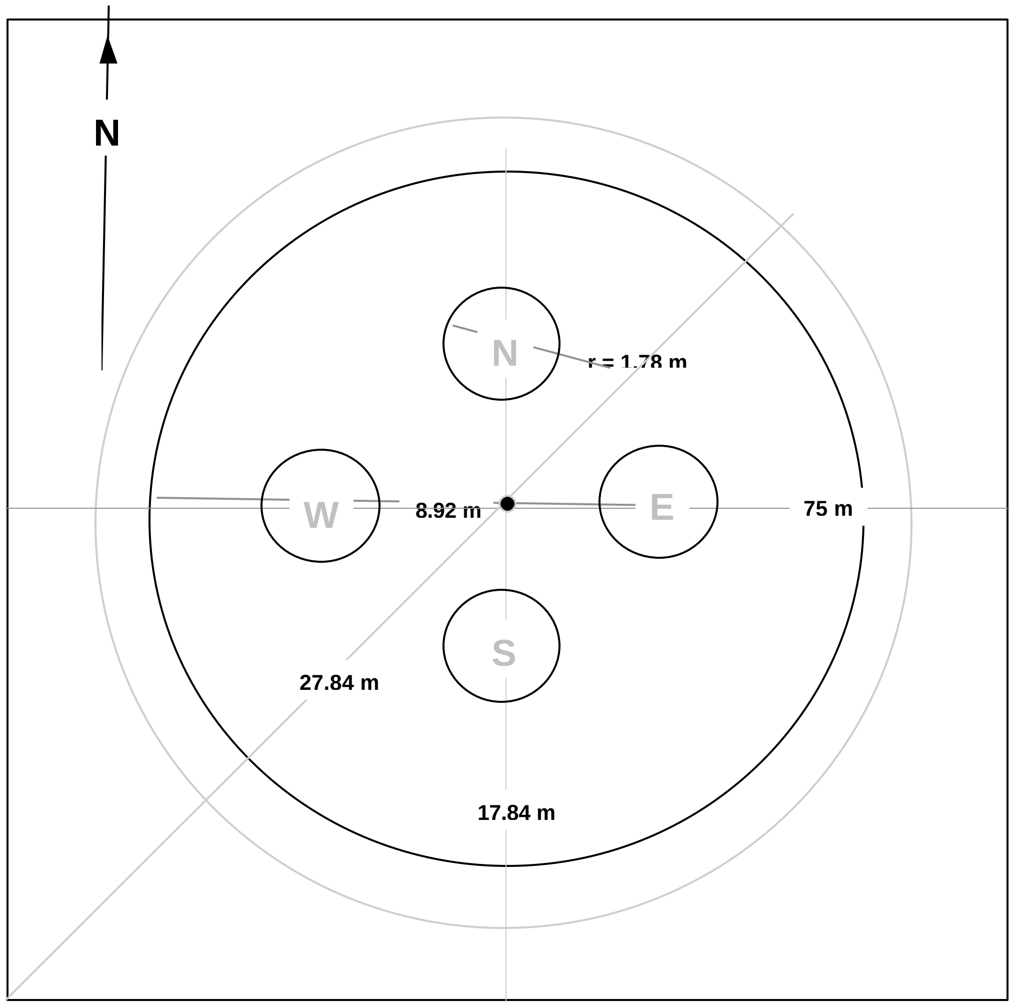
The main plot, which is used to record the tree information, is established using a radius of 17.84 m. Within the main plot, four 0.001 ha subplots are established to record information regarding the regenerating stems within the plot. These subplots are established in each of the four cardinal directions (north, east, south and west). The plots are circular, with a radius of 1.78 m.

A 10 m radius zone is established around the main plot to facilitate any destructive sampling that is done in conjunction with the PSP program. Additionally, a 150 ×150 m square buffer is established around the PSP. The purpose of the buffer is to protect the PSP. For example, if the area directly around a PSP was logged, the plot would be susceptible to windthrow. Having a buffer around the plot provides protection. Also, the buffer is used to conduct sampling which is related to the PSP program but which might be damaging to the plot or trees. For example, any sectioning of stems could not be conducted within the PSP itself and would be done outside the main plot, from within the buffer.

2.1. Summary of Tally Forms

Form Number	Description
PSP FORM 1	Directions to plot, location sketch map
PSP FORM 2	Legal location, AVI type, regeneration plots
PSP FORM 3	Soil and site description
PSP FORM 4	Shrub, moss, herb, grass data; ecosite classification
PSP FORM 5	Tree tally sheet
PSP FORM 6	Height trees, age tree data, site tree data

Figure 1. Permanent sample plot configuration



3. Location of Plot Centre

3.1 Establishment

At establishment, locations of the stands selected for PSP establishment will be provided on AVI forest cover maps. Air photos of the area will also be provided. Locations of the stands are predetermined so as to fall within a certain covertype stratum. The location for a PSP in a selected stand will be determined randomly by using a 75x75m grid. The grid is to be placed over the selected stand. Each grid point that falls within the selected stand will be assigned a number (the total number of grid point in the stand is referred to as N). A random number (from 0 to 1 will be selected from a random number table). This random number is then multiplied by N; the resulting product is the number of the grid point where the plot will be located.

The plot centre is located using three reference points: the tie-point, the witness tree and GPS. The tie-point should be a permanent land feature, such as the intersection of a road and a bridge, the intersection of two permanent roads, etc. Detailed directions to the plot centre should be given from this tie point. The directions will often include intermediate landmarks such as seismic lines. The witness tree is located at a logical point between the tie point and the plot centre. A compass bearing and distance, from the witness tree, are used to locate the plot centre. For example, if the tie point was the intersection of two roads and the directions to the plot included first traveling 600 m down a seismic line before following a compass bearing into the stand, the witness tree would be located along the seismic line where the compass bearing begins. Each plot centre is or will also be identified using GPS coordinates.

Marking of the Witness Tree

The tree selected as a witness tree should be one which will remain standing for a considerable length of time. Conifers, because of their greater life expectancy, should be selected over deciduous trees. A small metal plate which identifies the plot number, the legal location of the plot and the distance and bearing to the plot centre is nailed onto the tree. The tree should have a blue strip painted around the tree just above and below the plate. Select the witness tree as you are heading towards the plot center, mark it with flagging but do not paint it or fill in the access information on the witness tree plate until you leave the plot. In some circumstances, the plot centre may have to be moved or the plot deleted. This might occur if there is some disturbance in the stand in which the plot is located. The plot would then have to be moved and a more appropriate witness tree might be selected.

The plot's legal location is recorded on the PSP FORM 2 (Appendix 1), along with the AVI stand number and the GPS coordinates if available. All instructions for locating the plot, in relation to the tie-point, the witness tree and GPS coordinates are recorded on PSP FORM 1. The declination used in establishing the plot should also be recorded. Use sketches to help with the directions. The location should be sketched onto the forest cover map and the plot centre marked with a pin-prick on the air photo.

Plot accessibility is recorded on the PSP Plot Form using the following categories: road (R), ATV (A) or helicopter (H).

3.2 Remeasurement

Once a plot has been established, there should be adequate information available on the establishment plot form for relocating the plot. Record any changes to the plot access which have occurred since the previous measurement. Check the witness tree and ensure the plate is still attached securely. Replace the nails or plate if necessary. Repaint the blue strips. While traveling to plot centre, confirm that the azimuth and bearing to the plot centre are accurate. Confirm or determine the GPS coordinates at plot centre.

4. Establishing Plot Boundaries

4.1 Establishment

Once the plot centre has been reached, mark it using an aluminum post, approximately 1 m in length. The post should be hammered into the ground so that it is securely anchored. The top 12 to 18 inches of the post should be painted blue to facilitate its relocation. The location of plot centre, in relation to three surrounding witness trees should also be recorded, in case the center post is lost. The azimuth and bearing to three witness trees are recorded on the PSP FORM 2. The witness trees are tagged and marked along with the other plot trees.

Ensure that the stand in the immediate area of the plot (i.e., 27.84 m radius) has not been damaged by any human-caused disturbance, including seismic lines and skid roads. In the case of neighboring clearcuts or other large scale disturbances such as a primary road, ensure that the disturbance falls beyond 27.84 m of the plot centre If unacceptable damage is present, the plot centre should be moved. If possible, continue further along the same bearing at a predetermined distance (e.g., 100 m). If the disturbance is still present then the plot centre should be moved further along the same bearing. The plot can also be moved perpendicular to the line of travel. Always remain inside the stand in which the plot was originally located. In some cases, the plots will have been selected for establishment in partial cuts or clearcuts. In these cases the plots should not be moved outside the disturbance area. Plots which fall in natural stand openings are not moved. Plots which fall in riparian areas should not be moved. In general, moving plots should be avoided. Record any damage in the plot on the PSP FORM 2 using the appropriate code (Table 1). At establishment, man-made damage should not usually be present, unless the plot was established within a partial cut or cutblock. Natural damage may be present both within the plot or the buffer.

The plot boundary is established at a horizontal distance of 17.84 m. If the plot falls in an area with a slope of 10% or greater, the plot layout must be corrected to account for the slope (see Appendix 2 for correction factors). The plot boundary should be outlined during establishment using topofil line or flagging tape. The plot boundary should be measured initially using at least 8 radii. Any tree near the boundary should be checked to see if it is in or out of the plot. All borderline trees should be checked. A borderline line tree is considered inside the plot if the centre line of the tree, at the germination point, is 17.84 m or less from the plot centre.

Aluminum posts are also used to mark the centre of the regeneration/sapling subplots. These subplots are located north, east, south and west (360°, 90°, 180° and 270°) of the plot centre, at a distance of 8.92 m. The plots are circular, with a radius of 1.78 m. The plot is small enough that the boundaries do not necessarily have to be laid out on the ground. In cases where there is substantial regeneration, it may be necessary to mark the boundary with topofil line or flagging tape.

Table 1. Plot and Buffer Damage Codes

Code	Description
1	None
2	Natural Damage
3	Manmade Damage
4	Natural and Manmade Damage

The plot buffer is established as a square, 150×150 m (Figure 1). To establish it in the field, proceed 75 m north from the plot centre. Mark out the buffer from that point, by following the appropriate compass bearing. A topofil should be used to measure distances for buffer establishment. Paint blue squares, approximately 20×20 cm on the trees along the buffer. Trees should be painted about every 3 to 5 m, depending on the density of the stand and the size of the trees. The objective is to be able to easily see the paint at any point along the buffer. The buffer trees are painted on the side facing out from the plot so that they will be seen as the plot is approached. If trees suitable for painting are not present mark the boundary using blue flagging ribbon.

Any damage within the buffer should be identified on the PSP FORM 2 using the codes listed in Table 1.

4.2 Remeasurement

On remeasurement, use the existing plot centre post to reestablish the plot boundary. If the post is missing, reestablish it using the surrounding witness trees. If the subplot posts are present, they can also assist in relocating the plot centre. Any missing subplot posts should also be replaced. All plot posts should be repainted blue.

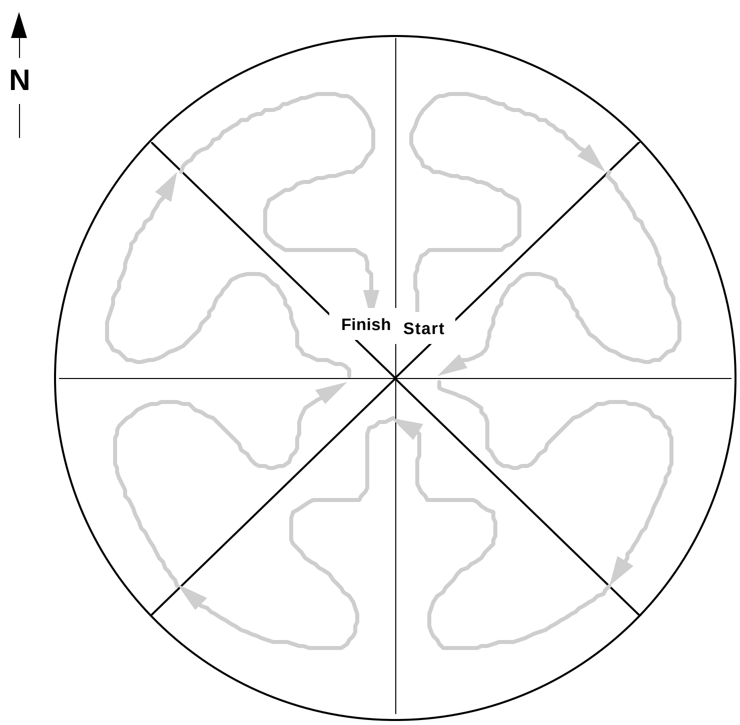
Check the buffer and repaint the buffer trees if necessary. Check both the plot and the buffer for any damage (e.g., seismic line, logging) that may have occurred since the previous measurement and record these on the PSP Plot Form.

5. Numbering Trees

5.1 Establishment

The eight radii used to establish the plot boundary are also used in determining the pattern for numbering trees within the main plot. Tree numbering begins in the north - northeast section and continues clockwise. Within the sectors, the trees should be numbered in swaths as shown in Figure 2.

Figure 2. Permanent sample plot tree numbering pattern.



Tree numbers should proceed consecutively from whatever starting value is selected. All trees with a diameter at breast height (dbh) of 7.1 cm or greater are considered part of the tree strata and are numbered and tagged.

Trees will be tagged using a length of aluminum or galvanized wire with a numbered tree tag placed on the wire. These tags will usually come pre-numbered. The wire should be long enough to hang loosely around the tree; allowing for future growth. The wire is then crimped shut with an aluminum sleeve. This method of identifying the trees was selected to avoid damaging the trees with nails.

Occasionally, trees may be missed when the initial numbering is carried out. These trees may be noticed further along the tagging process or after, as the trees are being measured. If this occurs, the tree should be numbered with the next consecutive number in the series for the plot. For example, if the PSP has 204 trees and one was missed, it would become tree 205. There is room on the tally sheet to record the number of a neighbouring tree to facilitate the location of the initially missed tree. This is necessary since the tree location is not related to its position within the plot (i.e., not located logically by position within the tagging scheme).

Trees which are forked are treated as a single stem or two stems depending on the height at which the fork occurs. If the fork occurs below 1.3 m (breast height), it is treated as two separate stems. Each fork will be numbered, tagged and measured separately. Trees forked above breast height are treated as a single stem.

5.2 Remeasurement

On remeasurement, the PSP Tree Tally Forms will have information from the previous measurement so the field surveyors can ensure all trees previously identified on the plot are accounted for. Any trees which have lost tags should have these tags replaced. These trees must be renumbered with the same number used previously. The position of the tree within the tagging swath and the tree's characteristics (species, dbh, possibly height) should be used to help identify the number associated with any trees that have lost tags.

Any stems which have grown into the plot since the previous measurement (i.e., have now reached 7.1 cm dbh or greater) must be numbered. These trees are given numbers which are unique to the plot (i.e., not already used for other trees in the plot).

All wires used to tag the trees should be checked to ensure they are still loose enough to avoid possible damage to the tree. Wires which have been damaged should be replaced.

6. Measuring Trees

6.1 Establishment

Measurement of the trees within the PSP can be divided into several distinct tasks. Species, dbh, crown class and condition are recorded for all trees within the 0.1 ha main plot. Additionally, heights are recorded on a sub-sample of the stems. A sample of trees from just outside the plot, but within the buffer, are selected for aging and for determining the site index for the PSP.

6.1.1 Tree Tally

For each tree that is 7.1 cm dbh or greater, record the species using the two letter codes provided in Table 2. Standing dead trees are included in this tally. Inclusion of these trees will facilitate plot remeasurement and provide information on the dynamics of the stand. For a standing dead tree to be tallied, it must be able to withstand a firm push. **The dead trees should not, however, be pushed over**; the surveyor should give the tree a gentle push and use their discretion in considering it standing dead.

The dbh will be recorded for all trees within the plot. Breast height is considered to be 1.3 m above the point of germination. A stick, marked at 1.3 m should be used to ensure that breast height is determined accurately; **do not estimate breast height**. Mark the location of breast height on each tree using a thin strip of blue paint. This strip should only be 1 - 2 cm thick, since it will be used on subsequent remeasurements to identify the location at which to remeasure diameter.

In a few instances, it may not be appropriate to record the diameter at breast height. For example, there may be a large branch stub or stem swelling at breast height. If this is the case, mark a position just above or below the distortion and use this location to record the diameter. This position, not breast height, is the one which should be marked with paint to ensure consistency in future remeasurements. Record the offset of the diameter measurement on the tally sheet in the comments (e.g., 'dbh recorded at 1.26 m').

Table 2. Species codes

Species	Common Name	Code
Abies balsamea	balsam fir	FB
Abies lasiocarpa	alpine fir	FA
Betula papyrifera	white (paper) birch	BW
Larix laricina	tamarack	LT
Larix occidentalis	western larch	LW
Picea engelmannii	Engelmann spruce	SE
Picea glauca	white spruce	SW
Picea mariana	black spruce	SB
Pinus banksiana	jack pine	PJ
Pinus contorta	lodgepole pine	PL
Populus balsamifera	balsam (black) poplar	PB
Populus tremuloides	trembling aspen	AW
Pseudotsuga menziesii	Douglas-fir	FD

Figure 3 shows examples of where germination point, breast height and diameter measurements would be located.

Crown class is generally recorded for all live stems in the plot. Crown class describes the position of an individual tree within the general canopy. It is assessed by looking at the crown of an individual tree in relation to the crowns of the trees within the plot.

The crown class is recorded on all stems except those that are standing dead (condition code of 25), have a broken stem or top (condition codes 24 or 19) or are severely leaning (severe cases of condition code 23).

Five crown classes are recognized, as described in Table 3 and Figure 4.

Table 3. Crown class characteristics.

Crown Class	Characteristics	Code
Dominant	- crown extends above the general level of the canopy	D
Codominant	- crown forms the general level of the canopy	C
Intermediate	- crown below but extending into the bottom of the general level of the canopy	I
Suppressed	- crown entirely below the general level of the canopy	S
Open-grown	- used only in very open stands, where the tree is not really part of a canopy	O

Figure 3. Germination point and breast height determination.

Figure 4. Crown class position.

Condition codes are used to record any visible damage to the tree or conditions which affect the tree. There is room on the tally sheet to record up to three codes for each tree. The codes are listed in Table 4 in their order of priority. This is important in instances where more than three codes apply. If this is the case, record the three codes that have the highest priority.

Detailed descriptions of the conditions codes is provided in Appendix 2. Some discretion needs to be used in applying the codes, especially to deciduous trees. For example, deciduous stems, by nature, will be 'forked' at some point. If the forking is the result of normal branching habits (e.g., healthy branches within the crown) it should not be recorded. Also, crook, which is quite common in some stands of aspen, should only be noted if it is relatively severe.

6.1.2 Height Trees

Height and height to live crown are measured on a subsample of the trees (≥ 7.1 cm dbh) within the main plot. Heights will be measured on every fifth tree, to a maximum of 20 trees per species per plot. At a minimum, 5 trees of each species must have height measured, except where fewer than five trees of a species occur. Heights should not be recorded on dead trees (condition code 25), trees with broken stems or tops (condition codes 24 or 19) or trees with severe forks or leans (severe cases of condition codes 13 or 23).

An 'X' should be marked with lumber crayon on each height tree in the direction from which the tree height was recorded. This will facilitate quality control on the height measurements.

Details regarding proper methods for determining heights are provided in Appendix 2.

6.2 Remeasurement

To facilitate remeasurement, the PSP Tree Tally Form will list the previous tree numbers along with the species, dbh and height. Condition codes will be displayed for any standing dead or missing trees (condition codes 25 and 26).

6.2.1 Tree Tally

For each stem in the tree strata (i.e., ≥ 7.1 cm dbh) species is re-identified at each remeasurement. The previous species call is provided on the tally sheet. This helps ensure that an error has not been made in the previous measurement.

The original paint strip identifying breast height should be located, remarked and the current dbh recorded. The tally sheet will display the previous dbh. If the dbh has increased since the previous measurement the dbh is recorded on the tally sheet. If the dbh has decreased since the previous measurement, the measurement must be rechecked before it is recorded. Indicate on the tally sheet that the measurement has been double-checked. If the dbh has increased by more than 0.5 cm per year since the last remeasurement (i.e., by more than 2.5 or 5.0 cm, depending on the remeasurement cycle), it must also be double-checked.

Condition codes are assigned to the trees at each remeasurement. The previous condition codes are provided in the 'Comment' field. Standing dead trees from the previous measurement will be recorded on the tally sheet. Once the stem is dead and down (condition code 27) or can not be found (also given a condition code of 27 in this case since it can be assumed to have fallen down), it will no longer be listed at remeasurement. Missing trees, which will occur only rarely, will also be listed in case they 'reappear'.

Table 4. Condition codes, by priority.

Code	Condition
26	Missing (no measurements)
29	Cut down (no measurements)
27	Dead and down (no measurements)
25	Standing dead (no crown class)
01	Conks
30	Stem insects
31	Stem disease
32	Foliar insects
33	Foliar disease
91-96	Hawksworth mistletoe rating
24	Broken stem; $\geq$ 10 cm DIB at break (no crown class)
02	Open scars
19	Broken top; $\leq$ 10 cm DIB at break (no crown class)
34	Stem form defect; $\geq$ 7 cm DIB at point where defect begins
35	Dead top, dieback
14	Pronounced crook
13	Fork
36	Closed scars
23	Leaning
22	Limby
28	Same stump (forked below breast height)
12	Burls and galls
?	Sweep
37	Unknown
00	No defect

6.2.2 Height Trees

The trees selected as height trees at establishment will continue to be height trees in subsequent remeasurements, unless the tree becomes damaged (e.g., broken stem or top) or dead. If a height tree becomes damaged or dead, it should be replaced with another tree of the same species. The replacement may be in the vicinity of the original tree or could be located elsewhere in the plot.

If the full complement of 20 height trees which are required for each species has not been reached with the current number of trees, ingrowth into the tree strata should be subsampled for height. Continue sampling every fifth ingrowth tree until 20 trees per species have been identified as height trees.

If a minimum of five height trees per species was not identified in the previous measurement, this minimum should be obtained by sampling ingrowth into the tree strata. This can be done by measuring all ingrowth of a particular species or, if numbers warrant, every fifth ingrowth tree of a particular species, until the desired minimum of five trees per species is reached.

7. Sapling and Regeneration Measurements

Plot stems which do not meet the size requirement for the main tree plot (i.e., 7.1 cm dbh) are recorded using four 1.78 m radius subplots, establis hed north, east, south and west of plot center.

7.1 Saplings

Saplings consist of all stems greater than 1.0 cm dbh and less than 7.1 cm dbh. The stems in this stratum are not numbered or tagged. They are identified on the tally sheet using the number 999, prefixed by a subplot identifier (e.g., N999 for saplings in the north subplot, E999 for saplings in the east subplot, etc.). The species, dbh and crown class is recorded for all saplings. Height is recorded on a subsample of the stems, according to Table 5. The samples for sapling height measurement should be selected clockwise, begining in the north sapling subplot and continuing through to the east, south and west subplots. For example, saplings would first be taken from the north subplot. If more than two saplings in a particular height class were present, these would be selected clockwise from the north bearing within the subplot.

Table 5. Sapling height requirements.

DBH Class (cm)	No. Sapling Heights
1.1 - 3.0	2
3.1 - 5.0	2
5.1 - 7.0	2

7.2 Regeneration

Regeneration includes all stems which are greater than or equal to 0.3 m in height and less than 1.1 cm dbh. The stems in the subplot are dot tallied on the plot form by species and height class.

8. Site Description

All PSPs will have some basic site, soil and vegetation information collected. This information will generally be collected only once, usually at the time of plot establishment. PSPs established in regenerating or young stands may have some components of the site description reassessed periodically, to track changes in the understorey vegetation and surface soil characteristics over time. Surveyors will be instructed regarding which PSPs should have site description information collected (PSP FORM 3).

8.1 Age Trees

In order to avoid damaging the trees within the PSP, plot age is established by aging trees located just outside the main plot. Eight age trees are sampled for each species with a substantial presence in the main plot (i.e., which account for at least 30% of the overstorey crown closure, based on the AVI field type within the plot). Age trees must be dominant or codominant trees. Each tree selected as an age tree is bored at DBH height (i.e., 1.3 m). Cores will be taken back to an office environment for age determination. Ensure that the plot and tree number, species and the location from which the core was taken are recorded on the straw used to store the core. In deciduous trees, two cores, perpendicular to each other, should be taken from each sample tree to facilitate aging the trees.

Age trees are selected from within a 10 m radius of the main plot (i.e., from between 17.84 and 27.84 m of the plot centre). No samples are selected, however, from within 1 or 2 m of the main plot. Within the sampling zone, the closest 8 dominant or codominant trees are selected, beginning from the north of the plot and continuing in a clockwise direction (see Figure 5). If 8 dominant or codominant trees are not present within the 10 m wide zone, widen the radius as required. Refer to SRMS for aging in cutblocks.

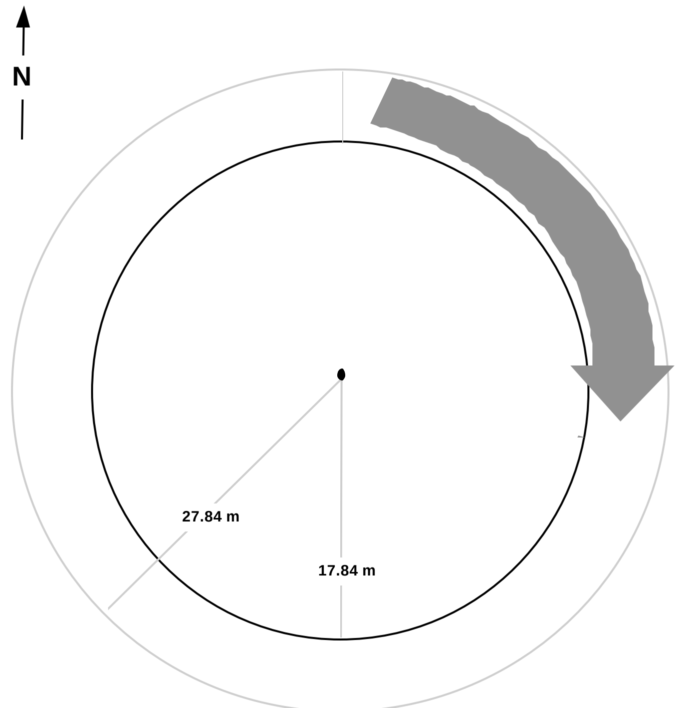


Figure 5. Age tree sampling zone.

8.2 Site Trees

Two trees of the dominant species on a PSP are to be selected and measured as site trees. If the plot is located in a mixedwood stand, then two of the dominant conifer and two of the dominant deciduous stems should be selected. All site trees are selected from the same area as the age tree (i.e., 10 m radius around the outside of the main plot). The site trees must be dominant or codominant stems that do not show signs of suppressed growth. They must not have any major stem form defects, since a height measurement will be required. The increment cores should be examined for any signs of serious suppression. If they do show signs, the trees should not be selected. The site trees can be selected from the age trees which have already been sampled. Surveyors should keep track of potential site trees as the age trees are sampled.

Information on the site trees is recorded on the PSP Site Form. Record the species, dbh and height for each tree. An increment core must be taken at breast height (two perpendicular to each other if deciduous) so that breast height age can be determined. Site trees should have a stump increment core taken as well.

8.3 Ecosite Classification

The site, soil and vegetation information required for each PSP can be found in the ecosite classification manual requirements for the particular location. For Drayton Valley and Edson PSPs the *Field guide to forest ecosystems of west-central Alberta* (Corns and Annas 1986) is the appropriate reference. In Slave Lake the *Field guide to ecosites of northern Alberta* (Beckingham and Archibald 1996) will be utilized. In all cases data will be recorded on PSP FORMS ?   The methodolies for data collection are described in the manuals. Classification of the site can then be completed referencing the appropriate field guide.

9. Quality Control

A quality control program is carried out as part of Weyerhaeuser Canada Ltd.'s PSP program. Quality control helps ensure that the PSP plots are established and remeasured accurately. Accuracy is extremely important in any field sampling program, but especially so in a PSP program which involves sampling for incremental growth. The relatively strict accuracy requirements for the program reflect the importance of taking accurate measurements.

Table 14 outlines the allowable errors for the various measurements. Measurements which fall within these allowable errors are considered correct.

Approximately 1 in every 5 PSPs (20%) will be checked for quality. This number may be reduced if the field surveyors consistently maintain high quality standards. Standard quality control checks for a PSP plot will involve checking 5% of the measurements within a plot. More than 5% may be checked at the discretion of the check cruiser. A listing of the standards which have to be met for a PSP plot to be considered acceptable are provided in Table 15.

Table 14. Allowable errors.

Measurement	Allowable Error
Directions from Tie-Point	- directions from the tie-point to the witness tree must be complete enough to facilitate plot relocation (specific allowance has not been defined because of variability in distances, etc.)
Witness Tree	- appropriate tree selected; clearly painted and flagged
Plot Centre Location	- bearing and horizontal distance to the plot centre must be within 2° of the bearing and within ± 2% of the distance;
Plot Access	- access code must be correctly identified
Plot Centre Stakes	- plot and sub-plot (regeneration) stakes must be driven securely into the ground and be clearly painted and flagged
Regen. Plot Location	- sub-plot (regeneration) stakes must be within 2° of the bearing and ± 0.2 m of 8.92 m
Site Slope %	- percent slope for the plot must be within ± 5%
Site Aspect	- aspect must be within ± 10°
Soils/Site Information	- categorical soils and site data must be within one category
Vegetation Information	- cover class must be within one class; no species with a percent cover of greater than 2% should be missed
Ages	- ages must be within ± 2 years for conifers and ± 5 years for deciduous trees
No. of Trees	- no error allowed; all stems 7.1 cm dbh or greater within the plot boundary must be tagged and numbered
No. of Saplings	- no error allowed; all stems 1.1 cm dbh or greater within the regeneration plots must be recorded
No. of Regen.	- must be within ± 2% of the total number within the plot (e.g., it is acceptable to miss one in 50 regeneration stems)
Tree/Sapling Species	- no error allowed, all species must be identified correctly
Regen. Species	- a maximum of ± 2% of the regeneration stems may be incorrectly identified
Breast Height	- breast height should be located within ± 0.02% of 1.3 m (i.e., within 2.6 cm) from the point of germination
Tree DBH	- must be within ± 0.3 cm
Sapling DBH	- must be within ± 0.2 cm
Height/Height to Live Crown	- must be within ± 3% with discretion used for the identification of where live crown begins
Crown Class	- a maximum of 5% of the stems can be misclassified by one crown class; no stems can be misclassified by more than one class (e.g., identifying a stem as an I when it is a D)
Condition Code	- a maximum of 5% of the stems can be incorrect; no errors can be made involving codes 29 and 27 and obvious cases of codes 13 and 23

Table 15. Check cruise standards.

Measurement	Standard
Tree DBH	- if more than 5% of the total tagged trees checked are incorrect (not within 0.3 cm) the diameters for the entire plot will have to be remeasured
Height/Height to Live Crown	- if more than 20% of the heights checked are incorrect (not within 3%) the heights for the entire plot will have to be remeasured
Crown Class	- if more than 5% of the crown classes checked are incorrect the crown classes for the entire plot will have to be remeasured
Condition Code	- if more than 5% of the condition codes (not 5% of the stems) are incorrect or considered missed the condition codes for the entire plot will have to be remeasured