Long Term Study of Growth and Development of Mixed Stands of Spruce and Aspen

WESBOGY

Experimental Design, Data Collection and Database Maintenance Manual

WESTERN BOREAL GROWTH AND YIELD ASSOCIATION

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PREFACE to version of July, 2004

The manual has been organized to present background on the design of this experiment (Sections 1, 2, and 3), technical details on setup and measurement protocol (Section 4) and data preparation and database maintenance (Section 5). Several appendices are included including a comprehensive data dictionary and other data forms. For field data collection, the data dictionary provides the essential information needed during the re-measurement process. Section 4 provides the detail on the overall process and installation setup. The database maintenance section 5 is needed when data is prepared for submission, archiving and analysis. This version of the manual includes extensive revision including rearrangement, addition and deletion of sections. Several major technical issues have been addressed to clarify or add procedures. Appendix 7 is a compilation of tables and figures which support the document.

TABLE OF CONTENTS

1 Introduction 7
2 Nature of the WESBOGY long-term Research 7
2.1 Value of Work 7
2.2 Background 7
3 Experimental design 8
4 Installation Establishment, Measurement and Maintenance 9
4.1 Installation Selection 9
4.2 Installation and Plot Location Map 10
4.3 Installation Description 10
4.4 Installation and plot maintenance 10
4.5 Plot Establishment 11
4.5.1 Plot numbering 11
4.5.2 Buffer strips 11
4.5.3 Surveying Plot and Buffer Corners 12
4.6 Planting of spruce trees 12
4.7 Plot Tending 12
4.8 Plot layout and tree numbering 13
4.8.1 Planted Plots (all except 13, 14, and 15): white Spruce 13
4.8.2 Thinned Plots (all except 6, 12 and 15) 15
4.8.3 Natural density aspen Subplots (plots 6, 12, and 15) 15
4.8.4 Mapping of tree locations 23
4.9 Trees, measurement schedule and thinning to treatment density 23
4.9.1 Before thinning 24
4.9.2 In conjunction with thinning 24
4.9.3 After thinning 26
4.10 Maintenance of a Field Journal 26
5 Data processing and maintenance protocols 26
5.1 Data processing procedures 26
5.2 Microsoft Access Database Structure 27
5.3 Data Error Checking Procedures 27
5.4 Error Checking Database 28
5.5 Examples and discussion 28
6 References 30
7 Appendices 31
7.1 Example installation and plot location maps 31
7.2 Tree Data Form and Dictionary 33
7.3 2004 condition codes 42
7.4 1990 - 2003 condition codes 50
7.5 Correspondence between 1990-2003 and 2004 condition codes 53
7.6 Other measurements -- Site Description, Soils, and Vegetation Forms 54
7.6.1 Site description 54
7.6.2 Soils and Nutrient Cycling Study 54
7.6.3 Vegetation 54
7.7 Data Handling Procedures Flow Diagram 61
7.8 Database Structure (Microsoft Access 2000) 62
7.9 Conditions used for Error Checking 63
7.10 Additional Fields Used in Error Checking Database Structure (Microsoft Access 2000) 66
7.11 Items reviewed and revised for this version of the Procedures Manual 67

LIST OF FIGURES

Figure 1 Numbering white spruce on high density (plots 1-6) 13
Figure 2 Numbering white spruce on low density (plots 7-12) 14
Figure 3 Numbering ingrowth trees 14
Figure 4 Un-thinned plots (6, 12, and 15): 1x1 m subplots 16
Figure 5 Un-thinned plots (6, 12, and 15): Expansion of subplots to 2x2 m 17
Figure 6 Un-thinned plots (6, 12, and 15): Expansion of subplots to 5x5 m 18
Figure 7 Un-thinned plots (6, 12, and 15): Expansion of subplots to the full 20x20 m size 19
Figure 8 SW 5x5m subplot layout for installations set out prior to 2000 with subplots centred on the 5x5 m subplot boundaries, Scale: 1 cell = 0.5 x 0.5 m 22
Figure 9 Timing of measurements just before and after thinning to treatment density 25
Figure 10 Point of germination and breast height. (used with permission of the Land and Forest Division, Permanent Plot (PSP) Field Procedures Manual, April 2002). 40
Figure 11 Height to live crown (used with permission of the Land and Forest Division, Permanent Plot (PSP) Field Procedures Manual, dated April 2002). 41

LIST OF TABLES

Table 1 Experimental design for a block of plots 8
Table 2 Plot numbers associated with spruce and aspen treatment densities 8
Table 3 Specifications for two alternative buffer zones 11
Table 4 Azimuths and distances from centre to plot and buffer corners 12
Table 5 Un-thinned plots (6, 12, and 15): subplot size and expansion summary 20
Table 6 Subplot expansion areas and factors with example estimates of tree/ha 20
Table 7 Trees to be measured in relation to plot/subplot, species and year of thinning 23
Table 8 Some examples of mistakes and wrong format in the data set 29
Table 9 The corrected data 29
Table 10 Tree Data Example 39
Table 11 2004 WESBOGY LTS Tree Condition Codes (based on ASRD/LFD tree condition codes) 43
Table 12 2004 WESBOGY LTS Condition Code Descriptions 44
Table 13 1990 - 2003 WESBOGY LTS tree condition codes (in priority order) 50
Table 14 Description of 1990 - 2003 WESBOGY LTS tree condition codes 51
Table 15 Correspondence table between 1990-2003 and 2004 condition codes 53

1 Introduction

Mixedwood stands are an important component and are typically the most productive forest lands in the boreal forests of western Canada (Kabzems et al 1986; Drew 1988). The most important commercial species are white spruce (*Picea glauca* (Moench) Voss) and aspen (*Populus tremuloides* Michx.). Management of this mixed forest type, however, has proved difficult (Drew 1988). The overall objective of this study is to advance our understanding of the dynamics of these mixedwood stands under management. This document describes a long-term regional study of tree and stand development under controlled densities for aspen and white spruce with removal of competing understory vegetation. The objectives are to assess total and individual species productivity in the various densities and mixtures. Early stand growth, mortality and crown dynamics will be used to develop an individual tree growth model. The data will also be used in development of a model of crown plasticity of hardwood and softwood trees in mixed stands.

2 Nature of the WESBOGY long-term Research

2.1 Value of Work

This long-term research project is a regional cooperative effort by industrial, federal, provincial, and university researchers to evaluate dynamics of forest development under intensive management over the full life of the stand. The long-term study is regional in scope and "forward looking" as it is based on the premise that future practices will be more intensive than those used today. In this sense it is not restricted to current operational management constraints and regulations.

The basic long-term study design calls for a series of installations throughout the region to be set up and maintained by the participants. The experimental design is based on the need to evaluate the effects of density and species mixture on growth and yield and crown dynamics in the boreal mixedwood. Further, once this network of plantations is established we foresee that the data and stands will be useful in studies of a wide variety of other biological and mensurational problems related to mixedwood plantations.

2.2 Background

After clearcut harvesting, aspen quickly dominates sites by regenerating from root sprouts (Schier 1981). White spruce is shade tolerant and in natural stands grows slowly in the understory of aspen for 50 or more years before achieving dominance. Efforts to manage mixedwood stands for better stocking and growth of the spruce have been only marginally successful (Drew 1988). Indeed, many plantations of spruce have suffered mortality and slow juvenile growth because of competition (Drew 1988).

In many areas of Canada, the tendency has been to describe the mixedwood land base as either deciduous or coniferous and after cutting, the sites are either allowed to regenerate to aspen or planted to white spruce. Silvicultural and harvesting operations as well as forest management planning are much easier with single species stands. In contrast, however, there is evidence that monocultures may be less productive than mixed species stands (Savill and Evans 1986; Vandermeer 1989). This may occur because of better utilization of space during the rotation, reduced pests and diseases (Gibson and Jones 1977) or better nutrient cycling (Vandermeer 1989) in mixed stands. The biggest gains in productivity are usually achieved when species have very different crown shape, different phenologies and tolerances to shade (Kelty 1989). The deciduous, intolerant aspen associated with tolerant spruce might be such a combination. Also, aspen contributes to rapid mineral cycling (Fowells 1965) and is considered necessary for maintaining fertility of luvisolic soils (Valentine et al. 1978).

It is clear that a heavy aspen canopy retards growth of a spruce understory (Day and Bell 1988), however, there are few data to support or refute the idea that plantation mixtures of aspen and spruce are more productive than monocultures. Selection harvesting of aspen, without damaging the spruce, is now possible using new harvesting technology. This, coupled with the potential and ecological advantages of mixtures demands further research on mixed stands. The optimum mix of these species is certainly not clear. Indeed long-term data on any plantations of white spruce are rare (however, see Berry 1987). The dynamics of these stands are poorly understood in natural conditions and almost no data exist on stand characteristics under controlled density for both species.

3 Experimental design

The design is a randomized block experiment with each company or agency setting up and maintaining one block. Each block consists of two installations, one on a superior site and one on a median site. Effectively this means that the experiment for each agency (block) can be analysed separately or in combination with other installations. Each installation has two replications of a series of 15 plots as described in Table 1.

Table 1 Experimental design for a block of plots

Replication	High Site Installation	Median Site Installation
1	15 Plots	15 Plots
2	15 Plots	15 Plots

Guidelines for selection of installations are given below. Even though there will be variation in the meaning of high and median site, common measurement of productivity will be possible. White spruce seedlings will be planted in recent clearcut areas where aspen is already established. Square plots will be used with buffers between plots.

A number of characteristics (constant conditions) will be considered fixed for this experiment. Microsite weeding and tending will be done annually within a 0.5 m radius of the spruce up to and including year 5. (See section 4.7). All competing vegetation (trees, shrubs, and grass) will be removed once each year. Grass will be clipped and removed in mid-summer. There will be no fertilization. Repellent for rabbits/deer may be used in problem areas. Initial planting of spruce will be at two densities (2000/ha and 1000/ha) corresponding to the high and low treatment densities for spruce. Local seed sources and nurseries will be used for procurement of seedlings. At year five, spruce and aspen will be thinned to treatment densities; objectives are to achieve desired densities but retain potential crop trees with relatively uniform spacing. At 50 years, the stands will be assessed to determine harvest time for the aspen.

Two independent variables (treatments) are based on density level of aspen and spruce. Aspen density will be at five levels -- 0, 200, 500, 1500, and 4000 / ha. Spruce density will be at three levels -- 0, 500, and 1000 / ha. Initial planting of spruce will be at two densities (1000/ha and 2000/ha) corresponding to the low and high treatment densities for spruce. At year five, spruce and aspen will be thinned to treatment densities.

Table 2 illustrates the combinations of spruce and aspen densities to be measured, and the plot number associated with each treatment. For example, plot 9 will have a white spruce density of 500 stems per hectare and an aspen density of 500 stems per hectare after thinning. Note that the physical location of plots must be randomly assigned.

Table 2 Plot numbers associated with spruce and aspen treatment densities

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

NOTES:
1. Plot numbers (1-15).
2. Empty cells (X) for extreme density combinations that are not of interest.
3. Row headers show spruce (Sw) density; column headers show aspen (Aw) density.
4. For each installation 30 individual plots are required.

The wide range in density level for aspen is considered desirable so that interactions between the species are more likely to be detected. The sixth density level for aspen will be based on natural (untreated) regeneration density levels; this "control" level will allow evaluation of the three spruce density levels in natural stands of aspen. The high density corresponds roughly to pulp production and the low density to sawlog production. It is assumed that careful tending of young trees in these stands will minimize early mortality; thus densities should be approximately the same until final harvest. Three cells (0 spruce with 0, 200, 500 aspen) will be deleted since they represent unreasonable densities for a pure aspen stand.

The long-term study is designed to evaluate the effect of spruce and aspen density levels on the development of plantations from establishment to final harvest. Growth and yield (variables are listed below), mortality, crown size and shape, and spatial distribution will be measured and used in the development of a quantitative model of stand development. In addition, regional and site variation will be quantified.

4 Installation Establishment, Measurement and Maintenance

Measurement of one installation should require a two man crew working for approximately one week (30 plots = 6 plots/day x 5 days), two weeks for each agency. Setup will require additional resources (approximately 3 weeks/installation).

4.1 Installation Selection

Each participant will be responsible for the plot tending and measurement of two installations. Documentation of installation location and measurement procedures are based on a combination of the various permanent sample plot procedures already used by participating agencies (Munn-Kristoff, et al. 1988).

Both replications for an installation should be on a common soil type. Each replication requires a minimum area of 1.35 - 2.4 ha (depending on width of buffer discussed below) with relatively uniform physical (slope and aspect) conditions which has been cutover within about 24 months of setup date and with evidence of uniform natural aspen regeneration (>4000/ha). Height of aspen regeneration should be less than 1.5m; aspen height below 1.5m will ensure that competition has not become a serious factor for survival of planted spruce. Variation in location of landings, skid roads, and access roads may require separation between plots or groups of plots. As a consequence each replication may require much more than the nominal area. Large scale photography, acquired after harvesting, may assist in preliminary location of individual plots within the cut block. Convenient (all weather) access is desirable.

The following checklist is provided to summarize desirable location for plots:

1. Evidence of uniform aspen regeneration > 4000 trees per ha,
2. Mid or upper slope position with slope less than 30 per cent,
3. Uniform soil conditions over the entire replication,
4. Similar aspect.

It is suggested that after plots are located, but before completion of the setup, a soil scientist be called in to insure that there are no hidden, major differences in the soil conditions among the plots.

Wherever possible, a formal reservation status should be placed on the installation area both within the agency and with the corresponding provincial land management agency. Where appropriate, coordinate activities with the local provincial managers to avoid conflict with established reforestation requirements.

4.2 Installation and Plot Location Map

The Installation and Plot Location Map has two main purposes. The first is to provide adequate directions for a person not familiar with the study area to locate the cutblock containing a replicate of plots. The second purpose is to illustrate the location of the 15 plots within the cutblock, relative to each other.

The Installation and Plot Location Map (see examples in Appendix 7.1) can be used in conjunction with other Site Description Forms (Appendix 0) or other similar forms for a complete description of the plots and their locations. Aerial photography or reference to available photos is desirable, and if possible, they should be recent photos taken after the site was harvested.

The header information on the Installation and Plot Location Map is identical to that for the Individual Tree Tally Sheet. The header information is coded as show in the Data Dictionary (Appendix 7.2).

A map of the area is to be drawn on the front side of this form at a scale of 1:15,000. The map should show all seismic lines, trails, creeks, lakes, roads, cutblocks, and any other pertinent features. Each plot within the cutblock should be clearly marked. Also include road names and distances to the nearest town or significant tie point.

Once a replicate of 15 plots has been established in a cutblock, a tie point must be established. Distances and directions or GIS coordinates should be recorded from each plot to other plots and/or a natural or man-made tie point. Acceptable tie points are:

- Where roads cross creeks
- The centre of road junctions
- Where transmission lines cross roads
- The point where roads pass into cutblocks

The directions from the nearest town or significant tie points to the plot should also be recorded.

4.3 Installation Description

Location and access should be completely documented using photography (aerial and ground) and maps. Physiography, soils, and climate should be summarized for the installation. Ecological classification should also be included in description of installations; Use of Alberta land classification forms are suggested (Appendix 0) for overall consistency. Where appropriate other approaches can be used in addition to the Alberta approach.

4.4 Installation and plot maintenance

The following items are to be checked at each visit:

1) Check the condition and tags of all the posts, centre and corners. Replace and retag where necessary.
2) Replace any tree tags if necessary.
3) Rate the overall condition of the plot and buffer noting any damage and their location on the plot maintenance sheet.
4) The tie-point for each plot must be confirmed. This includes checking the distance and azimuth from the plot centre to the tie-point. Keep in mind the distances are horizontal and must be adjusted for slopes exceeding 10%. Whenever possible, a second tie-point should be established in the event that the original tie-point is destroyed. Suitable tie-points include obvious bends in a nearby road, stream crossings such as bridges and culverts, or any other permanent land features.

4.5 Plot Establishment

Plots are square 0.04 ha with 20 m sides and 28.3 m diagonal with corners and the center permanently marked. This size will ensure adequate numbers of trees are present in the plots over the entire life of the study (8-40 spruce and 20-160 aspen trees at harvest time). Small subplot will be established in the natural density aspen plots to describe early growth and survival of aspen. Buffers will also be established around each plot as described below.

4.5.1 Plot numbering

Plot numbers (1-15) should be randomly assigned to the plot locations after they have been established on the ground. This in turn assures random assignment of aspen and spruce treatment densities to particular physical locations in each installation.

4.5.2 Buffer strips

In addition, treatments and activities applied to the plot are also to be applied in a buffer around each plot. A buffer is desirable to minimize surface and subsurface influence on a treated plot from outside vegetation (or natural conditions) since these conditions may be very different from the treatment within the plot.

The activities required to establish and maintain the buffer should follow the procedures applied to the plot with the exception that <u>tree measurements are NOT to be taken in the buffer</u>. This means that if spruce trees are planted in the plot then the buffer should include planting of spruce at the same density and spacing. Tending around the spruce trees should be applied in the buffer as well as in the plot. When thinning to aspen treatment density occurs, the buffer area should be thinned as well. <u>The general rule is that any treatment or activity applied to the plot should also be applied in the buffer</u>.

Strong and LaRoi (1983) reported radial root spread of spruce trees growing in mixed aspen/spruce stands ranging from 4 m at age 20 to 8.4 m at age 58. Based on these preliminary results, it appears that a 5-10 m buffer should be adequate. The difficulty with a wider buffer is the cost of maintaining treatment conditions; area for a 10 m buffer (.12 ha) is more than double that of a 5 m buffer (.05 ha). In addition larger homogeneous areas are required for the plots. For convenience of layout and maintenance it is probably better to go with either 5 or 10, not a value between these limits (Table 3).

Table 3 Specifications for two alternative buffer zones

5 m buffer	10 m buffer
30 x 30 m plot (0.09 ha)	40 x 40 m plot (0.16 ha)
0.05 ha buffer area; reduced cost	0.12 ha buffer area; greater cost
1 row of conifer planted in buffer; less plot insulation; if aspen is the dominating influence this may not be so significant	2, 3 rows of spruce planting; better plot insulation
easier to locate 30x30 m homogeneous areas	40x40 m areas more difficult to locate
root extension into the plot from trees located outside the buffer is likely by age 50 years	root extension into the plot from trees located outside the buffer is not likely
shading more likely from external sources	shading less likely from external sources
litter deposit more likely from external sources	litter deposit less likely from external sources

A 10 m buffer on each of the 4 sides of the treatment plot is preferred to minimize possible influences from sources outside the treated area. Unfortunately, cost is a major consideration and therefore some participants may be forced to consider using a 5 m buffer. The final choice will be made independently by each participant for their installations.

4.5.3 Surveying Plot and Buffer Corners

Record distance and azimuth, or UTM coordinates, from a permanent monument to the plot centre. Record actual azimuths and distances from the plot centre to plot and buffer corners. The plot centre, plot, and buffer corners will be identified using aluminum or steel posts (recommended: 16 gauge tubing, 4' long). Treatments and associated Plots numbers must be randomly assigned to a physical location. Posts will be color coded: center -- red; plot corners -- blue; buffer corners -- white. If possible the centre post should be aluminum tubing. Obviously variation in these specifications may be required. However, consistency among installations is desirable, especially if common re-measurement crews are used.

While orientation of the plot along cardinal directions is ideal, other orientations are acceptable. The following procedure is based on the AFS PSP Procedures (1990 section 2.1.1) and assumes that plots are oriented along the cardinal directions.

Locate the plot centre post. With a Staff compass (Brunton Pocket Transit or transit) set up at the plot centre, locate the plot and buffer corner posts using the following azimuths and distances (Table 4). Be sure to remove the metal centre post if it is not aluminum. Verify the location of corners by measuring the lengths of each side of the plot. The length of each side should be 20 ± 0.15 m. If not, relocation of corners is required.

Table 4 Azimuths and distances from centre to plot and buffer corners

Corner	Azimuth (degrees)	Distance (m)
NE	45	14.14
NE Buffer	45	21.21(5m); 28.28(10m)
SE	135	14.14
SE Buffer	135	21.21; 28.28
SW	225	14.14
SW Buffer	225	21.21; 28.28
NW	315	14.14
NW Buffer	315	21.21; 28.28

4.6 Planting of spruce trees

Plant local source spruce at 2000 / ha initial density for the high density plots (1-6). Plant local source spruce at 1000/ha initial density for the low density plots (7-12). Planting lines should be marked prior to planting to ensure that lines fall within the plot boundary. Where possible 2-0 stock should be used; early experience indicates that procuring stock may be difficult without sufficient lead time. The same stock should be used for each installation. Early planning for acquisition of seedling stock is essential.

Seedling requirements (10m buffer):
2880 / replication = (6 plots x 0.16ha x 2000/ha) + (6 plots x 0.16ha x 1000/ha)
5760 / installation
11520 / agency (two installations).

4.7 Plot Tending

Annually <u>before thinning</u> to treatment density, clean and weed the Micro-site (0.5 m radius) around each spruce in both plot and buffer until there are no new hardwood sprouts or conifers are above the grass/shrub layer. Remove all competing vegetation (trees, shrubs, and grass) in mid-to-late summer (after completion of growth) including removal of dead grass material. Report the approximate number of hardwood trees removed at each visit as well as removal method (hand/brush saw), cost and time. The purpose of the cleaning and weeding is to ensure that planted spruce trees are given the best possible chance to survive over the course of the experiment. This treatment will be applied to all plots (including natural density aspen plots 6 and 12), **EXCEPT** plots with no planted spruce (plots 13 and 14) and the completely untreated plot (plot 15).

Annually <u>for 5 years following thinning</u>, remove all hardwood trees that have reached 1.3 m height, except aspen crop trees. This treatment will be applied to all plots except the natural density aspen (plots 6, 12, and 15). Conifers that become established on the plot by natural seeding should be allowed to develop. Beyond the 5-year post-thinning period, new trees may become established and there may be in-growth of conifer and/or hardwood trees. The intent is to allow natural stand development for the remainder of the study.

4.8 Plot layout and tree numbering

4.8.1 Planted Plots (all except 13, 14, and 15): white Spruce

All spruce trees (720 per replication) are to be numbered and tagged, when planted, using a six digit code consisting of the row number (2 digits), tree number (2 digits) within the line, and with two additional digits coded as "00" digits to indicate ingrowth between planted stock (in anticipation of ingrowth). Trees are numbered sequentially along the planted rows. Odd numbered rows are numbered in a south to north direction, while even numbered rows are numbered in a north to south direction (Figure 1 and Figure 2). Pigtails or other metal stakes should be placed in the ground on the west side of each tree (again, consistency between agencies is desirable). The first line of spruce is that along the west boundary of the plot. From the time of establishment until year 5 when the thinning is undertaken, only the spruce trees are measured.

Ingrowth numbering is described in Figure 3. As an example of numbering ingrowth, if a spruce seedling reaches breast height to the west of row four between planted seedlings 000600 and 040700, the ingrowth would be numbered 040601. Ingrowth between the final planting row (most easterly) and the plot boundary are assigned a row number one greater than the final planting row and a tree number of “00”. If a Sw tree is replaced, use the same tree number and be sure the Establishment and Age fields reflect the status of new tree.

Figure 1 Numbering white spruce on high density (plots 1-6)

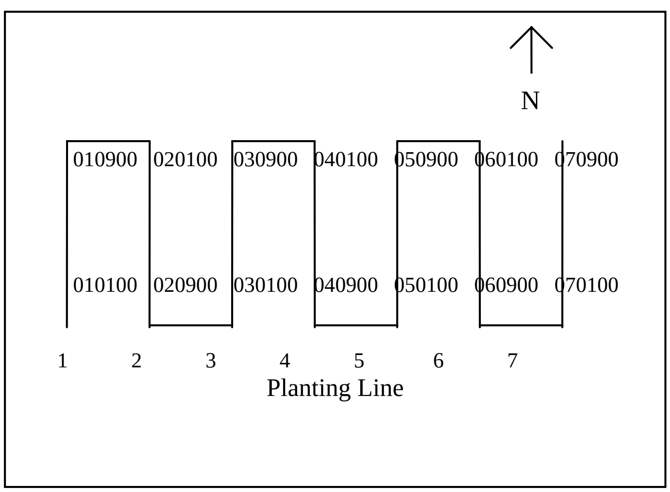


Figure 2 Numbering white spruce on low density (plots 7-12)

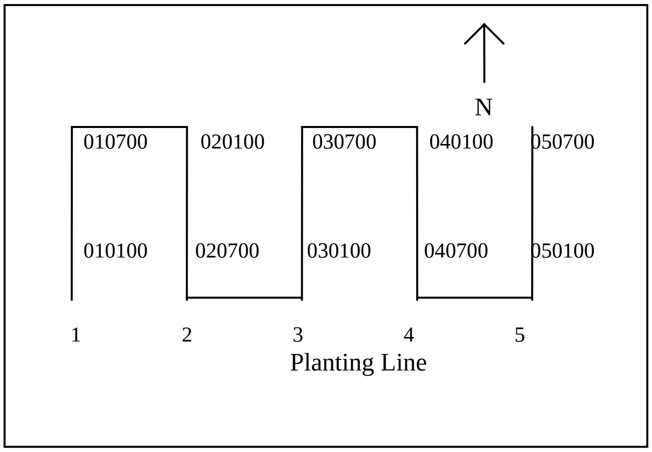
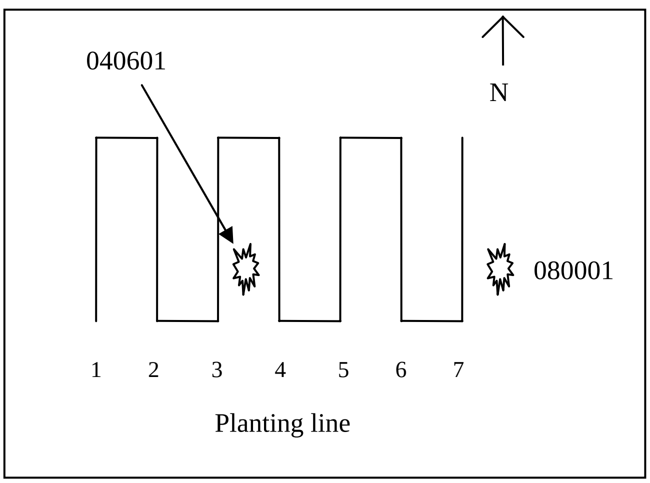


Figure 3 Numbering ingrowth trees



4.8.2 Thinned Plots (all except 6, 12 and 15)

Aspen trees are tagged and numbered beginning at year 5, after the plots have been thinned to treatment density. Following thinning to treatment density, aspen crop trees are to be numbered and tagged following the procedure as described for spruce.

Aspen numbering follows a method similar to that of the spruce. The “line” will be the area between spruce planting lines and will include a line “0” for the area between the left (west) boundary of the plot and the first spruce planting line. Aspen line 1 will include the area between spruce planting lines 1 and 2, and so forth. For example, an aspen tree located between row 1 and 2 and between planted Sw 5 and 7 would have a tree number 0105xx where xx is not already used for another tree, planted or ingrowth, of any species. Following thinning, aspen and poplar ingrowth is removed annually as it reaches 1.3 m height in all treated plots. When trees reach sufficient size, tree numbers should be painted on the trees as well.

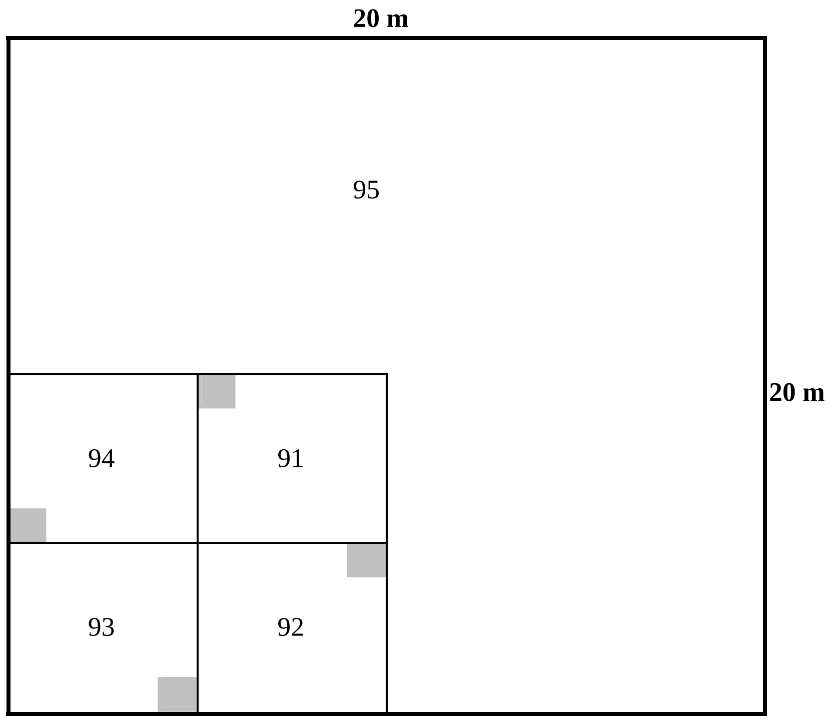
4.8.3 Natural density aspen Subplots (plots 6, 12, and 15)

Of the 15 plots in the basic treatment combinations, only plots 6, 12, and 15 are maintained at natural levels of aspen density. For this reason, these plots were selected for observing the early development of aspen. Since the establishment of aspen trees is frequently at excessively high density levels and there is no thinning of aspen on plots 6, 12, and 15, small subplots are a necessity to keep the number of tree measurements at a manageable level. This use of small subplots makes it difficult to describe some stand characteristics (e.g. top height) since the largest trees are not well sampled. As density declines with age, a gradual expansion of subplots up to the full plot size is desirable to better match with the data from the treated plots.

Trees of all species are numbered and tagged in each subplot using a six-digit code consisting of the subplot number (2 digits, in place of row number) and tree number (4 digits). Tree numbers are consecutive and cumulative as subplots are expanded; see the figures below for additional details, and remember that as the sub-plot size is increased, it is important to continue measuring trees in the smaller sub-plots.

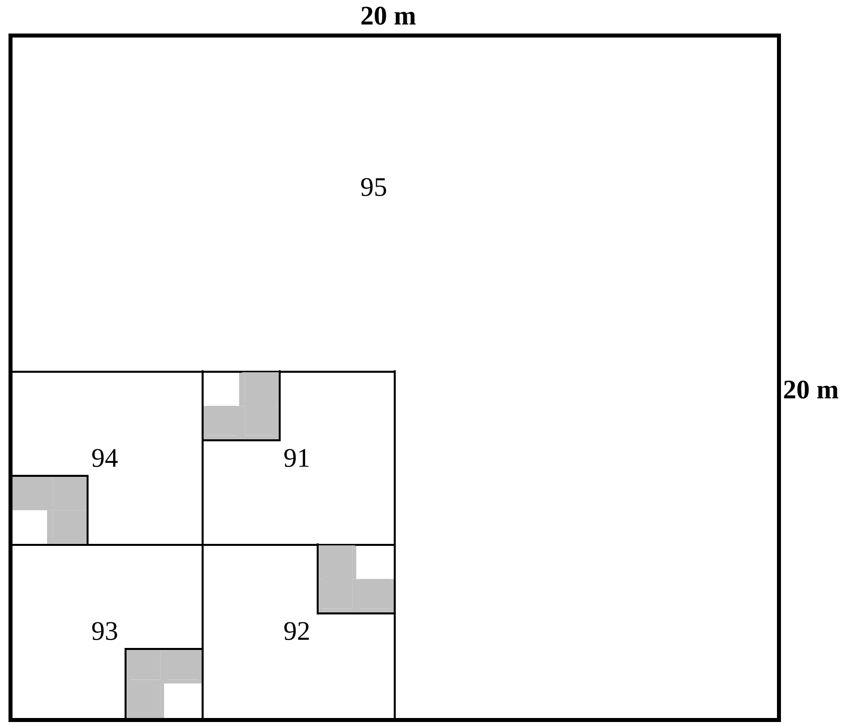
The main 20x20m plot can be partitioned into five subplots consisting of the four quadrants of the SW ¼ , subplot numbers 91, 92, 93, and 94, and the remaining ¾, subplot number 95 (Figure 4). In addition, there are four subplot sizes: 1x1 m, 2x2 m, and 5x5 m before expansion to the full 20x20 m size. Initially four 1x1-metre subplots are located at the corners of the central line of the SW ¼ of the 20x20 m plot (Figure 4). Record Type is used to indicate the subplot size on the tree data form. The subplot sizes, areas, Record Types and expansion years are summarized in Table 5. Graphic summaries of the area coverage (to avoid potential overlap and double counting) are shown in Figure 5, Figure 6 and Figure 7.

Figure 4 Un-thinned plots (6, 12, and 15): 1x1 m subplots



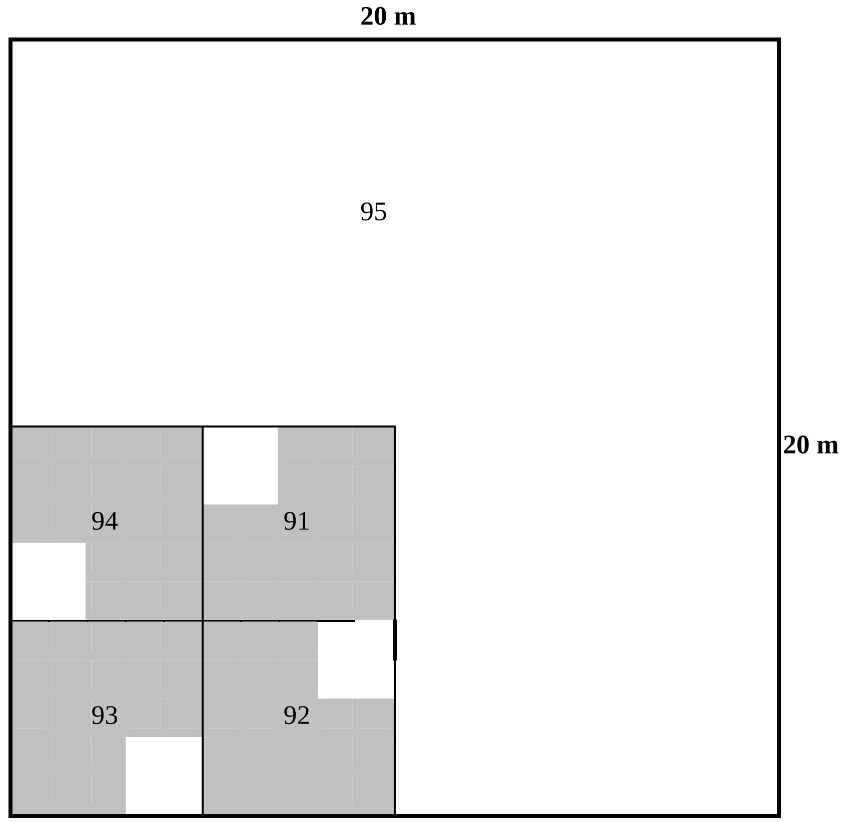
1x1 m subplots are indicated by the shaded area. Trees within the 1x1 m subplots (shaded) are numbered 91xxxx, 92xxxx, 93xxxx, 94xxxx as needed.

Figure 5 Un-thinned plots (6, 12, and 15): Expansion of subplots to 2x2 m



Subplots expanded to 2x2 m. New trees within the shaded portion of the 2x2 m subplots are numbered 91xxxx, 92xxxx, 93xxxx, 94xxxx as needed with the first number following the last number used in the 1x1 m subplot. Trees already recorded on the smaller subplots retain their numbers and provide data for the remaining 1x1 m portion of the 2x2 m subplot. Trees on smaller subplot continue to be measured.

Figure 6 Un-thinned plots (6, 12, and 15): Expansion of subplots to 5x5 m



Subplots expanded to 5x5 m. New trees within the shaded portion of 5x5m subplots are numbered 91xxxx, 92xxxx, 93xxxx, 94xxxx as needed with the first number following the last number used in the 2x2 m plot. Trees already recorded on the smaller subplots retain their numbers and provide data for the remaining 2x2 m portion of the 5x5 m subplot. Trees on smaller subplot continue to be measured.

Figure 7 Un-thinned plots (6, 12, and 15): Expansion of subplots to the full 20x20 m size

Subplots expanded to 20x20 m. New trees within the shaded portion of 20x20m subplots are numbered 95xxxx as needed. Trees already recorded on the smaller subplots retain their numbers and provide data for the remaining 10x10 m portion of the full 20x20 m plot. Trees on smaller subplots continue to be measured.

<u>For installations set up before year 2000</u>, subplots were <u>centred</u> on the quadrant boundary rather than on the <u>corner</u> and this causes a minor overlap when subplots are expanded (Figure 8). The expansion of subplots for this layout follows the general approach outlined for installations established after 2000. However, there is a small difference that is outlined in Figure 8 that must be handled correctly to avoid double counting of some trees.

Table 5 Un-thinned plots (6, 12, and 15): subplot size and expansion summary

Year	**Size (m)**	**Area (ha)**	**Record Type(s)****	**Figure**
1	1x1	.0001	11	Figure 4
6	2x2	.0004=.0003+.0001	22 + 11	Figure 5
*	5x5	.0025=.0021+.0003+.0001	55 + 22 + 11	Figure 6
*	20x20	.0400=.03+4*.0021+.0003+.0001	66 + 55 + 22 + 11	Figure 7
* Not implemented until density declines further (ratified at spring meeting 2003), 2x2 m sub-plots will be used up to at least age 18, pending ongoing review.				
** To indicate that expansion is cumulative. For example, for trees with numbers 92xxxx and Record Type 22, plot size is .0003 ha. Trees with numbers 92xxxx and Record Type 11, are the set of trees found on the 1x1 m (.0001 ha) subplot. The total count of trees in these two sets is the count of trees on the .0004 ha subplot 92.				

Additional details and examples for the subplot expansion are provided in Table 6. This table outlines and further links the RTYPE, subplot size and expansion of tree characteristics for the different subplot sizes. It is important to note that subplots are cumulative and that estimates can be made for characteristics (e.g. number of trees/ha) using any of several sources from the subplots. A weighted average procedure is needed to correctly combine per ha estimates from different plot sizes. The weights must be based on the plot size in ha. For example, the table shows that data from RTYPE 11 leads to the estimate of 100,000 trees/ha while that for the RYTPE 22 is 16,667. Yet when the two are combined either by pooling the trees/plot data or using the weighted average, the estimate is 37,500. These differences may occur frequently. Larger plot size reduces variability even though both estimates are unbiased.

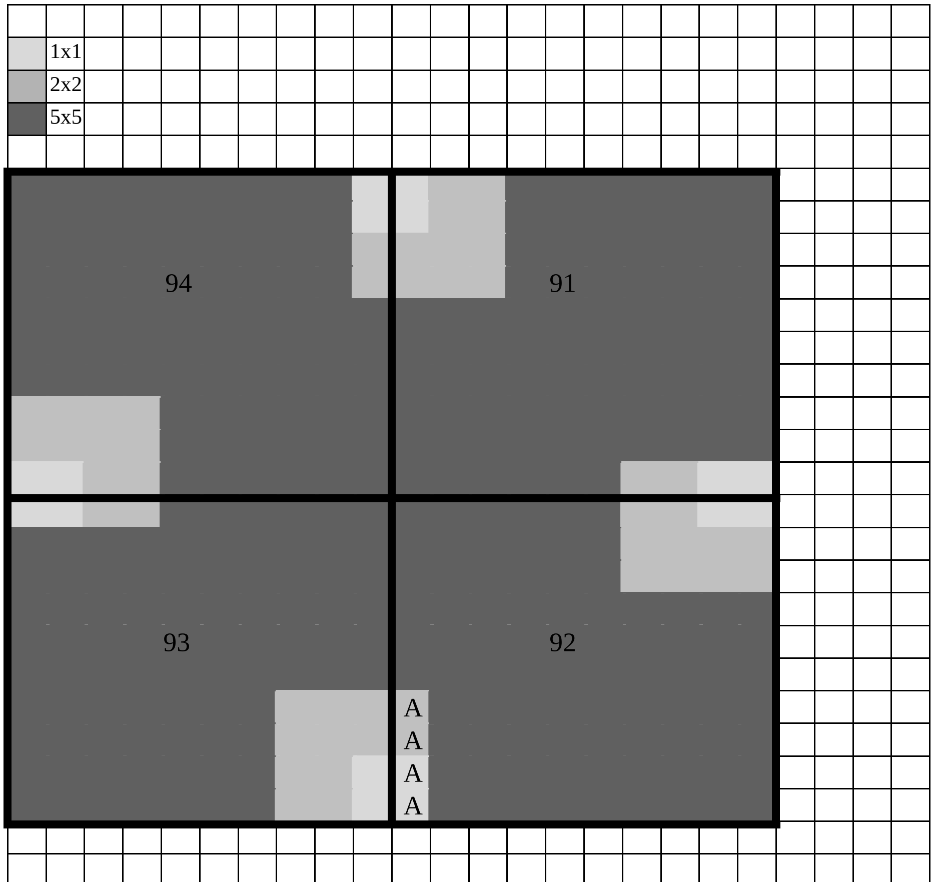
Table 6 Subplot expansion areas and factors with example estimates of tree/ha

RTYPE	Square plots (m x m)	Plot size (ha)	Expansion factor (Trees/ha)	trees/plot	trees/ha	wtd avg
11	1x1	0.0001	10000	10	100000	
22	2x2-1x1	0.0003	3333	5	16666.67	
11+22	2x2	0.0004	2500	15	37500	37500
55	5x5-2x2	0.0021	476	25	11904.76	
11+22+55	5x5	0.0025	400	40	16000	16000
	10x10=5x5*4	0.01	100	90	9000	
66	20x20-10x10	0.03	33	240	8000	
	20x20	0.04	25	330	8250	8250

Based on the comparison of subplot expansion options completed by Weyerhaeuser (Grande Prairie, Greg Behuniak, Fall/Winter 2002-2003 and reported at the Spring 2003 meeting) <u>the transition to 5x5 metre subplots has been deferred</u> owing to the excessive densities still found on the plots. The mortality trends for aspen will be further evaluated before a decision is made to move to a larger subplot. <u>This will be reviewed annually with the goal of keeping the number of trees on a 5x5 m plot at something less than 30 trees (12000/ha)</u>.

Until plots are expanded to 20x20 m, it will not be possible to estimate top heights that are comparable to those of the treated plots. Attempts to estimate top height using plot sizes smaller than 20x20 m will be biased (underestimating top height). The amount of bias increases as plot size decreases. This is partly evident by considering the 2x2 and 5x5 m plot sizes where the top height is estimated using the largest tree in the plot since each tree represents 2500 and 400/ha respectively for the two plot sizes. In addition, the excessive cost of measuring the full 20x20 m plot outweighs the benefit of having a good estimate of top height early in the life of natural stands. Bias will be less important with the 5x5 m plot, and it may be possible to develop an approximation to the amount of bias, using the data that Weyerhaeuser collected during Fall/Winter 2002-2003.

Figure 8 SW 5x5m subplot layout for installations set out prior to 2000 with subplots centred on the 5x5 m subplot boundaries, Scale: 1 cell = 0.5 x 0.5 m



1x1m subplot: Measure full plot including overlap on both sides of the centerline.
2x2m subplot: Measure the remaining ¾ of the 2x2m subplot including the 1x1m subplot and the 0.5 x 2.0 m overlap.
5x5m subplot: Using subplot 92 as an example, measure the remaining portion of the 5x5 m plot excluding the overlapping 0.5x2m portion already included in the 2x2 m subplot 93 (e.g. area A)
20x20m plot: expand by including the remaining ¾ of the 20x20 m plot (not shown in this figure).

4.8.4 Mapping of tree locations

All tree locations within the plot are to be mapped. However, the trees in the buffer zone and subplots are not included. Assuming between-tree competition is not significant before thinning to treatment density, tree mapping will be delayed until after thinning to treatment density has taken place. This significantly reduces the effort required for mapping since it includes only crop trees. Mapping tree locations will be of value for two uses: 1) location of trees at re-measurement time, and 2) evaluation of between-tree competition based on spatial location measures.

Transit and stadia techniques may offer a reasonably convenient way to map tree locations if completed before aspen get above 2 m or after leaves fall in late summer. Accurate laser survey instruments, with an electronic compass may also be used. This is an alternative to the procedure used by AFS:

"All tagged stems within the tree plot are stem mapped. Stem mapping is used to identify the position of each tree with respect to other surrounding trees and can be used in distance dependent growth models and is used in plot re-measurement to locate missing trees. A staff compass (or Brunton pocket transit/tripod) and a metric tape are used to determine the azimuth and distance to the centre of each tree, at breast height, from the plot centre. Azimuths are recorded from 0 - 360 degrees and distances are measured to the nearest 0.1 m." (AFS PSP Manual Section 2.1.4.9)

Expected number of trees to be mapped (per replication):
Aspen: (2 plots x 0 trees/plot)+(2 x 8)+(2 x 20)+(3 x 60)+(3 x 160)+(3 x ~ 200) = ~ 1316 trees
Spruce: (6 x 40)+(6 x 20)+(3 x ~ 5) = ~ 375 trees

4.9 Trees, measurement schedule and thinning to treatment density

Conifer ingrowth trees with height greater than 1.3 m are considered crop trees, and they will be tagged and measured accordingly. After thinning, aspen ingrowth greater than 1.3 metre in height are considered as crop tree unless they are removed as part of the plot tending requirements (Section 4.7). All deciduous trees greater than 1.3 metre should be tagged and measured in the same way as aspen.

Table 7 summarizes the definition of trees to be measured and the handling of ingrowth according to species and time of thinning to treatment density.

The LTS data dictionary (Appendix 7.2) describes the tree measurement and related variables.

Table 7 Trees to be measured in relation to plot/subplot, species and year of thinning

	Treatment plots (all plots except 6, 12, and 15)	**Un-treated, natural, plots (plots 6, 12, and 15)**
Before thinning	**Conifer**: All planted Sw **Deciduous**: None, except that in the <u>last year prior to thinning</u>, tag and measure all AW crop trees	**Conifer in full plots**: All planted SW and ingrowth trees of all species **Deciduous in subplots 91, 92, 93, and 94**: All species. Special rules apply when subplots are expanded (see Section 4.8.3)
After thinning	**Conifer**: Sw crop trees, tree number retained from before thinning AND <u>Ingrowth trees (HT > 1.3 m)</u> of all species **Deciduous**: Aw crop trees that were tagged and measured in the year immediately prior to thinning. Following thinning, deciduous ingrowth is removed annually until <u>most</u> ingress has ceased. After that time add ingrowth trees of all species.	**Conifer in full plots**: All species AND Ingrowth trees of all species **Deciduous in subplots 91, 92, 93, and 94**: All species AND Ingrowth trees of all species. Special rules apply when subplots are expanded (see Section 4.8.3)

4.9.1 Before thinning

All spruce and some aspen trees are to be measured at establishment and then annually after seasonal growth is complete until year 10. The normal measurement time is therefore usually in the late summer or fall, but could be as late as the following early spring before growth begins.

Establishment of Aspen at high (even excessive) density and cost of tree measurements suggests special procedures to keep the number of aspen trees measured at an acceptable level. Since sprouting occurs well into the early life of the stand and growth patterns are unclear, it is desirable to take measurements on some aspen trees during this early development period. For this reason, up to the time of thinning to treatment density, aspen are only measured on the natural aspen density plots (6, 12 and 15). Subplots of varying size are established on these plots (see section 4.8.3). Measurement of these selected plots provides data necessary to describe establishment (sprouting), growth, and survival rates for aspen from establishment until thinning to treatment density.

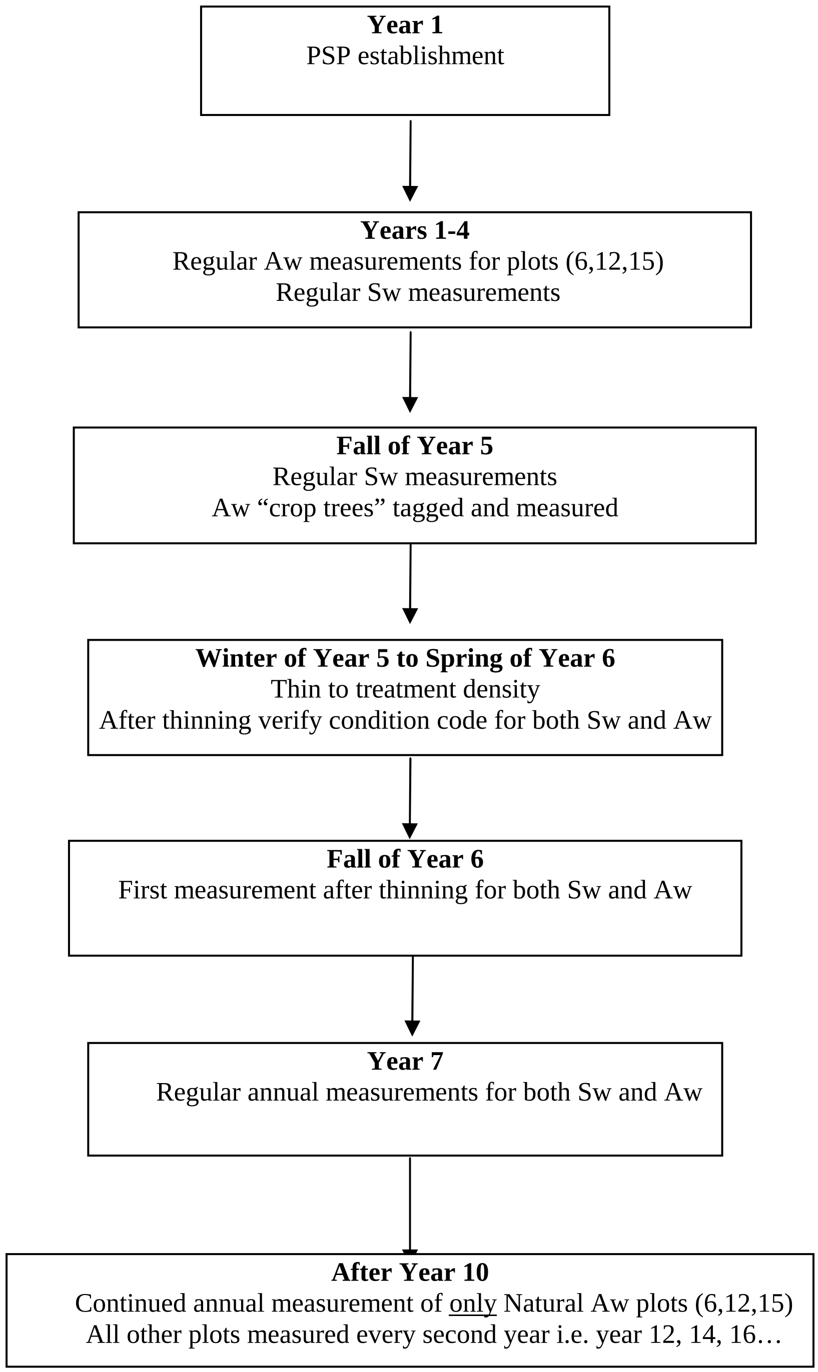
4.9.2 In conjunction with thinning

Aspen and spruce are thinned to treatment density at year 5 or earlier if competition develops and aspen stem differentiation occurs. Thinning should favor potential aspen and spruce crop trees while retaining relatively uniform spacing. Thinning should be completed between growing seasons.

At year 5, aspen trees for all plots, except the natural density aspen plots (6, 12 and 15) should be thinned to the designated treatment densities (Table 2). The spruce is thinned to the target densities for all plots. At the time of last measurement before thinning, aspen crop trees (those not removed in the thinning) should be tagged and measured. Thinning should be completed before the next growing season begins so the first measurement after thinning can be taken after the next growing season is completed (Figure 9).

After the thinning is completed, the condition code needs to be verified for both Sw and Aw to identify any damage during the thinning process. Other measurements are not required but the post-thinning condition codes need to replace the pre-thinning codes in the data for the year of thinning. The following year (after a whole growing season) regular annual re-measurement continues. Figure 9 shows a detailed diagram of the process. The data file should show only one measurement for the year of thinning, but it should include both the Aw and Sw crop trees.

Figure 9 Timing of measurements just before and after thinning to treatment density



4.9.3 After thinning

From the time of thinning to year 10, re-measurements proceed as they did before thinning.

After year 10, re-measurements will be made biennially at the even years beginning with year 12 (ratified at the 2002 AGM). The decision to move to less frequent re-measurement will be deferred until the density level on the natural aspen density (un-thinned) plots is at more stable level and a longer interval is needed to ensure acceptable accuracy in the indirect measurement of height increment (direct measurement of height increment is difficult after trees reach 5-6 m). It is expected that the re-measurement interval may be decreased to 4 years by age 18 and to 8- years by age 26.

During the time of biennial measurements, a special visit to the natural density aspen plots (6, 12, and 15) will be made in the odd years (e.g. 11, 13…) to record only survival data for all trees (in-growth will not be recorded). This will allow better evaluation of survival trends during the coming years. Analysis for the first installations reaching 10 years has shown that natural density aspen plots (6, 12, and 15) still have densities that are much higher than that expected after 10 years (10,000 stems/ha). High density levels of natural aspen cannot be maintained and it is expected that substantial additional self-thinning mortality will occur between age 10 and 20 years. The main cost will be for the re-measurement of these trees on only the natural density aspen plots (6, 12, and 15). Since other plots will not be measured, and there will not be any treatments or tree tending and cost should be considerably less than the full measurement. However, we do not want to miss out on the any major mortality events or other decrease in density that is expected to occur during this time.

4.10 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.

5 Data processing and maintenance protocols

5.1 Data processing procedures

Annually collected data will follow the process outlined in Appendix 7.6. The flow diagram outlines the 8 steps involved in managing WESBOGY LTS data.

Start: The annual data collection process can occur in late fall (after growing season) or early spring (before next growing season begins). The data input process should begin immediately after the data field collection is complete. This allows for the opportunity to return to the field to correct missing erroneous data.

Step 1: Data Input - Data can be input into Microsoft Excel or directly into a blank Microsoft Access 2000 database. Both paper and data logger approaches to recording data are acceptable. Templates for both platforms can be obtained from the WESBOGY Researcher. Use of the provided templates allows for easier data processes in later steps.

Step 2: Data Archiving - Original field sheets should be archived for later reference. Original data logger data should files should be burnt onto a CD and archived.

Step 3: Error Checking - Each agency should review their computer data files for data integrity. See the section on common errors to aid in locating trouble spots. Following the data cleaning and error checking process, 2 copies of the data should be burnt onto a CD, one for archiving and another to be sent to the U of A for further processing.

Step 4: Submit the data to U of A - A CD with the cleaned data should be submitted to the U of A no later than August 1st for the previous growth year. This should provide sufficient time to input data collected if the data was collected in the spring and is before the next years data collection.

Step 5: U of A error checking - The WESBOGY researcher at the U of A has developed comprehensive data checking routines in order to identify errors. The errors can come in many forms such as “typos”, missing data and illogical data (i.e. heights are too large for age).

Step 5a: If Errors Found - A report will be generated outlining the errors found. Suggestions for data corrections (where possible) will be made. In cases of missing data or correction is not obvious, the data and report will be returned to the agency to have the data corrected, if possible. Details of the U of A data error checking procedures can be found in Appendix 7.8 and 7.9.

Step 5b: If No Errors Found - If no errors are found proceed to step 6.

Step 6: The annual data will be appended to the “Agency Master database” and a copy retained at the U of A.

Step 7: An official CD with the complete agency master dataset will be sent to the agency.

Step 8: All the individual agency master datasets will be appended to create the “WESBOGY Master database”.

5.2 Microsoft Access Database Structure

Appendix 7.7 outlines the data structure (field names, type and size) for the Microsoft Access 2000 database.

5.3 Data Error Checking Procedures

The objective of the data error checking procedures is to create a consistent and error-free databases for all agencies which would facilitate efficient data management and analysis. The criteria used to error check the database is provided in Appendix 7.8.

There are 4 general areas of that were addressed in the data error checking procedure.

1. DATA FORMAT: Ensured that the database structure, naming conventions and field parameters were consistent over all agencies. This section also deals with the presence of extraneous fields. This is a requirement when all individual databases are appended to one another to create the WESBOGY master database. Appendix 7.7 describes the approved database structure, naming conventions and field attributes.

2. DATA CODING: Ensured that only permitted field codes and abbreviations were used within a particular field. Appendix 7.2 describes the permitted field codes for each of the discrete fields within the database.

3. UNITS of MEASURE: Ensured that the units of measure were consistent within each agency over all measurement years. Appendix 7.2 summarizes the units of measure for each of the continuous fields within the database.

4. UNSYSTEMATIC ERRORS: Errors can enter a database in many ways and can take on many forms. The errors discussed here refer to errors that are not systematic but rather are caused during the measurement process, during the data input phase or were inadvertently changed.

5.4 Error Checking Database

The error checking process requires that any changes made to the database are methodically and carefully made. In order to facilitate this process, within the main database, additional fields are added. Appendix 7.9 lists the new fields created, their type and size. The fields are followed by an "_O" represent the "original values" for comparison and checking purposes. The "ERRXXX" fields are error fields that will be populated with either an Err, Err0, Err1 or Err2. The following are the definitions for these errors.

Err - Is an error, no correction made (high priority)
Err0 - May not be an error (low priority)
Err1 - Coding error found, correction made with confidence (should review)
Err2 - Numeric error found, correction made with confidence (should review)

In order to assist in data correction process, the UofA researcher will make error corrections when the error is considered obvious and will be flagged with an "Err1 or Err2" code. In these cases the corrections should be reviewed and accepted by each agency. Each agency will used the following modifiers (o or x) to replace the 1 or 2 in the Err1 or Err2 fields providing guidance for the next stage of data error checking.

Where

- Confirmation (o): agree the change
- Disagreement (x): disagree and provide what should be
- Do nothing: no idea

The modified fields will take be either Erro, Errx or remain Err

5.5 Examples and discussion

Table 8 lists examples of common mistakes and unsuitable formats of data entry. The corresponding corrections are shown in Table 9. For all the examples, although crown radius north (crn), crown radius west (crw), height to live crown (hlc), azimuth (az), and distance (dis) were not measured, they have been added in the Table 9, because every variable must be included in the data file even if there is no entry for the field. For trees 920000 and 910000, there should have been entries for condition code 1 to tell whether the tree was missing or dead, because both root collar diameter and height were missing. For trees 111200 and 108000, the comments of tree condition were changed to a standard condition code. There should also have been an entry for age. The unreasonable data (record type 0, condition code 80, height increment 82.1 and 712.4) were corrected according to the original data. Note that zero as a record of height increment for tree 601000 is correct, because in this plot the height increment was measured but the height increment of this live tree was zero. These are some typical examples of data errors and their correction.

Table 8 Some examples of mistakes and wrong format in the data set

RTYP	AGCY	BLK	INST	REPL	PLOT	DATE	TRNO	SPP	EST	RCD	DBH	HT	HTI	CC1	CC2	CC3	AGE
11	Weyepa	2	MED	2	6	5/13/91	920000	AW	S	0.0		0.0					2
11	Weyepa	2	MED	2	15	10/7/91	910000	AW	S	0.0		0.0	0.0	0	0	0	3
9	Weyepa	24	SUP	1	1	8/8/91	111200	SW	P	0		GONE					
9	Weyepa	24	SUP	1	2	8/8/91	108000	SW	P	0.2		8.5		20		dead	
0	Weyepa	1	SUP	1	9	5/16/91	504000	SW	P	0.3	0.0	7.2	0.0	13	0	0	2
9	Weyepa	1	SUP	2	12	4/24/92	401000	SW	P	0.2		12.9	82.1	18	13	0	3
9	Weyepa	1	SUP	2	12	4/24/92	404000	SW	P	0.2		22.8	712.4	0	0	0	3
9	Weyepa	2	MED	2	3	8/27/92	601000	SW	P	0.4		29.5	0.0	1	80	0	4

Table 9 The corrected data

RTYP	AGCY	BLK	INST	REPL	PLOT	DATE	TRNO	SPP	EST	RCD	DBH	HT	HTI	CRN	CRW	HTLC	CC1	CC2	CC3	AZ	DIS	AGE
11	WPA	02	MED	02	06	19910513	9200000	AW	S								26					2
11	WPA	02	MED	02	15	19911017	9100000	AW	S								26					3
09	WPA	02	SUP	01	01	19910808	1101200	SW	P								26					3
09	WPA	02	SUP	01	02	19910808	1008000	SW	P	0.2		8.5					25	20				3
09	WPA	01	SUP	01	09	19910516	5004000	SW	P	0.3		7.2					13					2
09	WPA	01	SUP	02	12	19920424	4001000	SW	P	0.2		12.9	2.1				18	13				3
09	WPA	01	SUP	02	12	19920424	4004000	SW	P	0.2		22.8	12.4				00					3
09	WPA	02	MED	02	03	19920827	6001000	SW	P	0.4		29.5	0.0				18					4

6 References

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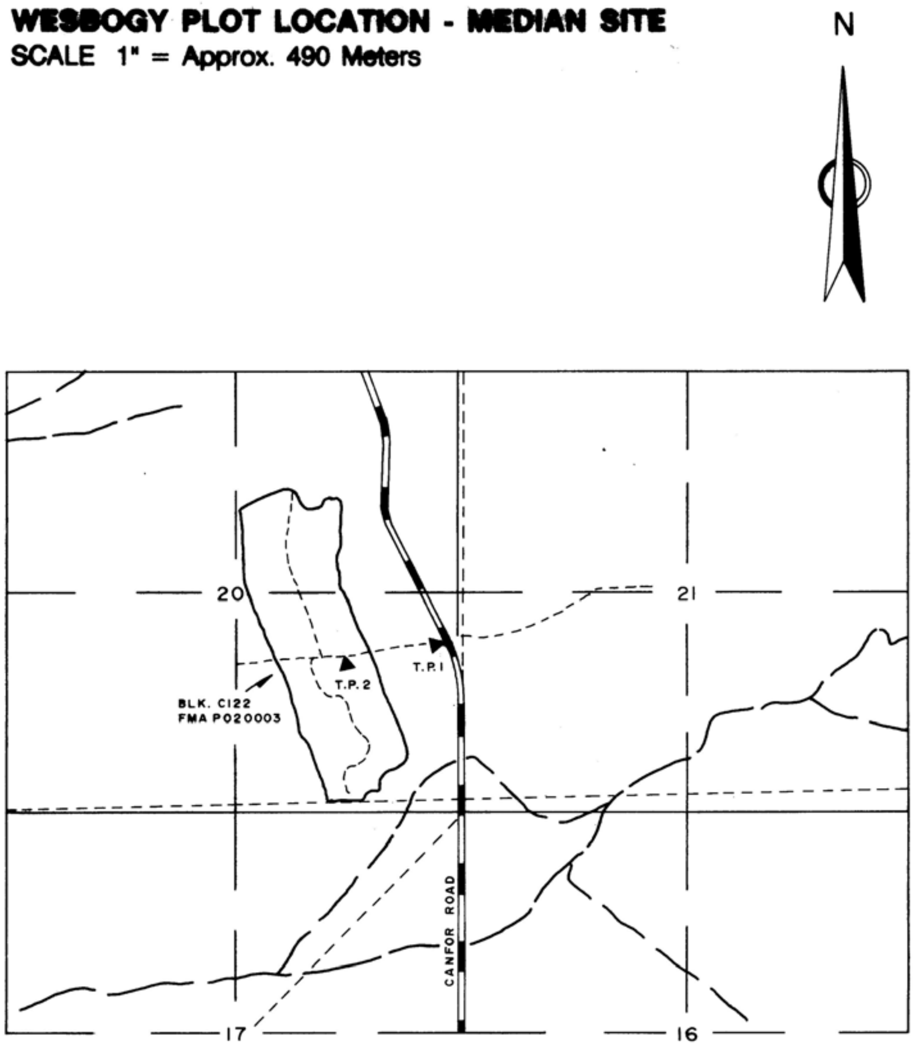
7 Appendices

7.1 Example installation and plot location maps

The following are included with the permission of Daishowa Marubeni Int (DMI).

WESBOGY PLOT LOCATION - MEDIAN SITE

SCALE 1" = Approx. 490 Meters



TWP. 85 RGE. 04 W6M

CANFOR MILL TO TIE POINT 1 **11.70 KILOMETERS**

TIE POINT 1 TO TIE POINT 2 **450 METERS**

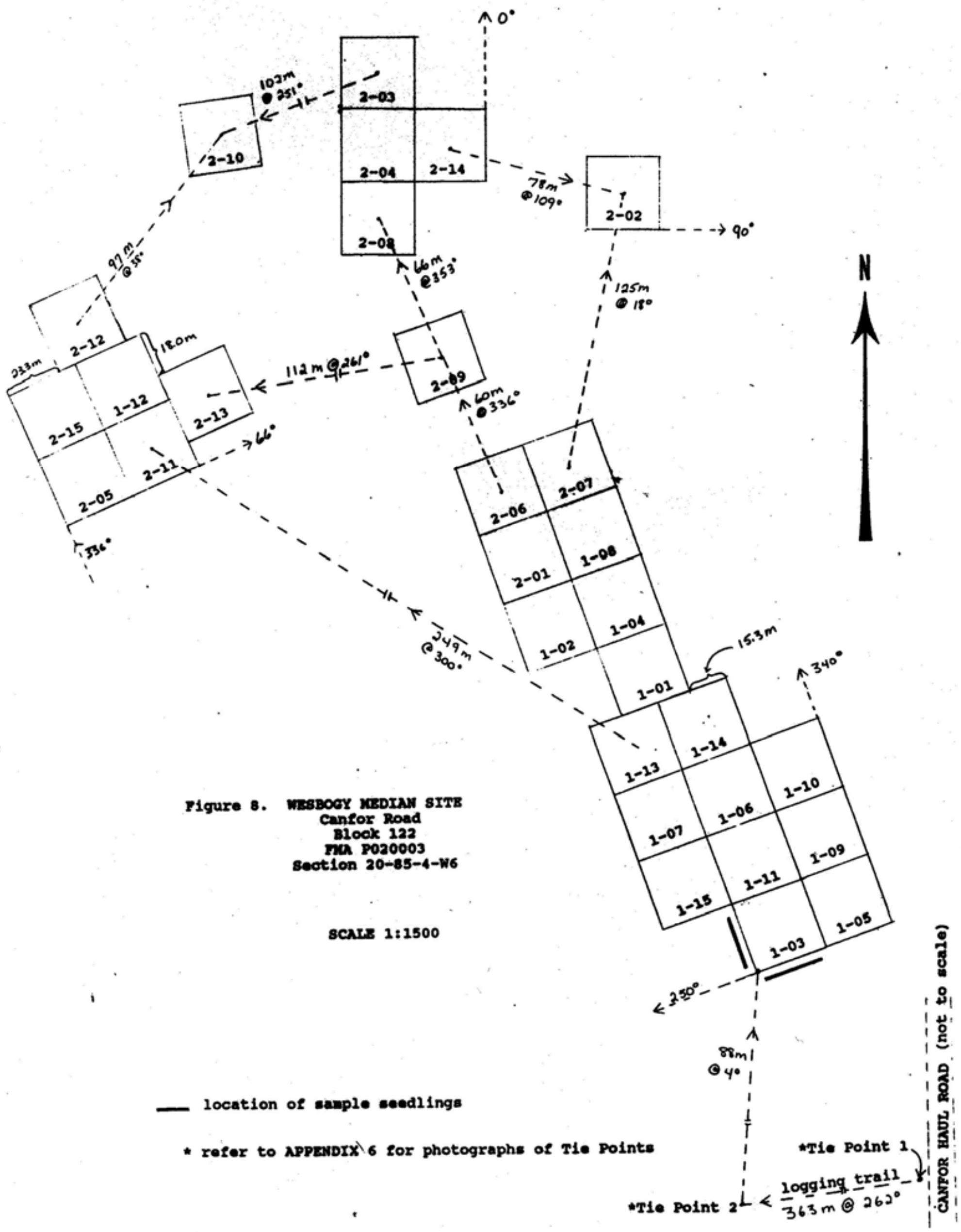


Figure 8. WESBOGY MEDIAN SITE
Canfor Road
Block 122
FMA P020003
Section 20-85-4-W6

SCALE 1:1500

— location of sample seedlings

* refer to APPENDIX 6 for photographs of Tie Points

12

7.2 Tree Data Form and Dictionary

Criteria for selecting trees to be measured are found in the section on trees and measurement schedule (Section 4.9). The following table, “Table 7 Trees to be measured in relation to plot/subplot, species and year of thinning”, is linked to that section.

Error! Not a valid link.

VARIABLE *required	**FULL NAME**	**FIELD TYPE**	**FIELD WIDTH**	**# of DEGITS**	**UNITS**	**DESCRIPTION**
RTYP *	RECORD TYPE	Numeric	2	NA	NA	Record Type is a two-digit field that identifies the type of data being portrayed. The benefit of these codes is that they provide an easy way to separate data before and after thinning to treatment density as well as other types of data and conditions. This will help to study the tree growth responses due to thinning treatment, and it will be particularly useful when the data from several agencies are combined in analysis. Record Type 09 indicates the trees before thinning. This code is only for white spruce because we do not tag aspen in treated plots before the thinning. Record Type10 indicates the trees after thinning and includes both spruce and aspen. For the natural density aspen plots (6, 12 and 15), subplot size is also identified by Record Type. For example, trees recorded in a 2x2 m subplot the Record Type will be “22”. Other codes identify site, soil, and other vegetation data. Allowable codes: 01 Site Description (Form 15B) 02 Soils data (Form 16B) 05 Vegetation data (Form 14B) 09 **Spruce Tree data before thinning 10 **Spruce and aspen Tree data after thinning 11 *Tree data (all species) from 1x1 m sub-plots 22 *Tree data (all species) from 2x2 m sub-plots (all tree species) 55 *Tree data (all species) from 5x5 m sub-plots (all tree species) 66 *Tree data from final expansion (20x20 m excluding the 10x10 area in subplots) (All tree species) -------- *Natural density aspen plots (6, 12, and 15) ** All other plots
AGCY *	AGENCY	Character	6			This field contains up to 6 alpha-characters to denote the agency or company responsible for this particular block of plots. Allowable codes: AFS Alberta SRD, PLFD Division, Edmonton ALP Alberta-Pacific Forest Industries Inc Boyle CFR Canadian Forest Products Ltd, Alberta Operations Grande Prairie

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DEGITS	UNITS	DESCRIPTION
						DMI Daishowa-Marubeni Int. Ltd. Peace River Pulp Div. LPC Louisianna-Pacific Canada Swan River, Manitoba NWT Northwest Territories, Renewable Resources WWD Weldwood of Canada Ltd, Hinton Division WDV Weyerhaeuser Canada, Alberta Division Drayton Valley WGP Weyerhaeuser Canada Ltd, Alberta Division Grande Prairie WPA Weyerhaeuser Canada, Saskatchewan Division Prince Albert
BLK *	BLOCK	Numeric	2			Each company or agency will set up and maintain one or more blocks. Enter a 2-digit number. For the first block, the entry will be "01". Allowable codes: 0-24
INST *	INSTALLATION	Character	3			Each block consists of two installations; one on a superior site and one on a median site. This field will contain 3 characters in uppercase: Allowable codes: SUP Superior site installation MED Median site installation
REPL *	REPLICATION	Numeric	2			Each installation consists of two replicates of a series of 15 plots. Therefore, this two digit, numeric field will be either 01 or 02. Allowable codes: 01 Replication number 1 02 Replication number 2
PLOT *	PLOT	Numeric	2			This is a two-digit number ranging from 01 to 15. Each plot must begin on a new tally sheet. Plot numbers are specified by treatment density according to Table 2. Allowable codes: 01 to 15
DATE *	DATE	Numeric	8			Measurement date is recorded as year/month/day, without any separator characters. For example October 9th, 1990 is entered as "19901009". Allowable codes: yyyymmdd
TRNO *	TREE NUMBER	Numeric	7			A six-digit code is assigned all trees in both treatment and natural density plots. Refer to Section 4.8 Plot layout and tree numbering for a full description of methods for tree numbering on the different plots. For treatment plots (all plots except the natural density aspen plots 6, 12, and 15), the tree number consists of the planting row (2 digits), tree number (2 digits), and in-growth (2 digits) for both deciduous and coniferous species. Refer to Section 4.8.2 for a complete description of methods for tree numbering on treatment plots. For the natural density aspen plots (6, 12, and 15), the six-digit code consists of the subplot number (2 digits) and tree number (4 digits). Refer to Section 4.8.3 for a complete description of methods for tree numbering on natural density aspen plots. Allowable codes:

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DEGITS	UNITS	DESCRIPTION
						0-999999
SPP *	SPECIES	Character	2			Denotes tree species Allowable codes: FA Alpine fir FB Balsam fir FD Douglas-fir LA Alpine larch LT Tamarack LW Western larch PF Limber pine PJ Jack pine PL Lodgepole pine PW Whitebark pine SB Black spruce SE Engelmann spruce SW White spruce AW Aspen PB Balsam poplar BW Paper birch
EST *	ESTABLISHMENT TYPE	Character	1			Denotes the origin of both aspen and white spruce. Allowable codes: ‘S’ indicates that the aspen seedling is of sucker origin ‘D’ indicates the seedling (aspen or spruce) is of seed origin ‘P’ is the planted spruce ‘R’ is any spruce that have been replanted due to mortality
RCD	ROOT COLLAR DIAMETER	Numeric		1	cm	RCD is measured just above the butt swelling, using small calipers. Record the measurement to 0.1 cm. RCD is measured until the tree passes 1.3 m height and the first DBH measurement is recorded. At that time both RCD and DBH will be recorded. In subsequent years, measurement of RCD is not required. Allowable codes: 0.0-5.0
DBH	DBH	Numeric		1	cm	After a tree reaches a height of 1.3 m, record its diameter at 1.3 m height. At the 1.3 m height, the measurement height point should be painted on the tree. To prevent damage to the tree, do not use nails. DBH measurements are recorded to the nearest 0.1-cm. The following measurement protocol is taken the Alberta SRD/PLFD PSP manual with the supporting Figure 10: "Breast height is 1.3 metres from the point of germination. Breast height is determined using a straight stick 1.3 m long. Using a metal diameter tape, measure the tree's diameter to the nearest 0.1 cm making sure the tape is perpendicular to the stem. Diameters are always taken at 1.3 m unless there are large branches or swellings right at breast height. These defects are to be avoided and the diameter is taken immediately above or below the distortion and a comment noting the problem is made on the tally sheet in the shaded comments section (e.g. DBH taken above swell)." (PSP Manual Section 2.1.4.3)

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DEGITS	UNITS	DESCRIPTION
						Allowable codes: 0.00-100.00
HT	TOTAL HEIGHT	Numeric		2	m	Total heights (stem length) should be measured to the nearest centimetre (0.01 m) for all live trees using a telescoping range pole. These poles are available to a maximum of 15 m. When use of a range pole becomes impractical other height measurement instruments may be used. Trees taller than 3 m should be measured to the nearest 0.1 m. Total height is the distance from the root collar (not the ground) to the tallest live point of the terminal leader. Allowable codes: 0.00-100.00
HTI	HEIGHT INCREMENT	Numeric		2	cm	Record height increment (current leader length) to the nearest centimeter (0.01 m). This measurement is required <u>in addition to total height</u> so that actual growth can be summarized. Current height increment is measured at each re-measurement until tree height makes direct measurement impractical. Height increment is recorded to the nearest centimeter. Total height may decline if there is top kill or dieback, while the new terminal bud recovers and grows. Direct measurement of height increment gives a check on the total height and reduces the variation in total height which may occur from one measurement to the next. Allowable codes: 0.00-200.00
CRN	NORTH CROWN RADIUS	Numeric		1	m	Measure the crown radius for all trees > 1.3 m height. Record the measurement to the nearest 0.1 m horizontally along the north direction from the centre of the tree. Allowable codes: 0.0-30.0
CRW	WEST CROWN RADIUS	Numeric		1	m	Measure the crown radius for all trees > 1.3 m height. Record the measurement to the nearest 0.1 m horizontally along the west direction from the centre of the tree. Allowable codes: 0.0-30.0
HTLC	HEIGHT TO LIVE CROWN	Numeric		1	m	The height from the root collar to the base of the live crown is recorded for all trees that have been measured for total height. This distance is measured to the nearest 0.5 m. The base of the live crown is the lowest point on the bole with a relatively complete whorl of live branches. This should identify where the crown breaks up and excludes isolated lower live branches. Figure 11 shows examples of base of live crown. Allowable codes: 0.0-100.0
CC1 * CC2 CC3	CONDITION CODES	Numeric	2			In 2004 new condition codes were adopted based on the ASRD codes. They are listed and described in appendix 7.3. Old condition codes and there descriptions for measurements taken between 1990 – 2003 are listed in appendix 7.4. The preface to appendix 7.3 discusses the adoption of the new condition codes and highlights the differences. In append 7.5 a correspondence table between the old and new condition codes is listed.

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DEGITS	UNITS	DESCRIPTION
						Up to a maximum of 3 condition codes can be recorded for each tree. Each tree should have at least one condition code, i.e. the field of condition code 1 must be filled. For a normal, healthy tree, enter 0. If root collar diameter and total height are omitted, the tree condition code must be given to show the condition (e.g. dead and down, missing) of the tree. As long as there is a condition code describing the status of a tree, the information should be recorded as a standard condition code instead of including comments. Multiple codes should be recorded in the order of priority based on effect on tree. In some cases a new condition code may be needed to describe special tree conditions. New condition codes should not be used without prior discussion and approval. If dead tree is coded dead on the first tree code, the second condition code should explain the cause of death. Three separate fields. The first condition code is mandatory, while the second and third condition codes are optional. Up to a maximum of 3 condition codes can be recorded for each tree.
AZ	AZIMUTH	Numeric	3	0	Degrees	A staff compass and a metric tape are used to determine the azimuth and distance to the centre of each tree, at breast height, from the plot centre. Azimuths are recorded from 1-360 degrees and distances are measured to the nearest 0.1 m. Ensure that the compass has the correct declination and record this on the top of the tally sheet. Alternatively a GPS device may be used to collect UTM coordinates. The database can have additional fields for the northing, easting, and elevation. For all plots except 6, 12 and 15 subplots, tree locations are to be mapped <u>after</u> thinning to treatment density. In addition, the azimuth and distance should be recorded for every conifer tree that reaches breast height. All hardwood ingrowth is removed until the stand has reached approximately 15-20 years after which any deciduous ingrowth will also be recorded. For plots 6, 12, and 15, the azimuth and distance should be recorded for every tree that reaches 1.3 m height. Allowable codes: 0-360
DIS	DISTANCE	Numeric		1	m	Distance from plot centre to a tree is measured to the nearest 0.1 m using a metric tape (see page 16). Allowable codes: 0.0-28.0
AGE	AGE	Numeric	2	0		Age is required for all planted spruce trees (all plots except 13, 14 and 15) and ingrowth conifer trees that reach 1.3 m height. Age is required for all deciduous trees in the natural density aspen plots (6, 12 and 15), following thinning all deciduous crop trees on thinned plots (all except 6, 12 and 15) and deciduous in-growth on any plot that

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DEGITS	UNITS	DESCRIPTION
						reaches 1.3 m height. The age of conifer ingrowth white spruce can be determined by counting branch whorls. For deciduous trees it can be estimated by counting nodes. Age is a required entry for each tree initially <u>and</u> at each re-measurement. Allowable codes: 0-200

RTYP	AGCY	BLK	INST	REPL	PLOT	DATE	TRNO	SPP	EST	RCD	DBH	HT	HTI	CRN	CRW	HTLC	CC1	CC2	CC3	AZ	DIS	AGE
09	WGP	01	MED	01	01	19971016	010100	SW	P	1.2		0.53	15				0			44	10.7	6
09	WGP	01	MED	01	01	19971016	010200	SW	R								26					
09	WGP	01	MED	01	01	19971016	010300	SW	R								88					4
09	WGP	01	MED	01	01	19971016	010400	SW	P	1.5		0.77	18				51			26	11.8	6
09	WGP	01	MED	01	01	19971016	010500	SW	R	1.2		0.62	15				42			23	13.4	4
09	WGP	01	MED	01	01	19971016	010600	SW	R								88					4
09	WGP	01	MED	01	01	19971016	010700	SW	P	1.6		0.81	18				51	42		18	16.6	6
09	WGP	01	MED	01	01	19971016	010800	SW	R								88					4
09	WGP	01	MED	01	01	19971016	010900	SW	R	1.1		0.57	21				51			14	20.1	4
09	WGP	01	MED	01	01	19971016	011000	SW	R								88					4
09	WGP	01	MED	01	01	19971016	011100	SW	R	1.1		0.46	14				0			12	23.2	4
09	WGP	01	MED	01	01	19971016	011200	SW	R								88					4
09	WGP	01	MED	01	01	19971016	021300	SW	P	1.5		0.9	25				28			18	26.1	6
09	WGP	01	MED	01	01	19971016	021400	SW	R								88					4
09	WGP	01	MED	01	01	19971016	021500	SW	R	1.2		0.45	16				42			21	22.7	4
09	WGP	01	MED	01	01	19971016	021600	SW	R								88					4
09	WGP	01	MED	01	01	19971016	021700	SW	P	1.7		0.84	20				42	51		25	19.6	6
09	WGP	01	MED	01	01	19971016	021800	SW	P								88					6
09	WGP	01	MED	01	01	19971016	021900	SW	R								88					4
09	WGP	01	MED	01	01	19971016	022000	SW	P	1.5		0.76	17				0			34	15.3	6
09	WGP	01	MED	01	01	19971016	022100	SW	R								88					4
09	WGP	01	MED	01	01	19971016	022200	SW	R	1.2		0.61	12				15			43	12.5	4
09	WGP	01	MED	01	01	19971016	022300	SW	R								88					4
09	WGP	01	MED	01	01	19971016	022400	SW	R	0.6		0.25	5				41	51		57	10.1	4
09	WGP	01	MED	01	01	19971016	032500	SW	P	1.1		0.63	18				0			64	13	6
09	WGP	01	MED	01	01	19971016	032600	SW	R								88					4

Table 10 Tree Data Example

Figure 10 Point of germination and breast height. (used with permission of the Land and Forest Division, Permanent Plot (PSP) Field Procedures Manual, April 2002).

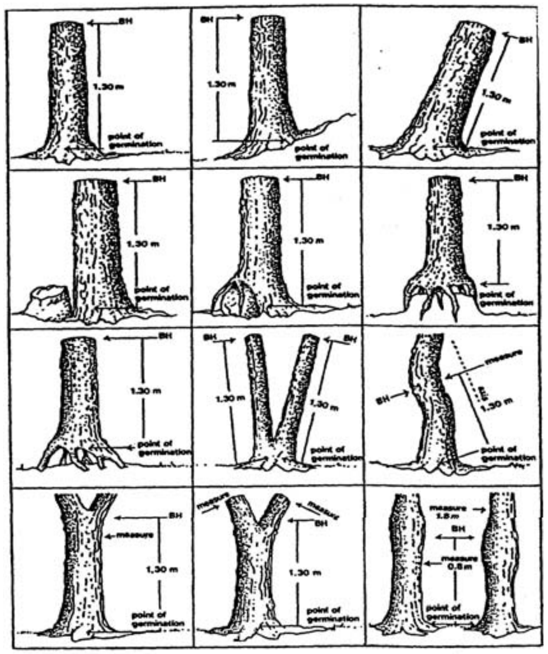
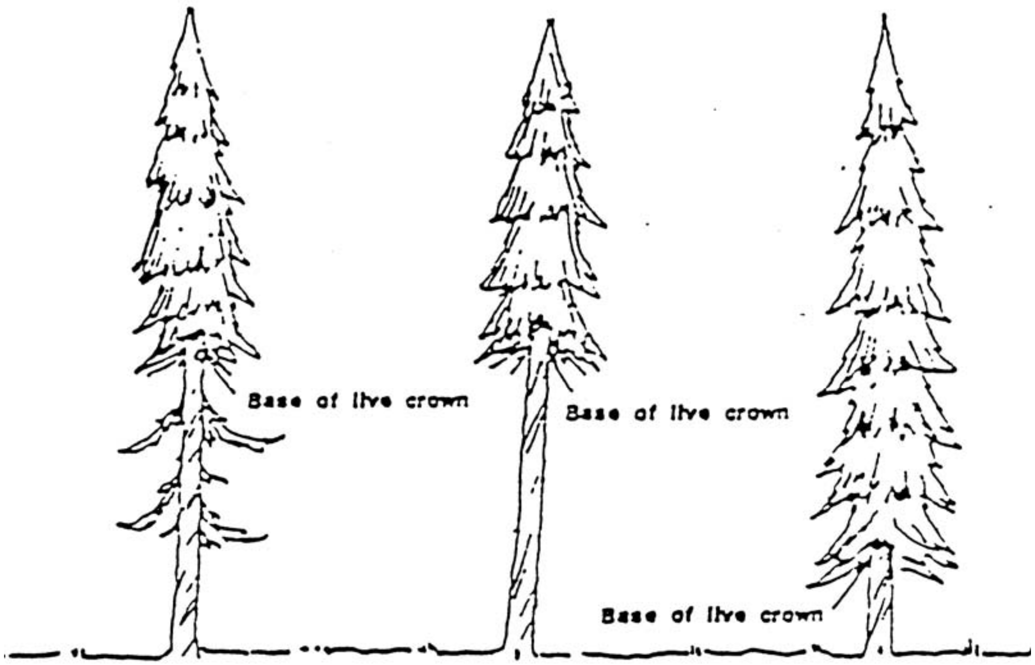


Figure 2.4 Determining Point of Germination and Breast Height

Figure 11 Height to live crown (used with permission of the Land and Forest Division, Permanent Plot (PSP) Field Procedures Manual, dated April 2002).



7.3 2004 condition codes

For the 2004 WESBOGY LTS re-measurements and onward, the ASRD condition codes have been adopted. The ASRD/LFD codes offer a more comprehensive and complete set than we have been using up to now. However, since our existing codes were largely adopted from older (LFS) codes, there are many similarities. Priority in specifying the code should be by order of influence on growth of the tree.

In appendix 7.3 a table of the new 2004 codes is presented as well as a table with their description.

In appendix 7.4 a table of the codes that were used between 1990 and 2003 (including 2003).

In appendix 7.5 a correspondence table that represents how the new codes relate to the old codes and a more detailed comparison of the similarities and differences is presented. This should provide field crews with guidance on how to make the necessary adjustments to the new codes. For the data that has already been gathered and stored digitally, the correspondence table will be used to convert all old data to represent the new codes. This will ensure that only one data coding system will exist. The conversion of old to the new codes will be handled by the U of A and should be transparent to the participating agencies.

An excellent reference is the ASRD PSP manual which has detailed descriptions as well as many illustrations. They are actively updating and improving their manual and illustrations and will soon have a website that we can utilize. We will not attempt to replicate their work but rather they have agreed to provide us with a copy for our use and distribution.

Please note:

1) It is no longer required to identify the insect pest or foliar pathogen as a second code, but rather choose the appropriate new code.
2) There are no longer severity rating for insect attack and foliar disease.

Table 11 2004 WESBOGY LTS Tree Condition Codes (based on ASRD/LFD tree condition codes)

Code	Description		Code	Description
00	Healthy		47	Witches Broom
01	Insects (generic only)		48	Frost Crack
02	Disease (generic only)		49	Dying (NO CC)
03	Rabbit Browsing		51	Conks/Blind Conks
04	Sheperds Crook		52	Open Scars
05	Browsing (Other)		53	Burls and Galls (DBH>9.1cm)
06	Fire		54	Fork
07	Mechanical		55	Pronounced Crook
08	Windthrow		56	Broken Top (<=10cm DIB at Break, DBH>9.1)(NO CC)
09	Climate		57	Limby
10	Flooding		58	Leaning (DBH>9.1cm + if sever NO CC)
11	Poor Planting		59	Broken Stem (>+10cm DIB at Break), DBH>9.1)(NO CC)
12	Suppression		60	Generic woodpecker feeding
13	Frost Heaving		61	Dead and Down (NO CC)
14	Erosion		62	Stem Insects (bark and Sawyer Beatles)
15	Missing		63	Stem Disease (Cankers)
16	Dead Top/Dieback		64	Foliar insects
17	Poor Seedbed		65	Foliar disease
18	Herbicide		66	Stem Form Defect (>=7.0cm DIB at point where stem form begins)
19	Western Gall Rust (only on Pine)		67	Closed Scars
20	Armillaria Root Rot		68	Atropellis canker
21	Moldy Planting Stock		69	Comandra Blister Rust
22	Multiple Leader		70	Elytroderma needle cost of pine
23	Poor Form		71	Hypoxylon Canker
24	Broken Top (New or Old)		72	Spruce cone Rust
25	Dead & Standing (NO CC)		73	Stalactiform Blister Rust
26	Snow press (NO CC)		74	Tomentosus Root Rot
27	Dead Top Dieback with NEW Leader		75	Spruce Spanworm
28	Sucker(s) from OLD Stump		76	Cone Maggot
29	Cut down		77	Coneworm
30	Terminal Weevil		78	Eastern Spruce Budworm
31	SW Gall Aphid		79	Mountain Pine Beetle
32	Tent Caterpillar		80	Spruce Beetle
33	Root Collar Weevil		81	Spruce Needle Rust
34	J-Root		82	Yellow Headed Spruce Sawfly
35	Leaning (NO CC)		83	Large Aspen Tortrix
36	Same Stump		84	Excavations by woodpeckers
37	Unknown		85	Yellow-bellied sapsucker feeding
38	Pitch Moth		86	Small mammal feeding on tree bole
39	DBH Taken on New Leader		87	Small Cavity
40	Nutrient Deficiency		88	Large Cavity
41	Mouse (feeding)		89	Hollow tree or hollow bole section
42	Ungulate feeding/rubbing		90	Beaver (feeding/harvesting)
43	Domestic livestock (rubbing)		91-96	Hawksworth Mistletoe Rating System
44	Nest		97	Not used
45	Other mammalian/avian evidence		98	Data changed by office
46	Sweep/Bow		99	Do not look for tree

Notes: No CC means no crown class.

Table 12 2004 WESBOGY LTS Condition Code Descriptions

Condition Code		Description
00		Healthy - No Defect.
01	Insects	Damage or mortality due to destruction of plant parts or tissue by insects. Look for evidence of eggs, egg cases, nests, chewed plant parts, etc. Similar signs on plants located off site may aid in identification of insect mortality.
02	Disease	Damage or mortality caused by disease or fungi. Cankers, discoloration, rust spotting, fungal coverings, etc. help to identify mortality under this code.
03	Rabbit Browsing	Trees killed or damaged by rabbits can be identified by clean, sharp cut marks along the branches and stems (approximately 45^{o} angles). Chewed bark and needles also indicate rabbit damage.
04	Shepherd's Crook	Damage results in blackening and wilting of young shoots and leaves. Tips of the blackened shoots often bend back. On older leaves brownish black, irregularly shaped spots appear.
05	Browsing (other animals)	Mortality or damage due to browsing by ungulates or other animals (e.g. moose, cattle, beavers). Look for chewed tops with rough cuts or breaks.
06	Fire	Mortality or damage due to actual burning of the seedling or scorching by nearby flames. **Not to be used when seedlings are killed by sun scald**.
07	Mechanical	Trees killed or damaged by mechanical or physical means such as scarification machinery, trampling or crushing by animals, etc. Stem scars and rough breakage help to identify mortality under this code.
08	Wind Throw	Damage or mortality due to crushing by fallen or displaced logs, snags, branches, uprooted trees, etc.
09	Climate	Trees damaged or killed solely by climatic factors. These include death by freezing, sun scald, severe desiccation, ice accumulation, red belt, etc.
10	Flooding	Trees damaged or killed by drowning alone. Look for evidence of high water marks on the seedling, or in the immediate area. Pull tree out of ground and check roots to see if the root outer coverings is falling off and is blackened.
11	Poor Planting	Damage or mortality due to improper placement of nursery stock (hand or mechanical planting). Trees may have been planted too deep, too shallow, too loosely, or at an acute angle.
12	Suppression	Trees which have been suppressed by the surrounding vegetation for a period of time long enough to damage or kill them. Mortality may be due to severe lack of light, water, nutrients (removed by the competition) or by physical smothering (i.e. heavy grasses). Reference to the previous year's damage tally may help in determining this mortality call. A tree that is over topped by grass or shrubs is not necessarily suppressed. Look for a spindly main stem with very few long needles spaced wide apart or evaluate the last five increments. If the tree has only grown 1cm a year, it is probably suppressed.
13	Frost Heaving	This code is used only when mechanical frost action can be clearly identified as the direct cause of damage or mortality. Usually upheaval and separation of the seedling's root system from the soil occurs as a result of ice lens formation. This is most commonly associated with containerized seedlings planted in silty soil.
14	Erosion	Damage or mortality due to the removal of the seedling's seedbed, by the forces of water, wind or soil slumping. Trees killed by partial or total burial (deposited soil or organic matter) would also be tallied using this code.
15	Missing	This code is to be used when a seedling from the previous year's measurement cannot be located. It can also be used where the seedling was removed from the site and probably died (i.e. tag found, no morphological signs of live seedling remaining). Using in conjunction with code 25 **ONLY**.
16	Dead top/Dieback	Top is dead (die back) without any indication of insect or climate (frost) damage.
17	Poor Seedbed	This code is to be used only when the cause of death or damage for a seedling can be traced to the type of seedbed on which it is growing. In most cases the seedling will show signs of desiccation due to the poor moisture holding capacity of the seedbed material (e.g. rotten logs, dry clay).
18	Herbicide	Should only be used when the cutblock (or parts of the cutblock) has received a recent herbicide treatment; either before or after the stock was in place. Spruce seedlings exhibit needle loss and/or reddish brown coloration of stems and foliage. Deciduous species exhibit yellowish/brown leaf mottling and dieback of terminal growth. Hexazinone causes reddish brown coloration of conifer foliage and needle loss. Deciduous foliage turns red to black. Glyphosate causes chlorosis especially in new growing shoots. 2,4-D causes rapid growth and spiralling and twisting. If applied during conifer flush bad dieback similar to frost damage may occur. Often chemical damage will also be indicated by phytotoxicity spotting on exposed foliage.
19	Western Gall Rust(only in Pine)	This code is used when Lodgepole pine damage or death can be attributed to Western Gall Rust. This is usually clearly identifiable due to swelling of succulent tissue (and

Condition Code	**Description**
	subsequent formation of a gall) and the bright orange spores produced in that affected area. This gall can be on the main stem or a lateral branch.
20 Armillaria Root Rot	This code is utilized when a seedling is damaged or killed by Armillaria Root Rot. Identification of the disease is in recognizing mycelial fans of the cambium of damaged and dead trees. Pull tree out of ground and examine root collar.
21 Moldy Planting Stock	This code is usually used on Bareroot Planting Stock. Grey mold will usually be found around the root collar and lower branches.
22 Multiple Leader	This damage code is commonly used on planted stock. When a tree has two or more leaders, but is otherwise healthy this code should be entered. The tree is considered multiple leadered if all leaders are within 5cms (height) of each other. This code also applies to saplings and regeneration that appear forked. Be aware of normal branching of deciduous trees.
23 Poor Form	This code is used on trees which exhibit a general poor form, due to previous damage. It is commonly used with Advanced stock which was damaged by scarification activity.
24 Broken Top (New or Old)	It should be used as long as the broken top is noticeable and has some effect on the growth of the tree.
25 Dead Tree/Standing	Tree has no signs of being alive. A standing dead tree is one that is dead but still standing. No green foliage or buds present. The tree must be able to withstand a firm push. Record a diameter and species but do not record height. Pound nail into tree. **No crown class**.
26 Snow Press	This code is normally used for trees that show signs of being pressed down to the ground for a few years after germinating or being planted.
27 Dead Top Dieback with New Leader	This refers to stems that have had previous leader damage and a new leader has formed.
28 Sucker(s) (From Old stump)	Refers to stems that have been cut-down through thinning and have started to sucker. Do not re-use the previous stem number, but assign a new number to each sucker.
29 Cutdown	Self explanatory.
30 Terminal Weevil	Terminal leaders of Pine or Spruce bend over and die. Two or more years growth are affected. **Bore Holes** which are exit holes for the larvae **MUST** be present to use this code.
31 Spruce Gall Aphid	Galls located at the end of new growth and may persist for many years.
32 Forest Tent Caterpillar	A tent of a silk forms on the tree and the caterpillars defoliate the tree.
33 Root Collar Weevil	This weevil feeds mainly on Sw, Pj and Pl. They feed in the bark and cambial area of the host tree at or below the duff surface, causing copious flows of resin. The tunnels often girdle small trees. This insect allows root rots to enter the tree.
34 J-Root	This code is used after the tree has had a poor planting code in the previous measurement.
35 Leaning	Tree leaning more than 20% off of vertical axis.
36 Same Stump	Used when 2 or more trees can be distinguished above ground level but below DBH. Used a lot on Deciduous that have been cutdown and resprouted at stump.
37 Unknown	This condition code is to be used only when there appears to be something affecting the tree but the other condition codes do not describe the situation. This would include burnt trees etc. A description of what is affecting the tree should be included as well in the comments column. In the event that this code is used for more than 5% of the tallies, it is up to the crew leader or a forester to decide on the cause of the condition.
38 Pitch Moth	Primary host is Lodgepole Pine. May weaken or kill the terminal leader, resulting in stem deformities and height growth reduction. Blisters are mainly on main stem and are characteristic resin coated up to 20mm in diameter.
39 DBH Taken on New Leader	
40 Nutrient Deficiency	This may occur on blocks that have had the humus layer removed by scarification (i.e.; Blade). Trees are chlorotic and usually in bare mineral soil. Usually noted on spruce. May be confused with flooding damage.
41 Mouse Feeding	Mice and voles can girdle seedlings and consume seeds. See Rangen and Roy (1997) for more detail.
42 Ungulate feeding/rubbing	Ungulate feeding on twigs is generally recognized by the ragged appearance of twig terminals. Rubbing of trees as antler rubs and feeding on bark also occurs; these conditions are further described in Rangen and Roy (1997). Antler rubs can also be associated with “scrapes” (smaller patches of scraped ground) and small tufts of hair on twigs.If the bark on aspen trees has been consumed ensure that ungulates (as opposed to other mammals) are responsible. The extent of the bitten area, track identity and grooves that indicate tooth size and pattern should all be inspected in order to differentiate ungulate bark feeding from similar feeding by small mammals (i.e. see code number 86 and applicable photograph).
43 Domestic livestock (rubbing)	Rangen and Roy (1997) describe rubbing of trees by livestock; rubbed trees are

Condition Code	Description
	occasionally seen in areas where cattle grazing occurs. If this code is used, ensure that other signs in general area (i.e. presence of cattle droppings, cow trails and grazed vegetation) also supports this.
44 Nest	This code indicates the presence of a nest on a given tree in the PSP. It refers only to an "open" nest; cavity nests are excluded from this category as it is difficult to ascertain if a given cavity is indeed used as a nest site. Field guides that assist with the identification of "open" nests are available (see Harrison 1979). Of particular importance are colonial complexes of large nests on islands in lakes. Mammalian nests also exist and should be indicated as such if this is known. To do this, use the comments section which applies to a given tree and indicate as required. If the occupants of the nest can be identified, the identity can also be entered in the comments section.
45 Other mammalian/avian evidence	Other agents (i.e. bears, grouse, shrew, pocket gophers) which leave evidence on trees or leave evidence closely associated with trees are described in Rangen and Roy (1997)). Pocket gophers leave soil mounds (Rangen and Roy (1997)). Bears can leave a characteristic series of claw marks on aspen trees, indicating that the tree was scaled, and rotted stumps/logs are also occasionally ripped apart. In addition, it has been suggested that bark on live trees is occasionally consumed (see Hiratsuka 1987 for a depiction). Ensure that ripped up stumps/logs, etc. are accompanied by other evidence of bear.
46 Sweep/Bow	Is a gradual bowing or curving of the main tree system. It has no decay significance but may cause a loss of volume.
47 Witch's Broom	Yellow witches broom is the most conspicuous disease of sprice in the prairie provinces.
48 Frost Crack	A frost crack is a deep radial splitting of a trunk caused by an uneven skrinkage of the wood after a sudden drop in temperature. The crack usually astart at the base and extend up the trunk.
49 Dying	Tree is in distress and will die before next measurement.
51 Conk/Blind Conk	Conks appear most frequently on the underside of dead branch stubs or on the underside of live branches in the crown. Conks, by definition, are woody, shelflike basidiocarps (fruiting bodies) of wood-rotting fungi.
52 Open Scars	Open scars are wounds which have been penetrated through to the cambium. These wounds must not be healed over and may be caused by a variety of reasons such as fire, lightning, old blazing, machinery, animals, etc. Scars are considered to be entry points for decay fungi. Animal damage usually penetrates the cambium therefore code as an open scar. A common mistake is to call stem disease such as atropellis canker an open scar.
53 Burls and Galls	Burls are abnormal swelling of the main stem or branches resulting from abnormal wood cell development following disturbance to the cambial layer Galls are localized trunk and branch swelling of mainly tissue. There is little or no damage to the underlying wood. Do not mistake western gall aphid for a gall, it is a foliar insect.
54 Fork	Forks usually develop when there is malformation, injury or death of the terminal leader. Forks tend to be V-shaped and will only be recorded when above 1.3 m (DBH level). Forks below this point are recorded as same stump (condition code 28). Natural branching on deciduous trees is not to be recorded. A fork must be at least 7.0 cm DIB, 2.5 m past the fork to be considered. The ASRD PSP manual demonstrates the difference between forks and natural branching.
55 Pronounced Crook DBH $\geq$ 9.1 cm	This condition develops from the death of the terminal leader or the breaking off of a forked leader. When this occurs, a lateral branch takes over apical dominance. A crook is recorded when the inside bark diameter is at least 7.0 cm, 2.5 m above the defect.
56 Broken Top DBH $\geq$ 9.1 cm	Broken tops are recorded when the tree bole is <u>less than</u> 10 cm DIB (diameter inside bark) at the break. **<u>No Crown Class</u>**.
57 Limby	A tree is recorded as limby if more than 75% of the tree has live, low sweeping branches. In general, if the majority of the trees in a plot are limby then this code is not recorded.
58 Leaning	A tree is considered leaning if it is standing greater than 20^{o} off of vertical. If the angle is greater than 45^{o} to the ground, the tree has a severe lean. **<u>No crown class if severe</u>**.
59 Broken Stem	A broken stem is recorded if the tree bole is <u>greater than</u> 10 cm DIB at the break. **<u>No crown class</u>**.
60 Generic woodpecker feeding (often smaller species)	Species such as the Black-backed woodpecker and Three-toed woodpeckers will often leave signs like this on old coniferous trees, and Hairy and Downy woodpeckers

Condition Code		Description
		typically peel off scales ("scale") and "peck" the bark as do Pileated woodpeckers in summer months (Conner 1979). Note the evidence of very small holes (arthropods) and holes made by the woodpeckers themselves. The appearance of tree trunks fed on in this manner is often reddish from a distance.
61	Dead or Down	A dead and down tree is one that was previously tagged and measured in a PSP plot but at the present time is now dead and no longer standing. The cause of death must be by natural causes (i.e. windfall, beavers, insect or disease, etc.). **No crown class**.
62	Stem Insects	This code is recorded when there is evidence of an insect infestation attacking the bole of the tree. Bark beetles are the most prevalent stem insects but sawyer beetles and others are included.Bark beetles, Dendroctonus spp., are a very serious problem in Alberta. The adult female enters the bark in early summer and lays eggs in the tree's cambium. The eggs overwinter and hatch as larvae in the early spring. Damage to the tree is done by the larvae eating the cambium and usually results in death. The tree will not turn red until the next summer. Other symptoms of attack are piles of "sawdust" (frass) at the base of the tree, entry holes in the bark, and pitch tubes (the tree tries to push the beetles out with resin). The beetles also carry a blue stain that causes further deterioration of wood quality. Beetles attack all species of pines, spruce, and Douglas fir.Sawyer beetle infestations are common in burned timber.
63	Stem Disease	All diseases that infect the main stem are documented with this code. Included in this code are cankers, rusts, rotten branches and root rot. Stem cankers are caused by fungi that invade stems and branches resulting in localized areas of infection in the bark and underlying wood tissue. Cankers may be annual or perennial. In perennial cankers the infected area may be eventually exposed to the underlying wood when the deadbark sloughs off. A common stem canker on lodgepole pine is Atropellis piniphila. Exudation of resin from the bark surface is the first external symptom. They are sunken elongated on one side of the trunk and indicate resin flow. This can cause a distortion in growth and a blue-black stain on the wood. Stem rusts are also included in this condition code. Rusts are host specific parasitic fungi usually requiring two alternating living hosts. Stems and branches may be girdled resulting in large malformations or even death. In particular, Endrocronartium harknessii on young pines is a serious problem in Alberta. Spruce broom rust, Chrysomyxa arctostaphi, can also be noted but only if the broom is no longer green (i.e. red or missing needles). Large rotten branches typically appear on overmature, decadent trees and can be indicative of decay. Large rotten branches are those well below the base of the live Crown and are > 5 cm in diameter, are unweathered, appear punky, and are weeping. Often a black ring appears on the stem surrounding the branch. Some of the typical symptoms of Armillaria root rot are reddish brown or yellowish foliage; mycelial fans form between the bark and wood around the base; fungal (shoestring) strands in the soil surrounding the diseased roots and honey mushrooms growing around the base of the diseased tree.
64	Foliar Insects	This condition code pertains to all insects that infest parts of the tree off the main stem. Included in this category are the tent caterpillar, spruce budworm, jack pine budworm, spruce gall aphid, etc. The forest tent caterpillar, Malacasoma disstria, causes severe defoliation in hardwood stands in Alberta resulting in a significant reduction in annual growth. The spruce budworm, Choristoneura fumiferana, infests mature white and black spruce, and balsam fir stands. This insect attacks the buds and new needles. Their feeding spreads to old needles and eventually kills the tree. The jack pine budworm, Choristoneura pinus, attacks stands of jack and lodgepole pine and is a relatively new forest pest in Alberta. This insect feeds and spreads in the same manner as the spruce budworm.
65	Foliar Disease	This code is used for all diseases that infect parts of the tree off the main stem. Needle casts and blights, and needle rusts are included in this condition code.
66 cm	Stem Form Defects DBH $\geq$ 9.1	This condition code is used when there is damage or a distortion resulting in a loss of volume. The point at which the stem form begins must be at least 7.0 cm DIB. Included in this category are defects such as sweeps and bends, spiral grain, frost cracks, and windshake.

Condition Code	Description
	A sweep or bend is the gradual bowing or curving of the main tree stem. If has no decay significance, but may cause a loss of volume in a sawlog. Spiral grain is the twisting of the grain seen in exposed wood or in the direction of the bark fissures. Spiralling frost cracks and scars also indicate the presence of spiral grain. A frost crack is a deep radial splitting of the trunk caused by uneven shrinkage of the wood after a sudden drop in temperature. The cracks usually start at the base and extend up the trunk. They may be reopened repeatedly by wind stresses or low temperatures. Windshake is a splitting in the wood along the grain or less frequently within an annual growth layer. It is caused by wind or snow stresses and is also known as ringshake.
67 Closed Scars	Wounds that had penetrated the cambium but have now healed over are considered closed scars. A closed scar is characterized by an irregular indentation in the bole of the tree that would result in loss of volume due to poor wood quality. Before healing over, the scar provided an entry point for disease. Frost crack is not included in this code.
68 Atropellis Canker	Widespread on pine, from small to large trees. Symptoms are elongated, sunken, cankers on the stem with copious yellowish resin flow. Wood is discoloured blue/black.
69 Comandra Blister Rust	Pl and Pj are hosts. Local occurrence only. Infected stems are spindle-shaped with conspicuous swelling of the bark. Fungus is orange-yellow in early summer. Cankers are circular and grow laterally as quickly as longitudinally. They thus girdle the stem faster than stalactiform. It should not be confused with western gall rust which is mainly a swelling of the wood. Alternate host is Indian Paint Brush.
70 Elytroderma Needle Cast	Mostly on Pl. Current years needles turn red in fall. In severe cases only current needles remain, giving branches a "lion's tail" appearance.
71 Hypoxylon Canker	Hosts are aspen and balsam poplar. Canker starts as a slightly sunken orange-yellowish area on stem. Eventually girdles the stem and has an orange/black appearance. A mycelial fan on the cambium is a reliable field symptom.
72 Spruce Cone Rust	Rust is <u>only</u> on spruce cones. Cones become prematurely brown then orange-yellow. When spores are abundant the forest floor has an orange colour.
73 Stalactiform Blister Rust	Pl and Pj are hosts. Local occurrence. Causes slight swelling of bark. Orange-yellow in summer. Cankers are elongated and grow faster longitudinally compared to Comandra. Alternate host is Bastard Toad Flax.
74 Tomentosus Root Rot	Most important on Sw and Sb. Symptoms are excessive branch mortality, thinning of crown and openings in the stand. Disease develops slowly (over 15-20 years) so is not so obvious in regenerating stands.
75 Spruce Spanworm	Chiefly affects aspen. Damage shows mostly as holes in the leaves. Resembles forest ten caterpillar but no pupal cases or egg masses on the foliage. Caterpillars are typically light-green and have one prominent and two indistinct yellowish lines along each side of the body. The head is dark-brown.
76 Spruce Cone Maggot	No external symptoms. Dissected cone shows frass-filled spiral tunnel around the central axis.
77 Spruce Cone Worm	Feeding larvae expel frass which adheres to silken webbing on cone surface.
78 Eastern Spruce Budworm	First symptoms are webbing and frass in buds or on previous year's needles. Later, webbing is spun on branch tips. By late June tree crowns appear rust brown.
79 Mountain Pine Beetle	Main host is Pl. Symptoms are standing dead trees with beetle exit boles about eye-level. Accumulations of pitch or sawdust are conspicuous around entrance holes bored into the bark of trees by adult beetles from mid-July to mid-August.
80 Spruce Beetle	Host are Sw and Se. Symptoms are standing dead trees with beetle exit holes about eye-level. Conspicuous boring dust accumulates on bark below holes until the wind blows it away.
81 Yellow-headed Spruce	Feed on needles in the upper crown of the tree. Partly chewed needles and needle stubs impart a brownish color and ragged appearance to the foliage. No webbing present. Found on all spruce.
82 Spruce Beetle Rust	Discoloration of needles. May find dotlike sexual fruiting structures on needles. Infected needles drop prematurely.
83 Large Aspen Tortrix	Affected foliage has a clumped, irregular appearance and leaves do not move as freely in the wind as uninfested leaves. Larval instars feed within rolled leaves or within 2 or more leaves pulled together and secured with silken webbing.
84 Excavations by woodpeckers (likely Pileated woodpecker)	Feeding by Pileated woodpecker can occur on dead or scenescent deciduous and coniferous trees, and feeding holes are thought to occur towards the base of the tree

Condition Code	Description
	(Rangen and Roy 1997). Excavated holes indicate subcambial penetration (holes penetrate beneath the bark and into the sapwood) and large wood chips can be associated with excavations. Excavated feeding holes can be large. In such excavations, evidence of carpenter ants (burrows, sawdust) or other boring arthropods might also be found in the sapwood. In living trees with a sound bole, initial feeding hoels might be more restricted. Elsewhere in North America, the Pileated woodpecker has been found to excavate holes extensively in winter and to a grater extent that other woodpeckers (Conner 1979). The Hairy woodpecker might also create deeper holes in trees, however, it is considered an opportunistic feeder (Sousa 1987) and spends a smaller portion of its time "excavating" during winter months (Conner 1979). In Iowa, it has also been found to generally feed at higher locations in trees (5-7m) (Sousa 1987).If this feeding evidence exists on a given tree, indicate in comments its extent.
85 Yellow-bellied sapsucker feeding	There is a characteristic pattern of regularly spaced small holes left by Yellow-bellied sapsucker (also see Hiratsuka 1987 for another depiction of sapsucker feeding). These are often found on birch, however they also have been observed on willows, and have been reported on aspen and pine (Rangen and Roy 1997, Hiratsuka 1987).
86 Small mammal feeding on tree bole(hare,porcupine, squirrel, bushy-tailed woodrat)	When hares feed on twigs, it is generally thought that twigs are clipped off in a characteristic razored fashion (Figure 106, Rangen and Roy, 1997). Small mammals such as porcupine, woodrat and squirrel might also feed on bark; however, if such feeding evidence occurs high in trees, one could probably rule out hare because hare do not climb trees (also see Hiratsuka 1987 for a depiction of porcupine feeding on pine). Ensure other evidence (i.e. tracks, pellets, etc.) Supports a specific determination of the agent involved. Also refer to Rangen and Roy (1997) for more information on how to identify the specific causes of girdling and refer to Murie (1975) for assistance on identifying tracks if this is required. Evidence of squirrel feeding is common and could also be indicated, however, the value of this information is probably less valuable.
87 Small Cavity	Small woodpeckers create small cavities (approximately 5 cm in diameter) in snags and stubs, however, height of the cavity above ground probably varies. Among the species which might use such cavities are smaller woodpeckers, kestrel, chickadee, nuthatch, swallow, wren, flycatchers, and small mammals (etc). One could explore whether such cavities are occupied by rubbing the bark with a stick. Should a cavity be occupied the occupant (if known) should be identified in the comments section.
88 Large Cavity	A large cavity is a round/excavated opening greater than or equal to 10 cm in diameter. The cavity in the figure was approximately 15 m high. Pileated woodpeckers have been known to excavate such cavities, however, a variety of species (birds as well as mammals) may use them as nest sites, roosting sites or dens. As in the case of smaller cavities, one could investigate the identity of the occupant by rubbing/tapping the bark of such trees with a stick. If might be possible to ascertain the identity of the tracks which are associated with the cavity, during winter, by checking surrounding snow cover and identifying tracks that appear to lead towards the cavity in the tree (see Murie 1975).
89 Hollow tree or hollow bole section	Hollow trees can be used as denning sites by bats and other birds and mammals. This condition code should be used to identify these sites.
90 Beaver (feeding-/harvesting)	Beaver girdle large trees in a characteristic fashion and evidence of their harvesting activities (i.e. cone shaped stumps) are well known to many. Refer to Rangen and Roy (1997) and Hiratsuka (1987) for more details.
91-96 Hawksworth Mistletoe Rating System	Dwarf mistletoes are parasitic flowering plants requiring living hosts. Mistletoe is usually recognized by swellings on branches and stems or by witches brooms. Heavy infestation makes trees susceptible to secondary attack (such as bark beetles), lower wood quality and growth losses (can be from 30-60%). The major tree hosts in Alberta are: lodgepole pine, Douglas fir and larch. The Hawksworth Rating System for mistletoe is used to determine the severity of mistletoe infestation on individual trees Hawksworth 1961, 1977). If a tree has mistletoe, record only the 90 series code, do not record 33 unless there is a second distinct foliar disease.
98 Data changed by office	
99 Do not look for Tree	

7.4 1990 - 2003 condition codes

Table 13 1990 - 2003 WESBOGY LTS tree condition codes (in priority order)

00	Normal, healthy tree.
26	Missing
29	Cut down
27	Dead and Down
25	Standing Dead On first coding, Condition Code 2 should indicate cause of death. List may be desirable here...
17	Dying
40	Frost heaving
51\	Frost damage.
09	Bark beetles
01	Conks/Blind Conks
03	Stem Cankers
04	Mistletoe
21	Insect attack Condition Code 2 should indicate species of insect pest (Codes needed...also see other existing condition codes) Condition Code 3 should indicate Severity (1=light, 2=medium, 3=severe)
30	White pine weevil
31	Spruce bud midge
32	Yellow-headed spruce sawfly
24	Broken stem (below 10 cm top dib)
05	Root rot
02	Scars
18	Dead top
39	DBH taken on new leader
19	Broken top (above 10 cm top dib)
20	Animal or mechanical damage
08	Foliar disease Condition Code 2 should identify pathogen species Condition Code 3 should indicate severity (1=light, 2=moderate, 3=severe)
10	Frost crack
11	Wind shake (windthrow)
06	Rotten branches
07	Dieback
16	Spiral grain
14	Pronounced crook
13	Fork
23	Leaning
15	Sweep/Bend
22	Limby
28	Sucker(s) from old stump (forked below dbh)
12	Burls and Galls
41	Bushy top (multiple leaders)
42	Dead top, lateral branch has become dominant leader
99	Dead/Down 2nd time
88	Removed (Thinned)
71	Fire
72	Flooding
73	Poor Planting
74	Erosion
75	Suppressing
77	Poor Seedbed
78	Herbicide
79	Poor Form

Table 14 Description of 1990 - 2003 WESBOGY LTS tree condition codes

01 CONK/BLIND CONK -	Conks appear most frequently on the underside of a dead branch stub or on the underside of live branches in the crown. Conks, by definition are woody, shelf-like basidiocarps (fruiting bodies) of wood-rotting fungi. Blind conks appear as swellings around knots that result when the tree tries to heal over an abortive conk. In many instances, the affected knot is partially covered by sound wood; hence use of the term "blind conk." When these types of conks are suspected they must be cut into in order to positively confirm their presence. Moss-covered branch stubs and burls can be mistaken for conks especially when viewed from directly below. Black knots frequently develop from a superficial saprophytic fungus which feeds on the exuded sap from a wound, but, unlike blind conks, they are quite sound when cut into.
02 SCARS -	Scars are wounds, which penetrate through to the cambium. To be recorded, these wounds must not be healed over. They may be caused by a variety of factors such as fire, lighting, old blazing, machinery or animals. Scars are considered to be entry points for decay fungi.
03 STEM CANKERS -	Stem cankers are caused by fungi that invade stems and branches, causing localized areas of infection in the bark and underling woody tissue. Cankers may be annual or perennial. In perennial cankers the wood underlying the infected area may eventually be exposed when the dead bark sloughs off. A common stem canker on lodgepole pine is *Atropellis piniphila*. This can cause a distortion in growth and a blue-black stain on the wood. Stem rusts are also included in this condition code. Rusts are host-specific parasitic fungi usually requiring two alternating living hosts. Stems and branches may be girdled, resulting in large malformations or even death. In particular, *Endrocronartium harknessii* on young pines is a serious problem in Alberta. Spruce broom rust, *Chrysomyxa arctostaphi*, should be noted but only if the broom is no longer green (i.e., red or missing needles).
04 MISTLETOE -	Dwarf mistletoes are parasitic flowering plants requiring living hosts. Mistletoe is usually recognized by swellings on branches and stems of by "witches brooms." Heavy infestation results in reduced vigor (the tree may become susceptible to secondary attacks such as bark beetles), lower wood quality and growth losses (which range from 30-60%). The major tree hosts in Alberta are lodgepole pine, Douglas-fir and larch.
05 Root Rots -	Root rot is a fungal infestation on the roots of trees. Typical symptoms are the yellowing and thinning of foliage, reduced terminal growth and a distress cone crop. Root rots are not a serious problem in Alberta.
06 Rotten Branches -	Large rotten branches typically appear on overmature, decadent trees and can be indicative of decay. Large rotten branches are those well below the base of the live crown and measure larger than 10 cm in diameter (dob).
07 Dieback -	Dieback refers to top killing of the death of the terminal leader and may be caused by fungi, insects, climatic changes, drought, flooding, etc. Dieback may be progressive, appearing first in t he upper crown and spreading toward the base of the tree. Dieback usually does not result in the death of the tree.
08 Foliage Disease -	Foliage diseases are recognizable by a yellow, red, or brown discoloration of the foliage. Typical foliage diseases are needle blights, casts, and rusts. Foliage diseases are not yet a serious problem in Alberta.
09 Bark Beetles -	Bark beetles, *Dendroctonus* spp., are a serious problem on coniferous trees in Alberta. The adult female enters the bark in early summer and lays eggs in the tree cambium. The eggs remain there over winter and hatch as larvae in the early spring. Damage to the tree is done by t he larvae eating the cambium and usually results in the death of the tree. The needles do not turn r ed until the following summer. Other symptoms of attack are piles of "sawdust" (frast) at the base of the tree, entry holes in the bark, and pitch tubes (the tree tries to flood the beetles out with resin). The beetles also carry blue-stain fungi that cause further deterioration of wood quality. Beetles attack all pines, spruce and Douglas-fir.
10 Frost Crack -	Frost cracks are deep radial splitting of the trunk caused by uneven shrinkage of the wood after a sudden drop in temperature. The cracks usually start at the base and extend up the trunk. They may be reopened and extended repeatedly be wind stresses of further low temperatures.
11 Windshake -	Windshake is a splitting in the wood along the grain (growth ring) or, less frequently, within an annual growth layer. It is caused by wind or snow stresses and is also known as ringshake.
12 Burls and Galls -	Burls are abnormal swellings of the main stem or branches resulting from abnormal wood cell development possibly following disturbance to the cambial layer.Galls are localized trunk and branch swelling of mainly bark tissue. Little or no damage is done to the underlying wood.
13 Fork -	Forks usually develop following malformation, injury of death of t he terminal leader. Forks tend to be V-shaped and will only be recorded when above 1.3 m (dbh level).

	Forks below this point are recorded as trees having the same stump (category code 28). Natural forking on deciduous trees is not to be recorded.
14 Pronounced Crook-	Pronounced crook develops from the death or breaking-off of one of the leaders of a forked tree. It may also develop if the leader is broken off and a lateral branch becomes the new leader. A pronounced crook is more of a bend than a V-shape.
15 Sweep/Bend -	Sweep or bend is the gradual bowing or curving of the main tree stem. It has no decay significance. This is recorded when the sweep or bend is severe enough to cause a loss in sawlog volume.
16 Spiral Grain -	Spiral grain is the twisting of the grain seen in exposed wood or in the direction of the bark fissures. Spiralling frost cracks and scars also indicate the presence of spiral grain.
17 Dying -	A tree is considered to be dying when the amount of sound wood produced is less than the amount of sound wood lost on a yearly basis.
18 Dead Top -	Dead tops are those tops dead at least a year (versus top killing), obviously weathered and without any green foliage.
19 Broken Top -	Broken tops are breaks t hat occur above 10 cm dib (they are not used to indicate decay).
20 Animal or Mechanical Damage -	Woodpeckers and other birds frequently scar trees by making holes in the stems, providing an entry point for wood rotting fungi. Bear, deer, elk and moose can cause extensive damage by removing bark and cambium from the tree trunk. Rodents, including porcupines and beavers, can also damage trees. Mechanical damage refers to damage done to the tree by equipment and machinery such as trucks, skidders or bulldozers.
21 Insect Attacks -	Insects, specific to the genus, can attack any part of the tree, and in general are only recorded when t he actual insect is seen (not if only the symptoms of infestation are present). Insect attacks include infestations by sawyer beetles (a major problem in the slavage of fire killed timber), weevils, aphids, budworm, moths, etc. The forest tent caterpillar, *Malacosoma disstria*, causes severe defoliation in aspen stands in Alberta, resulting in a significant reduction in annual growth.
22 Limby -	A tree having long, heavy, low-limbed branches, is recorded as limby. Usually, limby trees are open-grown or older, dominant veterans.
23 Leaning -	To be recorded as leaning, a tree must have a noticeable angle from the vertical versus t he rest of the stand.
24 Broken Stem -	A broken stem is recorded if the tree bole is severed at a point below 10 cm dib (as distinct from a broken top).

7.5 Correspondence between 1990-2003 and 2004 condition codes

Table 15 Correspondence table between 1990-2003 and 2004 condition codes

2004	**Old**	**Old (1990 – 2003) description**	**Comment relating old to new codes**
00	00	Normal, healthy tree.	
51	01	Conks/Blind Conks	
67	02	Scars	Closed scars
63	03	Stem Cankers	Stem Disease
9x	04	Mistletoe	91-96 Hawksworth Mistletoe Rating System
20	05	Root rot	Armillaria Root Rot
63	06	Rotten branches	Stem disease
16	07	Dieback	Dead top/dieback
65	08	Foliar disease Condition Code 2 should identify pathogen species Condition Code 3 should indicate severity (1=light, 2=moderate, 3=severe)	Foliar Disease (Needle Blights and Rusts)
62	09	Bark beetles	Bark beetles (Bark and Sawyer Beetles)
48	10	Frost crack	
08	11	Wind shake (windthrow)	Windthrow
53	12	Burls and Galls	
54	13	Fork	
55	14	Pronounced crook	
46	15	Sweep/Bend	Sweep/bow
66	16	Spiral grain	Stem form defect (>=7cm DIB at point where stem form begins)
49	17	Dying	
16	18	Dead top	Dead top/dieback
56	19	Broken top (above 10 cm top dib)	Broken Stem (DIB <=10cm at break DBH > 9.1cm)
03 07 41 42 43	20	Animal or mechanical damage	03 – rabbit browsing 07 – mechanical damage 41 – mouse feeding 42 – ungulate feeding/rubbing 43 – domestic livestock (rubbing)
01 64	21	Insect attack Condition	01 – Insects 64 – Foliar insects
57	22	Limby	
35 58	23	Leaning	35 – leaning 58 – Severe lean
59	24	Broken stem (below 10 cm top dib)	Broken Stem (DIB>=10cm at break DBH > 9.1cm)
25	25	Standing Dead. On first coding, Condition Code 2 should indicate cause of death.	Dead and Standing
15	26	Missing	
61	27	Dead and Down	
28	28	Sucker(s) from old stump (forked below dbh)	Sucker(s) from old stump
29	29	Cut down	
30	30	*White pine weevil	Terminal Weevil
27	31	*Spruce bud midge	Dead top dieback with new leader
82	32	*Yellow-headed spruce sawfly	
39	39	DBH taken on new leader	
13	40	*Frost heaving	
22	41	Bushy top (multiple leaders)	Multiple Leader
27	42	Dead top, lateral branch has become dominant leader	Dead top dieback with new leader
09	51	Frost Damage	Climate
06	71	Fire damage	
10	72	Flooding damage	
11	73	Poor Planting	
14	74	Erosion	
12	75	Suppression	
17	77	Poor Seedbed	
18	78	Herbicide	
23	79	Poor Form	
29	88	Removed (Thinned)	Cut down
Delete	99	Dead/Down 2nd time	Do not look for tree

7.6 Other measurements -- Site Description, Soils, and Vegetation Forms

There are other measurements are also to be completed for this study. They include vegetation, soils, and site description. Associated forms are attached in Section 7.2

7.6.1 Site description

Site quality expresses the capability of forest land for growing trees. A good site usually shows better growth than the poor site. The most common method of assessing site quality depends on direct measurements of the productivity of trees (Smith et al. 1997). In this study, we use aspen site index to classify the high and medium site, and site characteristics should be recorded during the site selection (Form 7-1 attached).

7.6.2 Soils and Nutrient Cycling Study

Since soil properties and nutrient status will influence the growth and development of stand. Soil data should be collected from both at high and medium sites when the WESBOGY long-term installations set up (Form 7-2 attached). A study of soil and nutrient cyling is suggested beginning at the time of thinning to treatment density. This study would evaluate more detailed soil and foliar chemical characteristics, at 10 year intervals. Depending on interest by the participants and the research questions posed, the study might be conducted on a subset of installations. During the period between plots setup and thinning to treatment density, a project description should be developed including methods and measurement procedures and additional source of funds required to undertake this more costly study.

7.6.3 Vegetation

Grass, herbaceous plants, and other non tree species grow in more diverse patterns those among spruce and aspen trees. They all compete for growing space soon after aspen removal (Oliver and Larson, 1996). The vegetation data should be collected in the 20 m x 20 m plot during mid-summer using Form 7-3. These data should be collected in the summer of year 6 (following spacing), in year 10 and at subsequent 10 year intervals.

Form 7–1 Site Description Form

STUDY AREA:	Page of

Crew	Agency

Study Area I.D.		Plot No.	Day	Month	Year	Photos 35 mm Initials	Roll	PhotoNo.	SHEET	SECT	DIR

LSD						LATITUDE	LONGITUDE

NATURAL SUBREGION	Eco DISTRICT	GUID BOOK	ECOSITE	ECOSITE PHASE	COMM. TYPE	AERIAL PHOTOGRAPHY			

EXPOSURE 1	EXPOSURE 2	FLOOD	DRAINAGE	PERVIOUSENSS	SITE - MACRO	SITE - MESO	SITE - MICRO	SITE - SHAPE	E.MOISTURE	NUTRIENTS	SUCC.STATUS 1	SUCC.STATUS 2	Factors 1-Broad	Factors 1-Spec.	Factors 2-Broad	Factors 2-Spec.	SURFACE SUBSTRATE (% Cover) Decaying Wood	Bedrock	Cobbles and Stones	Mineral Soil	Organic Matter	Water

ELEVATION	ASPECT	SLOPE	Regen 1			Regen 2			Regen 3		
			SP	%	HT(m)	SF	%	HT(m)	SP	%	HT(m)

EXPOSURE TYPE
1. Not applicable
2. Wind
3. Insolation
4. Frost
5. Cold air drainage

Atmospheric toxicity

FLOOD HAZARD
1. No hazard
2. Rare
3. May be expected
4. Frequent

SOIL DRAINAGE
1. Very rapidly
2. Rapidly
3. Well
4. Moderately well
5. Imperfactly
6. Poorly
7. Very poorly

PERVIOUSENSS
1. Rapidly
2. Moderately
3. Slowly

SITE POSITION - MACRO
1. Apex
2. Face
3. Upper Slope
4. Middle Slope
5. Lower Slope
6. Vally Floor
7. Plain
8. Plateau
9. Hills
10. Upland
11. Benchland

SITE POSITION - MESO
1. Crest
2. Upper Slope
3. Middle Slope
4. Lower Slope

SITE MICROTOPOGRAPHY
1. Straight
2. Hummocky
3. Tussocky
4. Pitted
5. Irregular

SITE SURFACE SHAPE
1. Straight
2. Concave
3. Convex

ECLOLOGICAL MOISTURE
REGIME
1. Very xeric (very dry)
2. Xeric (dry)
3. Subxeric (moderately dry)
4. Submesic (moderately fresh)
5. Mesic (fresh)
6. Subhygric (moderately moist)
7. Hygric (moist)
8. Subhydric (moderately wet)
9. Hydric (wet)

NUTRIENT REGIME
1. Oligotrophic (very poor)
2. Submesotrophic (poor)
3. Mesotrophic (medium)
4. Permesotrophic (rich)
5. Eutrophic (very rich)
6. Hypereutrophic (e.g. saline)

SUCCESSIONAL STATUS
1. Pioneer seral
2. Young seral
3. Mature seral
4. Old seral
5. Young edaphic climax
6. Mature edaphic climax
7. Young climatic climax
8. Mature climatic climax
9. Disclimax
10. Non vegetated

DISTURBANCE FACTORS
1. Atmospheric
2. Cutting and soil disturbance
3. Dumping, disposal and spils
4. Fire
5. Plant/animal effects
7. Site improvement
8. Water related

Landscape Profile Diagram

Site Location

Location Description

Plot Representing (list community, soils, parent material, drainage, topographic position

Site Genonorphic

PARENT MATERIAL

TEXTURE

SURFACE EXP.

SOIL CLASS/

SLOPE/ASPECT

SOIL DRAINAGE

General Comments On Site Characteristics

Form 7–2 Soil Description Form

STUDY AREA:	Page of

Study Area I.D.	Plot No.	Day	Month	Year

Crew
Agency

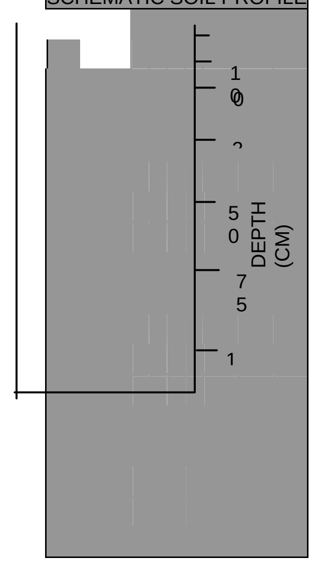
SOIL SUBGROUP		SOIL SERIES	HUMUS FORM CLASS		HUMUS FORM VARIANTS			

PARENT MATERIAL 1					
PM	Surf. Exp.	Mod. Proc.	Depth (cm)	Crs. Frag.	Texture Organic Component
PM	Surf. Exp.	Mod. Proc.	Depth (cm)	Crs. Frag.	Texture Organic Component
PM	Surf. Exp.	Mod. Proc.	Depth (cm)	Crs. Frag.	Texture Organic Component

Class	Veg.Modifier	Complex Modifier	Local LFM Modifier

DEPTH TO (CM)	
Effective Rooting	Water Table
Bedrock	Frozen Layer
Root Restriction	Carbonate
Salinity	

SCHEMATIC SOIL PROFILE



GENERAL COMMENTS ON SOIL CHARACTERISTICS
Soil Phase -
Erosional/Depositional Features at Site -
Charcoal (abundance, depth) -
Seepage (presence, depth) -
Other -

SAMPLE	LEVEL	HORIZON					HORIZON DEPTH cm		HORIZON THICKNESS cm		HORIZON BOUNDARY		SOIL TEXTURE/ ORGANIC COMPONENT	COARSE FRAGMENT DESCRIPTION							EFFER.
		DISCONT	HORIZON	SUFFIXES		SUBDIVISION			MIN.	MAX.	Dist.	Form		% BY Vol.	Gravel <7.5 cm %	Type	Cobbles 7.5 - 25 cm %	Type	Stones >25 cm %	Type	Degr. x vw w m s
	1																				
	2																				
	3																				
	4																				
	5																				
	6																				
	7																				
	8																				

HORIZON	LEVEL	STRUCTURE								CONSIST.				PH	PH	COLOUR 1				
		PRIMARY				SECONDARY											HUE			
		GRADE	CLASS	KIND	KIND MOD.	GRADE	CLASS	KIND	KIND MOD.	dry	Moist	wet	plasticity	Reaction	Method	Aspect	Number	letter(s)	Value	Chroma
	1																			
	2																			
	3																			
	4																			
	5																			
	6																			
	7																			
	8																			

HORIZON	LEVEL	COLOUR 2					MOTTLES									ROOTS 1				ROOTS 2				
			HUE				AB	SI	CO	COLOUR														
											HUE													
		Aspect	Number	Letter(s)	Value	Chroma	X F C M	F M C	F D P	Aspect	Number	Letter (s)	Value	Chroma	BoundDis. s c d	AB X V F P A	Size V F M C	Ori V H O R	Dist IN EX MX	AB V F P A	Size V F M C	Ori V H O R	Dist IN EX MX	Von Post
	1																							
	2																							
	3																							
	4																							
	5																							
	6																							
	7																							
	8																							

Form 7–3 Vegetation Description Form

Study Area	Plot No.	Day	Month	Year

Crew
Agency

PLOT AREA (ha)	SHAPE

	Main Canopy Tree(T1)	Dens. dist.	Under story Tree (T2)	Dens. dist.	Epiphytes (E)	Dens. dist.	Tall Shrub (S1)	Dens. dist.	Low Shrub (S2)	Dens. dist.	Herb (F)	Dens. dist.	Grass (G)	Dens. dist.	Moss (M)	Dens. dist.	Lichen (L)	Dens. dist.
SPECIES CODE	%		%		%		%		%		%		%		%		%	
TOT % COV																		
STRAT HT																		

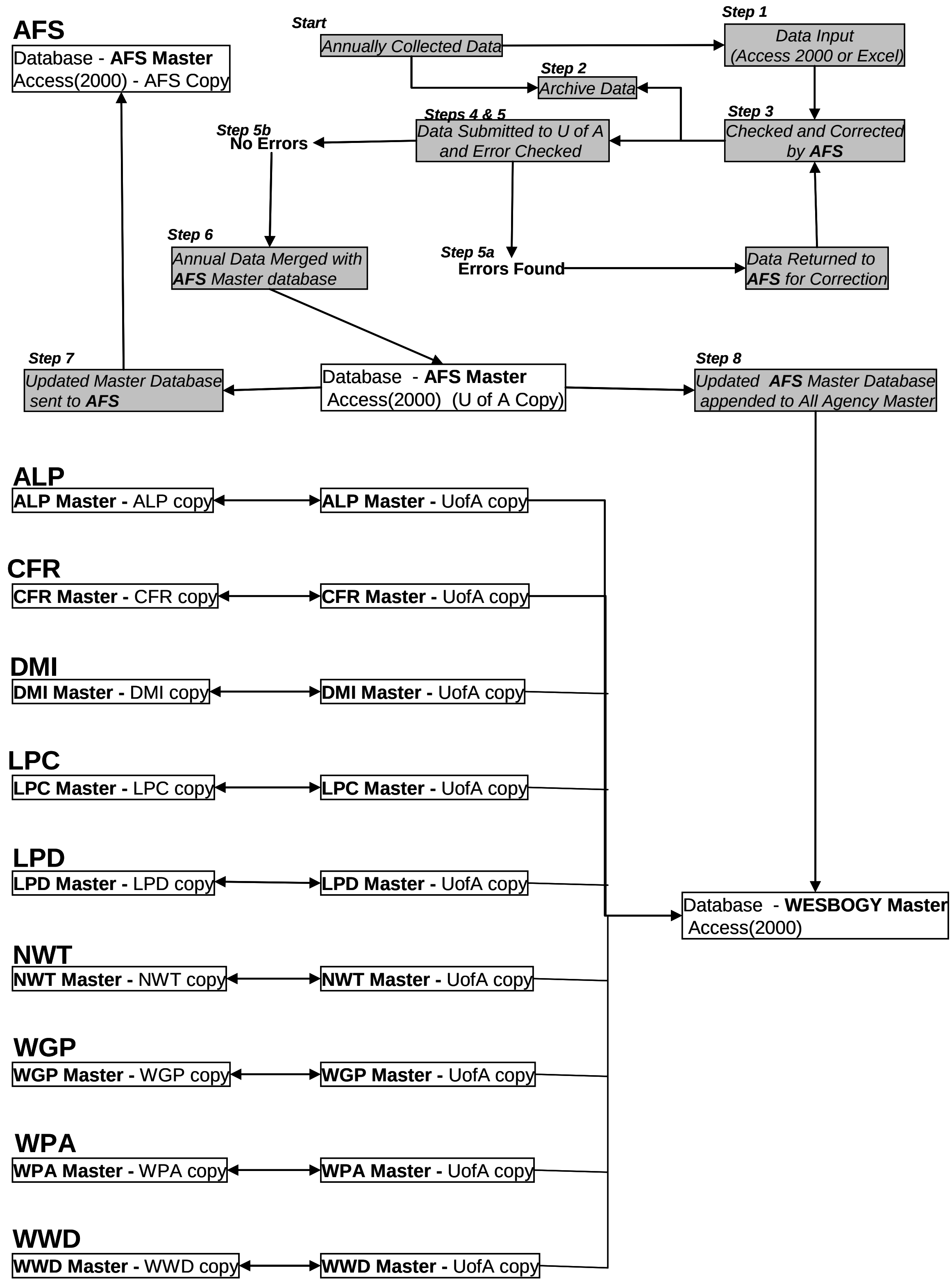
General Comments
% EXPOSED SOIL -
BROWSING & GRAZING -
Disease > 20%
VIGOUR -
OTHER -

	Main Canopy Tree(T1)	Dens. dist.	Under story Tree (T2)	Dens. dist.	Epiphytes (E)	Dens. dist.	Tall Shrub (S1)	Dens. dist.	Low Shrub (S2)	Dens. dist.	Herb (F)	Dens. dist.	Grass (G)	Dens. dist.	Moss (M)	Dens. dist.	Lichen (L)	Dens. dist.
SPECIES CODE	%		%		%		%		%		%		%		%		%	

DENSITY DISTRIBUTION CLASSES

1. Rare individual, a single occurrence	6. Several well spaced patches or clumps
2. A few sporadically occurring individuals	7. Continuous uniform occurrence of well spaced
3. A single patch or clump of a species	8. Continuous occurrence of a species with a few gaps in the distribution
4. Several sporadically occurring individuals	9. Continuous dense occurrence of a species
5. A few patches or clumps of a species	

7.7 Data Handling Procedures Flow Diagram



7.8 Database Structure (Microsoft Access 2000)

Columns

Name	Type	Size
RTYP	Long Integer	4
AGCY	Text	8
BLK	Long Integer	4
INST	Text	3
REPL	Long Integer	4
PLOT	Long Integer	4
DATE	Text	8
DATE_O	Text	20
GROWYR	Long Integer	4
TRNO	Long Integer	4
SPP	Text	2
EST	Text	1
RCD	Single	4
DBH	Single	4
HT	Single	4
HTI	Long Integer	4
CRN	Single	4
CRW	Single	4
HTLC	Single	4
CC1	Byte	1
CC2	Byte	1
CC3	Byte	1
AZ	Single	4
DIS	Single	4
AGE	Byte	1

7.9 Conditions used for Error Checking

Error type:

"ErrRtyp"	Record type is not allowed (RTYP is not 1, 2, 5, 9, 10, 11, 22, 55, 99, or is null)
"ErrBlk"	Block number is not allowed (BLK is not 1, 2, or is null)
"ErrInst"	Installation number is not allowed (INST is not SUP, MED, or is null)
"ErrRepl"	Replication number is not allowed (REPL is not 1, 2, or is null)
"ErrPlot"	Plot number is not allowed (REPL is out of the range 1-15, or is null)
"ErrSpp"	Species code is not allowed (SPP is not FA, FB, FD, LA, LT, LW, PF, PJ, PL, PW, SB, SE, SW, AW, PB, BW, or is null)
"ErrEst"	Establishment type is not allowed (EST is not S, D, P, R, or is null)
"ErrRcd0"	(1) RCD <= 0 (2) Null and ((HT>0 and HT<=1.3) or (HT > 1.3 and DBH=null))
"ErrRcd1"	RCD unreasonably large by age and specie due to measurement errors or wrong units

RCD upper ranges by age and species (cm)

Species (age)	< 3	3 to 5	6 to 8	>8
SW	3	5	7	10
AW	4	8	12	16

"ErrDbh0"	(1) DBH <= 0 (2) Null when HT > 1.3 m
"ErrDbh1"	DBH unreasonably large by age and specie due to measurement errors or wrong units

DBH upper ranges by age and species (cm)

Species (age)	< 3	3 to 5	6 to 8	>8
SW	0.1	2	5	8
AW	3	6	10	15

"ErrRcdDbh"	DBH >= RCD
"ErrHt"	(1) HT < 0.01 m (2) HT unreasonably large by specie

HT upper limit by species (m)

Species (age)	<=5	6-10	11-15	16-20	>20
SW	2	5	10	15	20
AW	5	10	15	20	25

"ErrHti"	(1) HTI <0 And (CC1, CC2, CC3<>7, 24, 18, 19, 42)

(2) HTI >=HT*0.8
(3) HTI unreasonably large by specie
(4) HTI=NULL and (HT>0.3 and <> 25, 26, 27, 29, 88, 99)

The upper limit of HTI by species (cm)

Species	SW	AW
Limit	80	200

"ErrHtDbh" HT/DBH ratio > 10

"ErrCrn" CRN <=0 or unreasonably large by specie

"ErrCrw" CRW <=0 or unreasonably large by specie

Crown upper limit (m) by species and age

Species (age)	<5	5-10	>10
SW	1.5	3	6
AW	2	4	7

"ErrCrnw" CRN*0.2 > CRW Or CRN < CRW*0.2

"ErrHtlc" (1) HTLC >= HT
(2) HTLC unreasonably large for AW and SW under 15 yrs without pruning

The upper limit of HTI by species (m)

Species	SW	AW
Limit	1	15

"ErrCc1" Health code is not allowed in CC1 or is null

"ErrCc2" Health code is not allowed in CC2

"ErrCc3" Health code is not allowed in CC3

"ErrCc13" Duplication of health code among CC1, CC2, and CC3

"ErrAz" AZ is out of possible range from 0 to 360

"ErrDis" DIS > 28.3 m

"ErrAge" AGE is out of possible range from 0 to 20 years or null

"ErrDate0" DATE field is null

"ErrDate6" Wrong date format of 6 digits

"ErrDate7" Wrong date format of 7 digits

"ErrDate81" Wrong date format of 8 digits: DMY or MDY
"ErrDate82" Wrong date format of 8 digits: MYD or DYM
"ErrDate83" Possible wrong date format of 8 digits: YDM

"ErrDate99" Other wrong date format, less than 6 or more than 8 digits

"ErrTrNo0"	Tree number field is null
ErrHTLC	HTLC>=HT
ErrRcd0	0
ErrRcd1	> upper limit
ErrRcdDbh	DBH >= RCD
ErrREPL	3

7.10 *Additional Fields Used in Error Checking Database Structure (Microsoft Access 2000)*

ErrDate0	Text	5
ErrDate6	Text	5
ErrDate7	Text	5
ErrDate81	Text	5
ErrDate82	Text	5
ErrDate83	Text	5
ErrDate99	Text	5
ErrRtyp	Text	5
ErrBlk	Text	5
ErrInst	Text	5
ErrRepl	Text	5
ErrPlot	Text	5
ErrSpp	Text	5
ErrEst	Text	5
ErrRcd0	Text	5
ErrRcd1	Text	5
ErrDbh0	Text	5
ErrDbh1	Text	5
ErrRcdDbh	Text	5
ErrHt	Text	5
ErrHti	Text	5
ErrHtDbh	Text	5
ErrCrn	Text	5
ErrCrw	Text	5
ErrCrnw	Text	5
ErrHtlc	Text	5
ErrCc1	Text	5
ErrCc2	Text	5
ErrCc3	Text	5
ErrCc13	Text	5
ErrAz	Text	5
ErrDis	Text	5
ErrAge	Text	5
ErrTrNo0	Text	5
RTYP_O	Double	8
AGCY_O	Text	20
BLK_O	Double	8
INST_O	Text	20
REPL_O	Double	8
PLOT_O	Double	8
TRNO_O	Double	8
SPP_O	Text	20
EST_O	Text	20
RCD_O	Double	8
DBH_O	Double	8
HT_O	Double	8
HTI_O	Double	8
CRN_O	Double	8
CRW_O	Double	8
HTLC_O	Double	8
CC1_O	Double	8
CC2_O	Double	8
CC3_O	Double	8
AZ_O	Double	8
DIS_O	Double	8
AGE_O	Double	8

7.11 Items reviewed and revised for this version of the Procedures Manual

Status	Description for items needing discussion
	Appendix 7 Tree Measurement. From LFD review (Grady Ung), suggestions that correspond to LFD PSP protocol 1. RCD is required until DBH >= 9.1 cm. 2. DBH is required on the 1st mortality year if old Height >=130cm. 3. No Az/Dist if cc1 = 27 / 29 / 88 / 99, otherwise, Az/Dist is required. 4. Tree codes: If cc1 = 25 / 26 / 27 / 29 / 88 / 99, Age = blank.

Status	Description for items already, or currently being, revised
Done	**Section 4.10**, The LTS database -- Data handling and maintenance protocol (Mike) This section is still under revision
Done	**Appendix 7.2 and 7.3**, Tree condition codes (From Daryl Gilday 13/8/2003) <u>These changes have not been completed. It is suggested that we adopt the Alberta LFD PSP tree condition codes that have been recently revised and expanded.</u> 1. Add new codes for disease and insects as per LFD listing in April 2002 PSP procedures manual. 2. List codes in numeric order in Manual Appendix E 3. Revise instructions to suggest that priority for recording the codes goes to “those having the greatest impact on growth” Impact on prior codes? Leave the codes prior to implementation date in original form? From LFD review (Grady Ung) b) Under "4.18 - Condition Codes", it states: "Up to maximum of 3 condition codes can be recorded for each tree. ..."; however, under "Appendix E" code 21, condition code 2 was used to indicate species of insect pest and condition code 3 for severity. These 2 codes were all directly related to code 21, what about all of the other major damage codes that could affect the tree, e.g., code 18, etc.? Code 08 is another code to think about. c) There are lots of shepherds crook reported by our staff for our plots. Which code can we use to identify this problem? **Section 6.18**. In regards to the Draft update of the manual I would comment on the condition codes. There was discussion in 2001 of updating the codes to simplify the severity ratings for damage codes like insect/disease. I had suggested at that time a system that would use code numbers like 61, 62, 63 for Sheperd’s crook light, med, severe. This would allow other condition codes to be used in unison. (eg heavy shepherd’s crook and fork and galls, all on the same tree). This may give a more accurate indicator of what is happening with that tree. Patrick Ewan, CanFor
Done	**Appendix 7**, Protocol for RCD/DBH measurement overlap
Done	Miscl Changes suggested by LP. See separate page (not included here)
Done	**Section 4.9**, Plot Re-measurement Schedule for moving to periodic (not annual) re-measurements after age 10; Initial discussion of options occurred at Spring 2002 meeting, and options were outlined in the “meeting minutes and annual report”: 2.2.6.1.3 Option 3 (2/4-year interval): Measure all plots at ages 10, 12, 14, 16 18, 22, 26

	2.2.7 Re-measurement protocol Sw age > 26 years from establishment 2.2.7.1 Proposed Protocol: 8-year interval (e.g. 34, 42, 50, 58, 64) From 2002 AGM minutes: 3. Mike Bokalo summarized the results of voting on LTS procedures and a motion was received from Greg Behuniak and seconded by Paul Leblanc that the affirmative results be adopted. The motion carried. The decision: After year 10 spaced plots will be re-measured every second year (even numbered years) and natural Aw densities will be re-measured every year.
Done	**Section 4.8.3**. Un-thinned Plots: subplot layout, expansion and numbering of trees – incremental tree number coverage, e.g. the 20x20 expansion for aw excludes the 5x5 subplot already being measured. From Fall 2002 AGM minutes: 5 .A suggestion for an alternative protocol for expansion of sub-plots in the LTS natural plots (6, 12, 15) was presented (by Mike Bokalo during the earlier technical session) and discussed to get preliminary reactions by the members. Reasons for the proposal were presented during the technical session by Mike including a primary benefit of smoother transition to the full 20x20 plot size and the opportunity to get full plot information much earlier. Greg Behuniak agreed to implement a small test of both the current protocol (expansion from 2x2 m to 5x5 m subplots) and the alternative protocol (implementing a 4.0 cm minimum DBH for trees on the full 20x20 m plot). The results of this test together with other ideas and concerns expressed by members will be reviewed by the Steering Committee and a recommendation made by the end of this calendar year. Greg Behuniak also asked for clarification on the procedures for removing any aspen suckers that pass 1.3 m height in the years following thinning. This will be reviewed and incorporated in modifications to the Field Manual as part of the review for expansion of sub-plots.
Done	LFD review and suggestions (Grady Ung) some items placed into “discussion” table
Done	Graphics needed for Appendices C and D DBH (LFD PSP Manual Fig 2.4) and base of live crown (LDF PSP Manual Fig 2.5 and definition section 2.1.4.5)
Done	**Appendix 7.2 Height increment** From LFD (Daryl Gilday), after moving to multiple year re-measurements do we still want to ask that increment be measured directly. Probably is no longer feasible? This was mentioned in the Spring 2002 meeting minutes. Added note for transition from direct to indirect measurement.
Done	**Appendix 7.2 total height**. From LFD review (Grady Ung): Two different ways of data collection method are mentioned for recording Total height and Height to Live Crown. i.e., when tree height is =<3 m, measure to the nearest 0.01 m, and when it is > 3 m, measure to the nearest 0.1 m. Is it necessary to have two specifications? With small trees recording height to only 0.1m will not give enough information on the early growth. I think we need two standards, one for small and the other for larger trees.
Done	**Section 4.7 Plot Tending**. AGM 2002: Greg Behuniak also asked for clarification on the procedures for removing any aspen suckers that pass 1.3 m height in the years following thinning.
Done	**Section 5**. Inclusion of data handling procedures, error checking and database management

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