Western Boreal Growth and Yield (WESBOGY) Association

Long Term Study (LTS) of growth and development of mixed stands of spruce and aspen

Experimental Design Summary And Plot Data Collection Manual

September 2003

DRAFT

PREFACE to DRAFT version of September 2003

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. The following two tables summarize the changes made or being contemplated. The first table outlines the changes already made and the second described several suggestions for change the may require additional discussion.

Status	Description for items already, or currently being, revised
	Section 7, The LTS database -- Data handling and maintenance protocol (Mike) This section is still under revision
partial	**Section 6.18 and Appendix 9.1**, 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?
Done	**Sections 6.11 and 6.12**, Protocol for RCD/DBH measurement overlap
Done	Miscl Changes suggested by LP. See separate page (not included here)
Done	**Section 4.11**, 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 5.3**. 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)

Status	Description for items needing discussion
Done	**Section 6.14 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.
	Section 6 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. Your thoughts on these would be helpful. Still under review.
Done	**Section 6.13 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 6.18 and Appendix**. Tree condition codes (LFD has revised theirs already). This draft includes both old and new codes with recommendations for implementation

PREFACE to version of 2000

This manual was written in 1990 for WESBOGY long-term aspen-spruce density study sites installation. Its purpose was intended as a reference for data collection. It was updated in May 1998 to clarify issues around plot thinning. It was revised in January 1999 for subplot misalignment and tree number, and also added the standard form, data dictionary. However, we found that some things have still to be updated. Major changes for this version are:

1. This version is combined the two documentations together for this version; *Regional White Spruce and Aspen Stand Growth under Intensive Management* and *Data Collection Manual*. We hope this version is more clear and complete to understand why we set up the long-term project, and how the PSPs are established in field.
2. At the1998 WESBOGY annual meeting, it suggested to switch from a 6-digit code to a 7-digit code, because the two digits for the tree number was not sufficient for the aspen sub plot when it expands to 5x5 m at the year 11. However, this problem only affects the sub-plots, located in non-treated plot 6, 12 15. On further discussion in the Steering Committee, we realized that since all trees are numbered when they are established, there is no ingrowth. This means that the original tree numbering which is a 6-digit code consisting of sub-plot number (2 digit), tree number (2 digit), and ingrowth (2 digit) could accommodate our needs. We can combine the 2 digits for ingrowth with the 2-digit tree number to allow for over 100 trees per sub-plot when it expanded to 5x5 m. With this change, it is possible to keep the original 6-digit code (sub-plot 2 digits, tree number 4 digits) for **all plots**, and use *record* type to separate sub-plots. We have decided to adopt the revised six-digit code for all species among all plots (treated, natural and sub-plots), because:
    1. In the long term, this will facilitate data collection and analysis.
    2. Tree numbers in regular plots are controlled by row (Figures 1, 2 8, and 9), and there should never be more than 99 trees per row;
    3. The revised coding system allows for over 100 trees when the sub-plot expands to 5x5 meter after year 11 (See Figures 3, 4, 5, 6, 11 and 12 for examples).
    4. Any new installations can utilize the new coding system. Existing installations do not have to retag trees in the field. If you have adopted the 7-digit code from last year, then you will need to revert to the 6-digit format (by dropping the zero added in the middle of the tree number) and you will have to add the Record Type to identify sub-plots by size.
5. The standard data format has been updated. In order to do the data analysis and future data management, we would like to ask our members to use a standard format for WESBOGY PSP data.

6. Record type has been clarified and updated this time. We added new record types, 11, 22, 55 and 99, to define the sub-plots, 1x1 m, 2x2 m, 5x5 m, and 20x20 m respectively. For new installations it is recommended to write the Record Type code on the field tag (55-91001 for subplot 91 expanded to 5x5 m).
7. Some other field technical issues were clarified in this version, such as root collar diameter, and definitions live crown and crop tree.

We thank the members of WESBOGY for their continuing contribution to update this manual.

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Stephen J. Titus

June 21, 2000

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1 Introduction

The boreal mixedwood association of western Canada is widespread and contains some of the most productive forest lands of the boreal forest (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 intensive 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 here 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 was the first 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 consists of two replications of a series of 15 plots described below (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 until the conifers are free from microsite competition. 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 seedlings. At year five (or when competition between trees begins), 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 (or when competition between trees begins), spruce and aspen will be thinned to treatment densities.

Table 2 illustrates the combinations of spruce and aspen densities to be measured, and the associated plot number. 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 will 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 in between the species are more likely to be detected. A 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 density levels 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

Each participant will be responsible for selection, setup, and measurement of two installations. Monumentation 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).

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. In a few cases it may be possible to locate the installation near a meteorological station.

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 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. Contacts for such services include Darwin Anderson, University of Saskatchewan, Department of Soil Science and Dawes Lindsay (retired) and Al Twardy both of Edmonton. Other names may be available from the provincial Institutes of Pedology.

Where 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 9.1) can be used in conjunction with other Site Description Forms (Appendix 9.4) 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 Section 6 (Tree measurement).

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 (**Error! Reference source not found.**) 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 over the entire life of the study (8-40 spruce and 20-160 aspen trees at harvest time). Small subplot will be established on the natural density aspen plots to describe early growth and survival of aspen that will likely establish at high densities.

4.5.1 Plot numbering

Plot numbers (1-15) should be randomly assigned to the plot locations after they have been established in 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
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 is preferred to minimize possible influences from sources outside the treated area. Unfortunately, cost may be a major consideration and therefore some participants may be forced to consider the 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.

Orientation of the plot is particularly convenient along the cardinal directions. Other orientation is 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 insure 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. Where possible the same stock should be used for the entire 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). It will not be applied to 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 Thinning to treatment density

Thin aspen and spruce 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 designed 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)

4.9 Crop and In-growth Trees

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 (see plot tending section). All deciduous trees greater than 1.3 metre should be tagged and measured in the same way as aspen.

4.10 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. 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

4.11 Plot re-measurement schedule

All plots are to be re-measured annually up to year 10. After that 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.

5 Plot layout and tree numbering

5.1 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). 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)

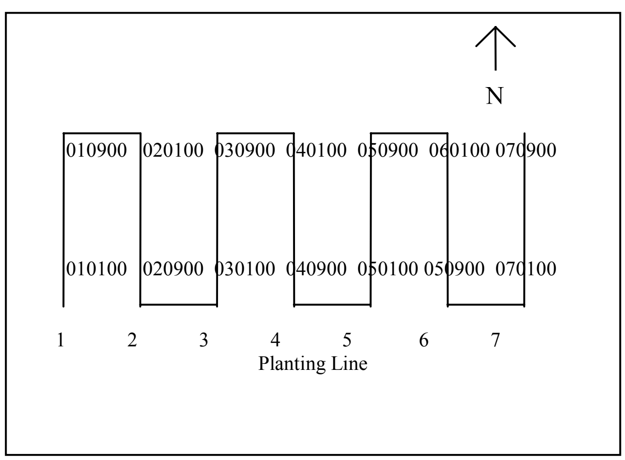


Figure 2 Numbering white spruce on low density (plots 7-12)

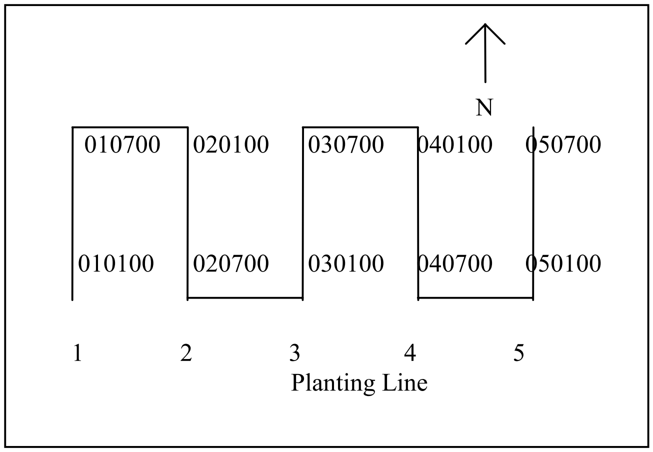
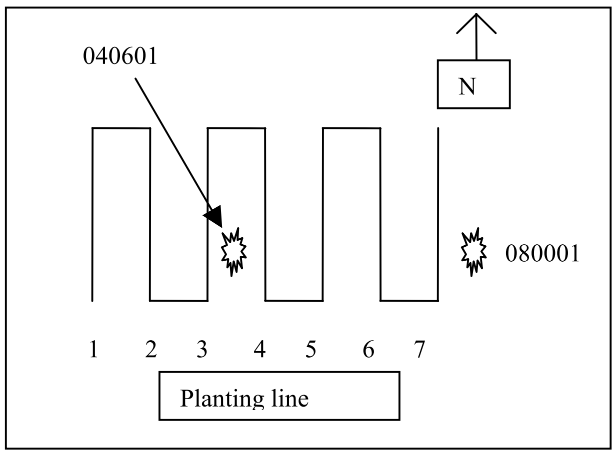


Figure 3 Numbering ingrowth trees



5.2 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, approximately 1300 aspen crop trees (depending on density levels in natural plots) per replication 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.

5.3 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 level 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. These subplots allow description of establishment, growth, and mortality for aspen and all other tree species.

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 five subplots of the main 20x20m plot consist 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 4, Figure 5, Figure 6 and Figure 7.

For installations set up before year 2000, subplots were centred on the quadrant boundary rather than on the corner 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 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)				
** 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.

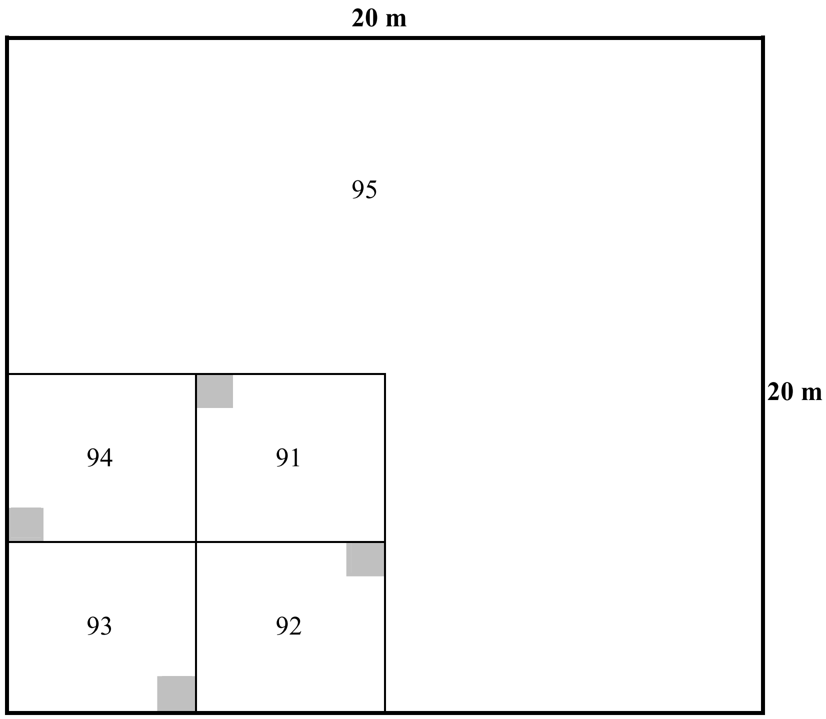
Table 6, Subplot expansion areas and factors with example estimates of tree/ha

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) the transition to 5x5 metre subplots was deferred 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. It 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).

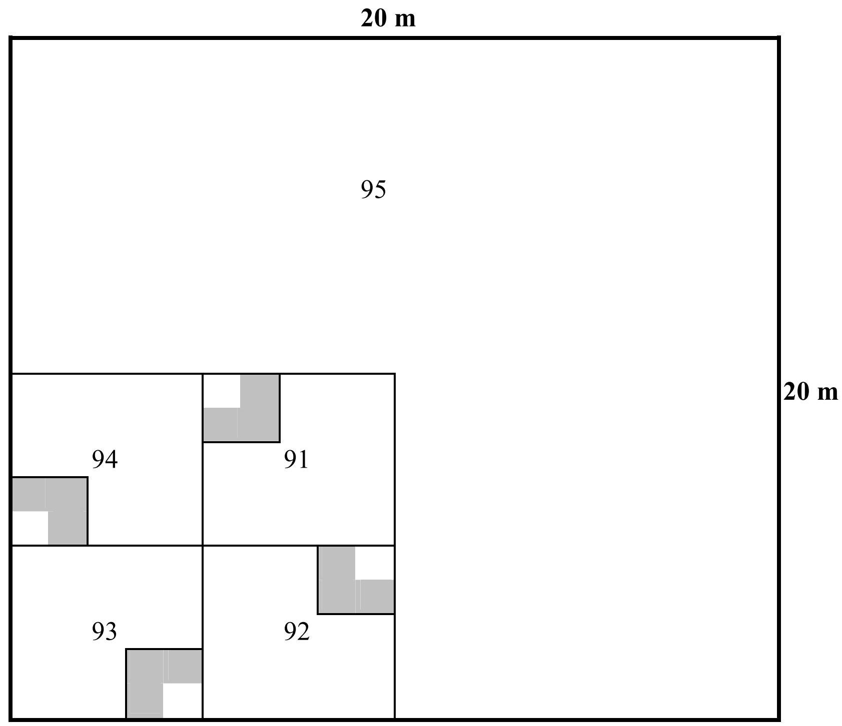
Until plots are expanded to 20x20 m, it will not be possible to make estimate for top height that are comparable to those of the treated plots. Attempts to estimate top height using plot sizes smaller than 20x20 m will be biased (underestimating top height). The amount of bias increases as plot size 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. Additionally, 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 (Fall/Winter 2002-2003).

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



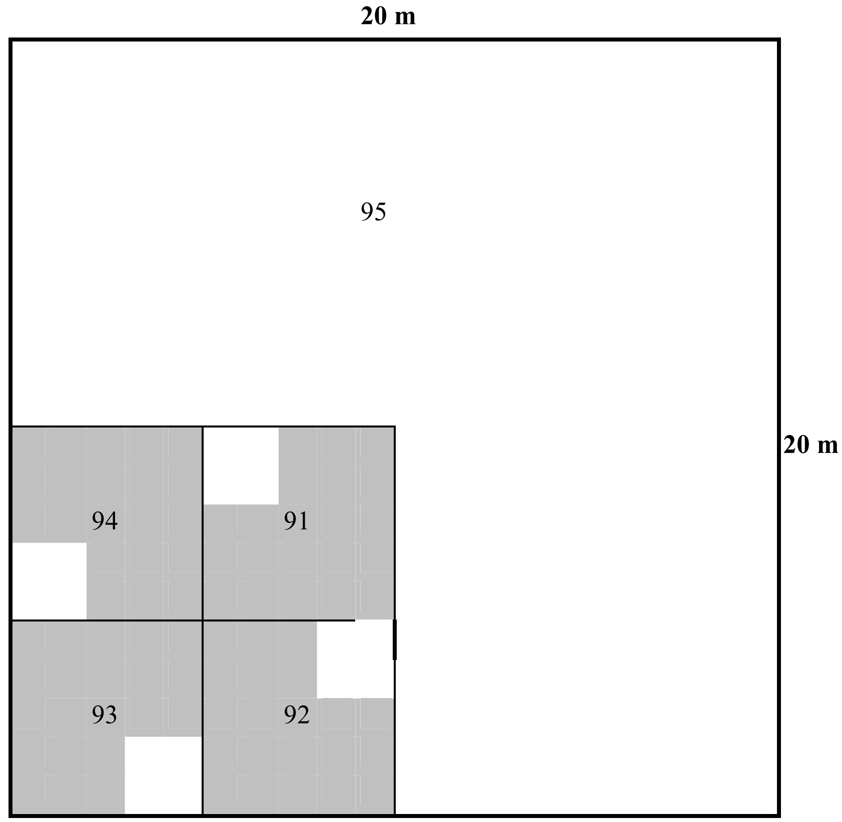
1x1 m subplots are indicated by the shaded area. Trees within the 1x1 m subplots (shaded) are numbered 91xxxx, 92xxxx, 93xxxx, 94xxxx as needed.

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



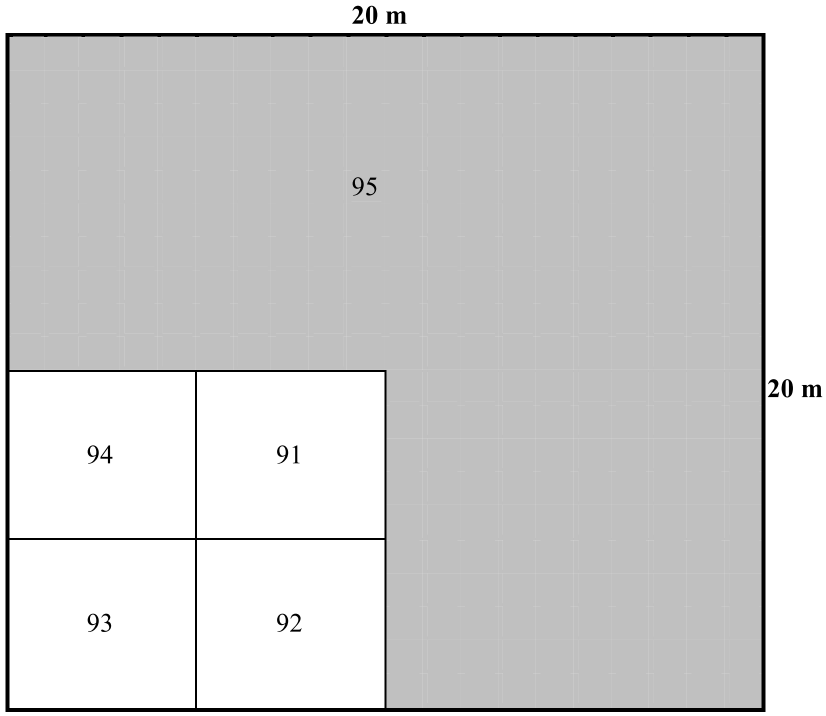
Subplots expanded to 2x2 m. New trees within the shaded portion of the 2x2 m subplots are numbered 91xxxx, 92xxxx, 93xxxx, 94xxxx as needed with the first number following the last number used in the 1x1 m subplot. Trees already recorded on the smaller subplots retain their numbers and provide data for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



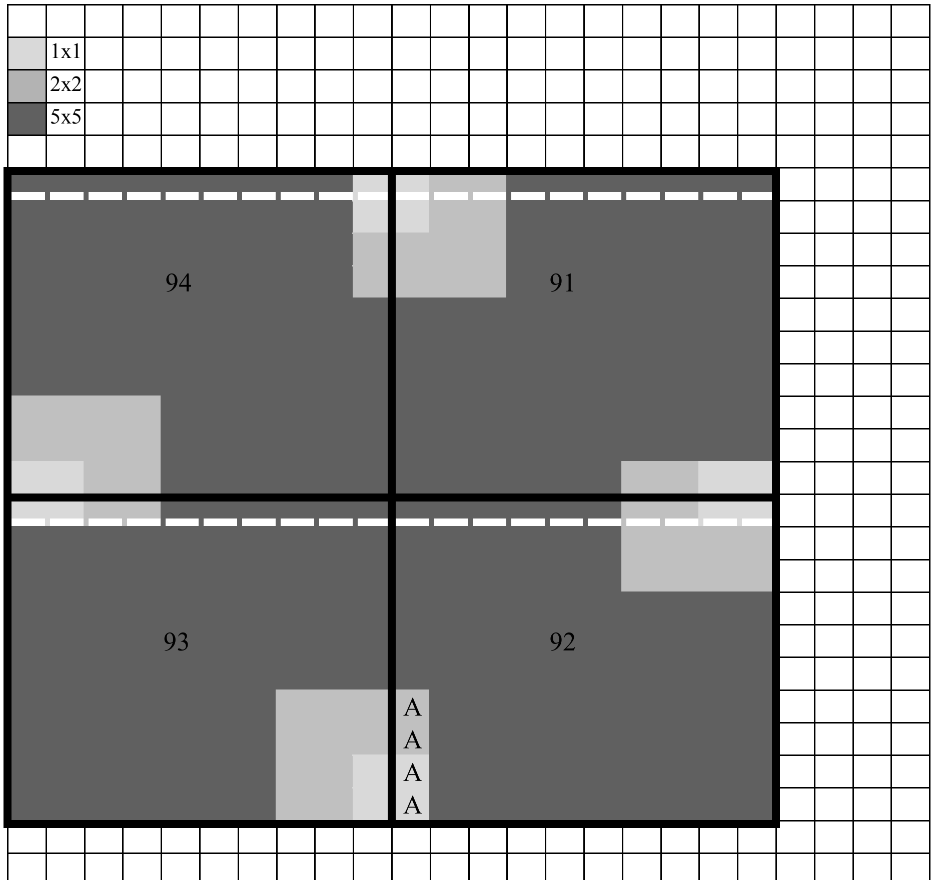
Subplots expanded to 5x5 m. New trees within the shaded portion of 5x5m subplots are numbered 91xxxx, 92xxxx, 93xxxx, 94xxxx as needed with the first number following the last number used in the 2x2 m plot. Trees already recorded on the smaller subplots retain their numbers and provide data for the remaining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

Figure 8, SW 5x5m subplot layout for installations set out prior to 2000 with subplots <u>centred</u> 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).

6 Tree Measurement and the Tree Data Form

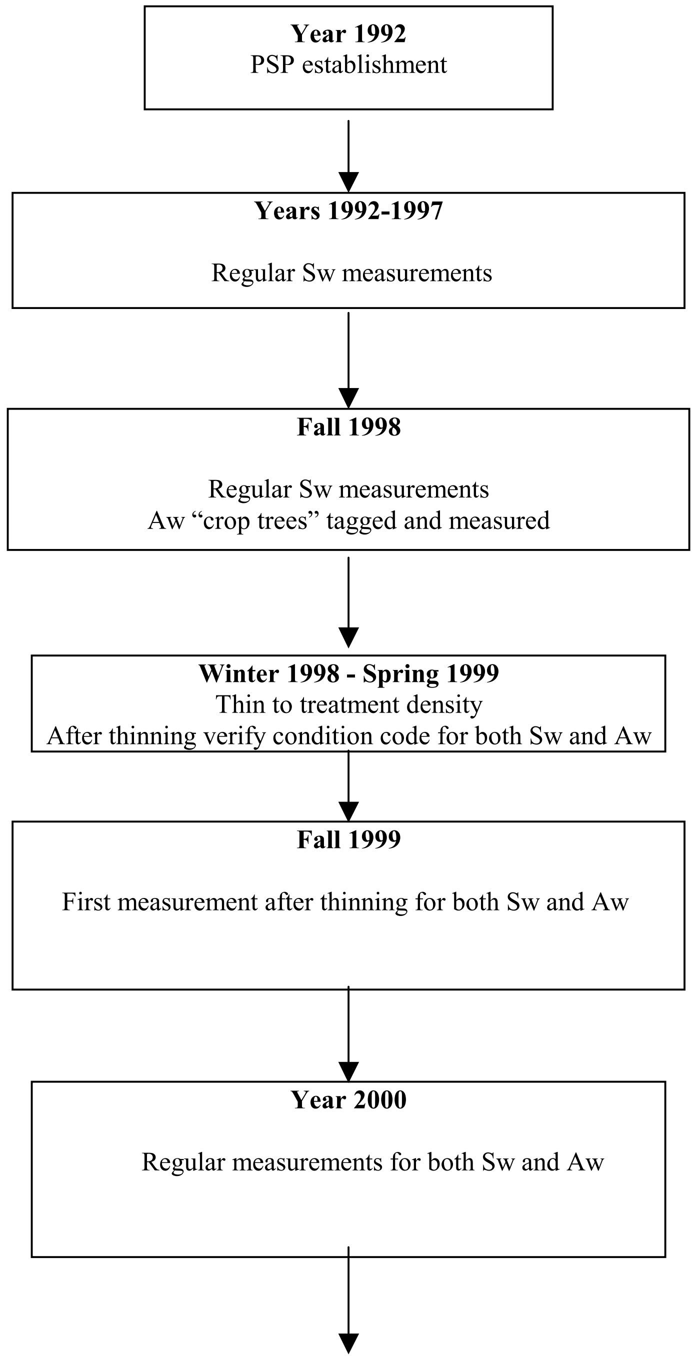
All spruce and some aspen trees are to be measured at establishment and then annually after seasonal growth is complete. The normal measurement time is therefore usually in the late summer or fall, but could be as late as the following early spring before growth begins.

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 5.3). 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.

Thinning should be completed between growing seasons. In the fall before thinning to treatment density, all regular measurements for spruce should be completed. Additionally and in preparation for the thinning, tag and complete the first measurement for the aspen "leave" or "crop" trees. 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 growing space created from thinning will start to refill by remaining trees during following growing seasons. 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



The trees to be measured and the handling of ingrowth differ according to species and time of thinning to crop density as shown in Table 7.

Table 7 Trees to be measured in relation to species and thinning

	White Spruce	Aspen
Before thinning	All planted Sw	All Aw found in subplots 91, 92, 93 and 94 only on un-thinned plots 6, 12, and 15
After thinning	Sw crop trees, number retained from above	Aw crop trees in all thinned plots and aspen in natural density subplots as above
Ingrowth	Include only when it reaches 1.3 m height	On plots 6, 12, and 15, include trees reaching 1.3-metre height. On thinned plots ingrowth is removed annually until a much later date when most ingress has ceased.

The following subsections describe the WESBOGY Individual Tree Data form (Table 8). Each variable on the data form is listed below, preceded by its column designations and followed by a brief description of the variable and how it is to be measured. A data dictionary to describe the variables of the standard data form is also attached (**Error! Reference source not found.**).

Table 8 Tree Data Form

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

6.1 Record Type

Record Type is a two-digit field (Table 9) 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.

Table 9 Descriptions for Record Type codes

Record Type Code	Description
01	Site Description
02	Soils data
05	Other vegetation data
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

6.2 Agency

This field contains up to 6 alpha-characters to denote the agency or company responsible for this particular block of plots. Agency denotations are shown in Table 10.

Table 10 Company and agency code

Company or Agency	File name code
Alberta Lands and Forest Services, Timber Management Division, Edmonton	AFS
Alberta-Pacific Forest Industries Inc Boyle	ALP
Canadian Forest Products Ltd, Alberta Operations Grande Prairie	CFR
Daishowa-Marubeni Int. Ltd. Peace River Pulp Div.	DMI
Louisianna-Pacific Canada Swan River, Manitoba	LPC
Northwest Territories, Renewable Resources	NWT
Weldwood of Canada Ltd, Hinton Division	WWD

Weyerhaeuser Canada, Alberta Division Drayton Valley	WDV
Weyerhaeuser Canada Ltd, Alberta Division Grande Prairie	WGP
Weyerhaeuser Canada, Saskatchewan Division Prince Albert	WPA

6.3 Block

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".

6.4 Installation

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:

SUP: for the superior sites
MED: for the median sites

6.5 Replication

Each installation consists of two replicates of a series of 15 plots. Therefore, this two digit, numeric field will be either 01 or 02.

6.6 Plot number

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.

6.7 Date

Measurement date is recorded as year/month/day, without any separator characters. For example October 9^{th}, 1990 is entered as "19901009".

6.8 Tree Numbers

A six-digit code is assigned all trees in both treatment and natural density plots. Refer to Section 5 Plot layout and tree numbering for a full description of methods for tree numbering on the different plots.

For treatment, all plots <u>except</u> 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 5.2 for a more 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 5.3 for a more complete description of methods for tree numbering on natural density aspen plots.

6.9 Species

Record the species code from Table 11.

Table 11 Tree Species Codes

CODE	SPECIES
AW	Aspen
BW	Paper birch
FA	Alpine fir

FB	Balsam fir
FD	Douglas-fir
LA	Alpine larch
LT	Tamarack
LW	Western larch
PB	Balsam poplar
PF	Limber pine
PJ	Jack pine
PL	Lodgepole pine
PW	Whitebark pine
SB	Black spruce
SE	Engelmann spruce
SW	White spruce

6.10 Tree Establishment Type

Record the appropriate code from Table 12 Seedling establishment Type Code tree.

Table 12 Seedling establishment Type Code

Code	Description
S	Sucker (vegetative reproduction)
D	Seed origin
P	Planted
R	Replacement for a previously planted tree

6.11 Root Collar Diameter (RCD)

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.

6.12 Diameter at Breast Height (DBH)

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 LFD 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)." (AFS PSP Manual Section 2.1.4.3)

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).

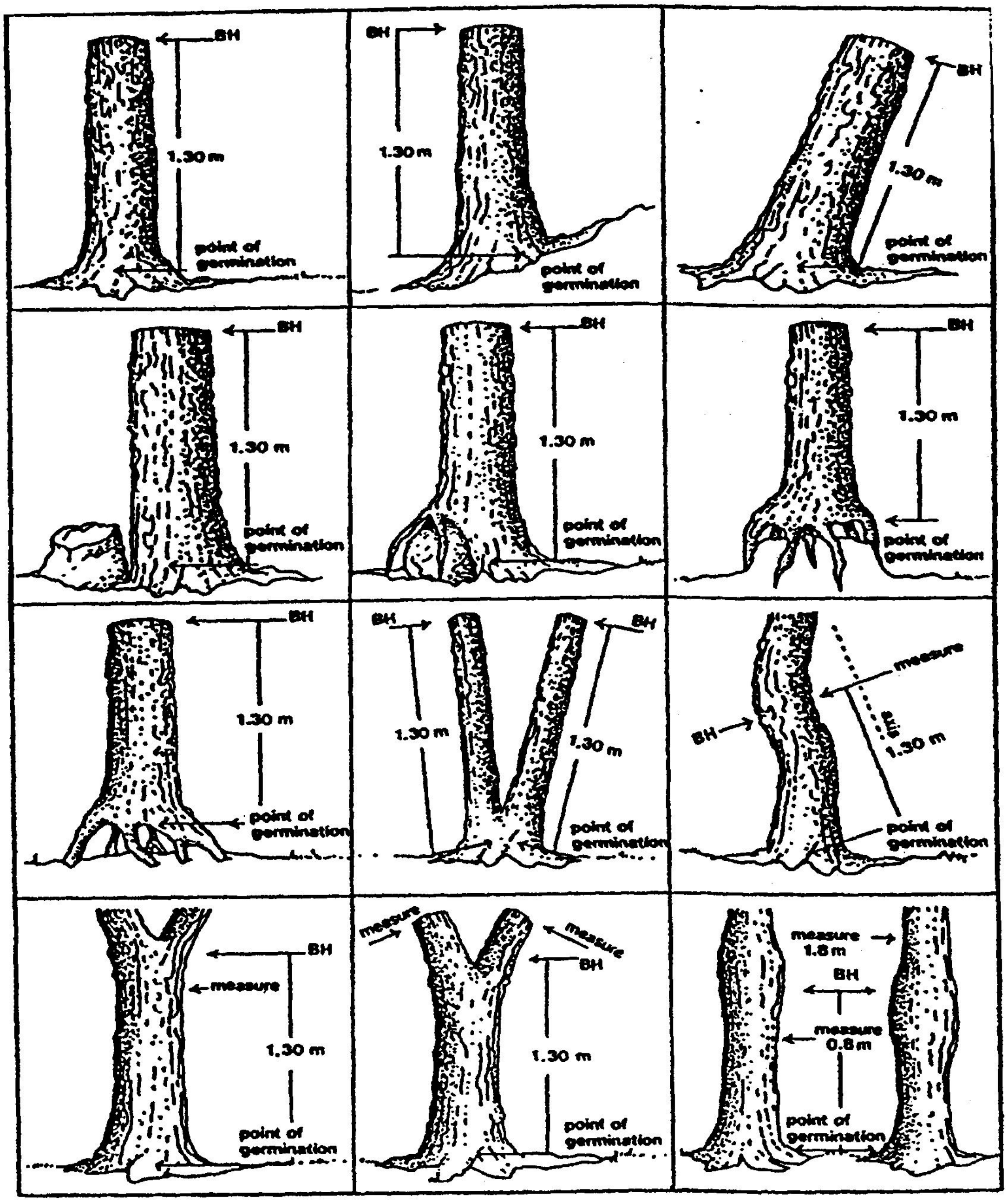


Figure 2.4 Determining Point of Germination and Breast Height

6.13 Total Height

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.

6.14 Height Increment

Record height increment (current leader length) to the nearest centimeter (0.01 m). This measurement is required in addition to total height 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.

6.15 Crown Radius, North

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.

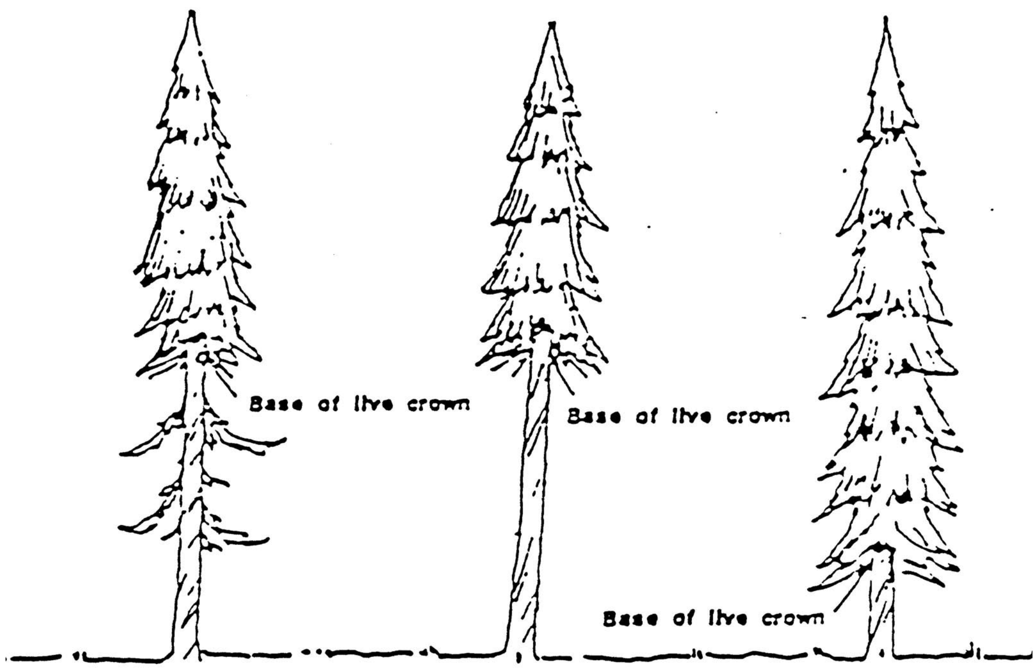
6.16 Crown Radius, West

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.

6.17 Height to Live Crown

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.

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



6.18 Condition Codes

[If new condition codes are adopted (see appendix 9.1), this section will be revised to reflect new condition codes]

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 00. If a tree is missing, the condition code should be given 26. Neither recording total height (a numerical variable) as "GONE", nor giving "MISSING" as comment is acceptable. 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 shown in the condition code list below. 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.

A list of codes by priority is provided in Appendix E. Since a tree may have more than 3 of these conditions, it is important to record only the three most important conditions as determined by the priority list. Refer to Appendix E for a description of each of the condition codes. As an example of the priority, if a forked tree with root rot is found to be dead, then the condition codes should be listed in the following order: 25, 05, and 13.

If dead tree coded dead on the first tree code (25 and 27), the second condition code should explain the cause of death. If the trees coded as insect attack (21) and foliar disease (08), the second should be followed to explain the severity (See Appendix E).

6.19 Azimuth & Distance

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 after 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.

6.20 Age

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 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 and at each re-measurement.

7 The LTS Database

Two copies of all installation files should be maintained. Original field sheets (if used) and other records should be maintained by company/agency. A electronic copy should be maintained at the University of Alberta. A journal should be maintained for all visits and other events affecting the installation.

- All fields must be completed for all tree records.
- Do not place notes or text in any data field.
- Use only approved codes and abbreviations.
- Use the Field abbreviations found in Table 13 (column label: Abbr) as field names in the database manager or place the names in the first row of the data file or spreadsheet.
- Check for validity of entries for each field. Table 13 provides a guide.
- Leave blank only those items not applicable or not measured.

7.1 Proposed Data Management Procedures May 2002

MIKE: from your separate document of last year

1) Move to single database platform. Microsoft Access (version 2000).

2) Develop a data input screen in Access, with data checking and validation routines.

3) Review current data capture procedures (ie. data loggers) and coordinate their use with access.

4) Review and Amend current database structure to address future needs.
    a. Issue: Expansion to Tree Condition codes 4 and 5. There are instances that tree condition codes 1,2 and 3 are all filled. This may result applicable condition codes not being recorded because of a lack of space.
    b. Issue: Addition of Growth Year to database structure. Measurement year and growth year must not always correspond. To maintain clarity in the database, both measurement year and growth year should be tracked.
    c. Issue: Addition of treatment year. The fact the treatment year varies between agencies and even within agencies, tracking these within the database removes the chance for error.

5) Within each Members database carry out Data Integrity Checks
    a. Confirm data integrity through data checks and summaries
    b. Confirm that data field naming conventions are maintained
    c. Confirm that field type characteristics (text vs numeric) are maintained
    d. Confirm that consistent units of measure are being used
    e. Remove extraneous fields
    f. Combine Aspen and Spruce Records into one database per Member
    g. Create 3 tables within each database, AW, SW and AWSW

    The above points a through g would be handled as part of adopting a common database program (Access) and database template.

6) Establishment of two meta-databases. Microsoft Access. Meta-databases maintain a history of changes to a database. Essentially, any change made to a database is logged as an event. The meta-database structure will be developed by the U of A and made available to all members.
    a. Each Member will maintain a meta-database tracking alterations/changes made to their respective database.
    b. The U of A will maintain a meta-database tracking the correspondence and recommendation made to each Member.

7) Database maintenance, updates and corrections will be the responsibility of each Member.

8) Use of CD burning technology to establish date stamped datasets. Each Member will burn and new CD with Current Database and Meta-database.
    a. This will be done every time a new year of data has been input
    b. When significant changes/error corrections have been made

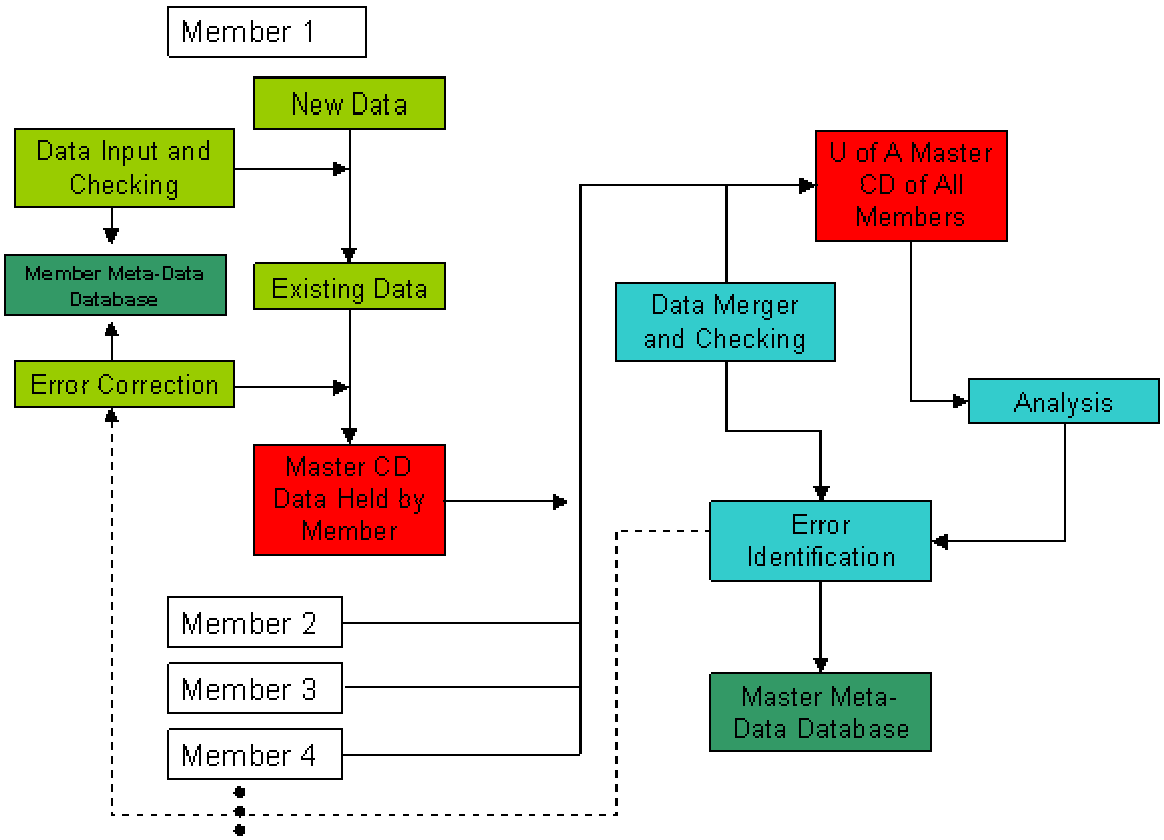
9) Data analysis will be done using date stamp CDs provided by each Member.

10) Data errors found during data analysis, will be logged in the U of A meta-database and forwarded to each Member for correction.

11) The U of A will develop routines to interactively append together Member databases. The U of A will also maintain a master database of all appended Member databases including a meta-database.

12) The facilitation of the above protocols will be coordinated by the U of A with the cooperation of the Members and/or their consultants.

13) Flow Diagram of Roles and Responsibilities of Members and the U of A



7.2 Examples and discussion

Table 14 lists examples of common mistakes and unsuitable formats of data entry. The corresponding corrections are shown in Table 15. 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 15, 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 13 Summary of data fields

Variable	Abbr	Allowable values or range	Required entry
Record type	**RTYP**	00-99	*
Agency	**AGCY**	see Table 10	*
Block	**BLK**	01-24	*
Installation	**INST**	MED, SUP	*
Replication	**REPL**	01,02	*
Plot Number	**PLOT**	01-15	*
Date	**DATE**	8 digits (yyyymmdd)	*

tree number	**TRNO**	6 digits	*
Species	**SPP**	See Table 11	*
Establishment Type	**EST**	See Table 12	*
Root Collar Diameter (cm)	**RCD**	0.0-5.0	
Diameter at 1.3 m ht (cm)	**DBH**	0.0-100.0	
Height, total (m)	**HT**	0.00-100.00	
Height Increment (cm)	**HTI**	0.0-200.0	
North crown radius (m)	**CRN**	0.0-30.0	
West crown radius (m)	**CRW**	0.0-30.0	
Height to live crown (m)	**HTLC**	0.00-100.0	
Condition Code	**CC1** **CC2** **CC3**	00-99	* at least one condition code is required.
Azimuth (degrees)	**AZ**	0-360	
Distance (m)	**DIS**	0-28-m	
Age	**AGE**	0-100	*

Table 14 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 15 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

7.3 Access Data Template

In order to standardize data entry and avoid the errors, we would like you to use the ACCESS standard data template, which we will send it to you separately, to store the WESBOGY long-term data. This standard data template looks as the same as WESBOY Standard Data Form (Table 8), but it works under ACCESS interface.

In this template, validation rules were set to minimize errors or out-of-range data. It has the restriction for data entry. If you enter a wrong data, it will complain, and tell you it is incorrect entry. Please do not make any change in this template. We recommend you use it AS IS.

7.4 *Appendix: LTS data dictionary*

MIKE: I'd like to compress this and delete the "Description" column to avoid duplicate descriptions. Hope you agree. Should an ACCESS list replace this table?

VARIABLE	VARIABLE NAME	FIELD TYPE	FIELD WIDTH	# of DECIMALS	UNITS	DESCRIPTION
RTYP	RECORD TYPE	Numeric	2			Denotes the various types of data collected. 01 Site Description (Form 15B) 02 Soils data (Form 16B) 05 Vegetation data (Form 14B) 09 Individual Tree data before thinning 10 Individual Tree data after thinning 11 Aspen data from sub-plots
AGCY	AGENCY	Character	6			Denotes the agency or company responsible for this particular block of plots. AFS Alberta Lands and Forest Services, Timber Management Division, Edmonton ALP Alberta-Pacific Forest Industries Inc Boyle CFR Canadian Forest Products Ltd, Alberta Operations Grande Prairie 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 sets up and maintains one or more blocks. Enter a 2-digit number. If there is only one block installed, 01 should be in this field.
INST	INSTALLATION	Character	3			SUP: for the superior site MED: for the medium site
REPL	REPLICATION	Numeric	2			01 for replication number 1 02 for replication number 2
PLOT	PLOT	Numeric	2			Plot numbers 01 to 15
DATE	DATE	Numeric	8			Record as year/month/day. For example 19901009 translates to October 9th, 1990.
TRNO	TREE NUMBER	Numeric	7			A six-digit code consisting of the row number (2 digits), tree number (2 digits) and ingress (2 digits). For example 0103500.
SPP	SPECIES	Character	2			Denotes tree species 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

VARIABLE	VARIABLE NAME	FIELD TYPE	FIELD WIDTH	# of DECIMALS	UNITS	DESCRIPTION
						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. ‘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		Root collar diameter to 0.1 cm using calipers (see page 14).
DBH	DBH	Numeric		1	Centimetres	Diameter at breast height to the nearest 0.1 cm (see page 15).
HT	TOTAL HEIGHT	Numeric		1	Metres	Total height should be recorded to the nearest 0.01 m when the tree height is ≤ 3 m, and to the nearest 0.1 m when it is >3 m (see page 15).
HTI	HEIGHT INCREMENT	Numeric		1	Centimetres	Height increment (length of current year’s growth) is recorded to the nearest centimeter (see page 15).
CRN	NORTH CROWN RADIUS	Numeric		2	Metres	Live crown radius from stem to northern edge of crown - to the nearest 0.01 m (see page 15).
CRW	WEST CROWN RADIUS	Numeric		2	Metres	Live crown radius from stem to western edge of crown - to the nearest 0.01 m (see page 15).
HTLC	HEIGHT TO LIVE CROWN	Numeric		2 and 1	Metres	Height to live crown (distance from ground level to first significant branching) to the nearest 0.01 m when the tree height is ≤ 3 m, and to the nearest 0.1 m when it is >3 m (see page 15).
CC1 CC2 CC3	CONDITION CODES	Numeric	2			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. This is a two-digit number field (see page 16 and 22; appendix E and F). 00* Normal, healthy tree. 26 Missing 29 Cut down 27 Dead and Down 25 Standing Dead 17 Dying 40* Frost heaving 51* Frost damage. 09 Bark beetles 01 Conks/Blind Conks 03 Stem Cankers 04 Mistletoe 21 Insect attack 30* white pine weevil

VARIABLE	VARIABLE NAME	FIELD TYPE	FIELD WIDTH	# of DECIMALS	UNITS	DESCRIPTION
						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 lader 19 Broken top (above 10 cm top dib) 20 Animal or mechanical damage 08 Foliar disease 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 Same stump 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
AZ	AZIMUTH	Numeric	3		Degrees	Azimuth from plot centre to a tree (stem mapping) is recorded from 1-360 degrees using a compass (see page 16).
DIS	DISTANCE	Numeric		1	Metres	Distance from plot centre to a tree is measured to the nearest 0.1 m using a metric tape (see page 16).
AGE	AGE	Numeric	2			The age of the planted stock will be known and should be recorded when the seedlings are first measured at time of planting. Age for aspen is recorded when the plot was established.

8 References

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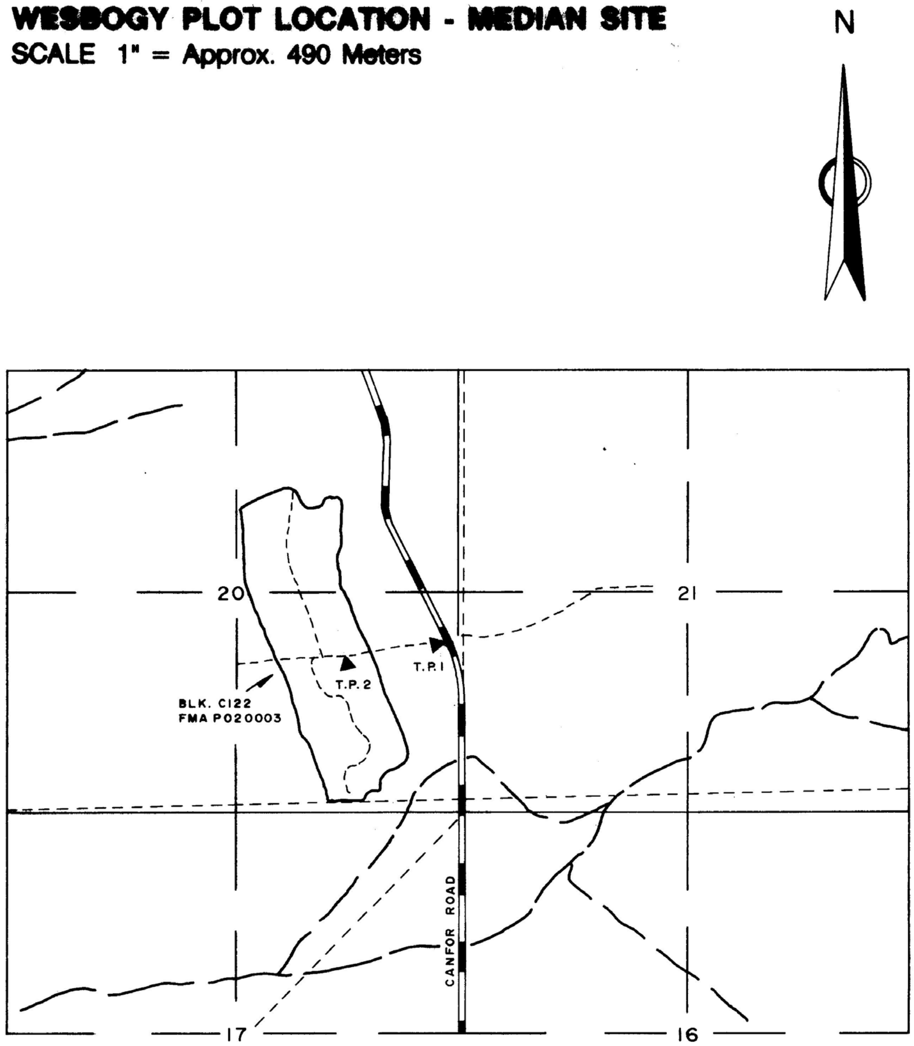
9 Appendices

9.1 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**

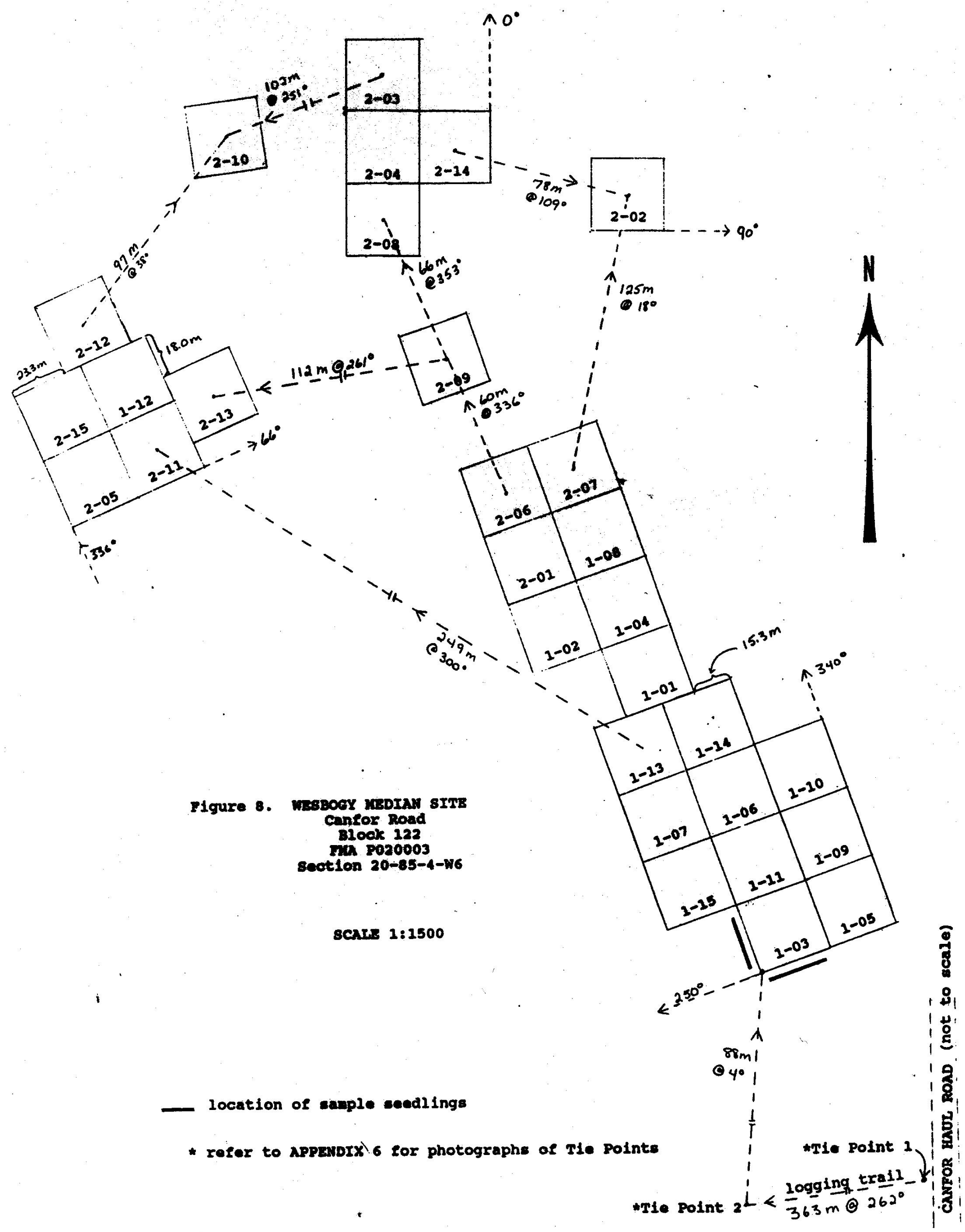


Figure 8. WESBOGY MEDIAN SITE
Canfor Road
Block 122
FMA P020003
Section 20-85-4-W6

SCALE 1:1500

— location of sample seedlings

* refer to APPENDIX 6 for photographs of Tie Points

12

9.2 List of existing and proposed condition codes

OVERVIEW TO PROPOSED REVISIONS:

I include here both the existing WESBOGY codes and the proposed codes that have been recently revised and adopted by ASRD/LFD. 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. The second table below lists our codes in numeric order and also provides a column of corresponding new ASRD/LFD codes with comments on how the two relate. In appendix 9.3, I have also included the more detailed descriptions of both new and old codes to allow more detailed comparison of the similarities and differences.

If adopted, it is proposed that the new codes become effective in June of 2004. Measurements taken after that date would be using the new codes and earlier measurement would retain the old codes until a time when the old codes can be replaced with new ones. In the interim, combined data analysis requiring tree condition codes and measurements before and after 2004 would be based on the correspondence Table 17 below.

Table 16, Current WESBOGY LTS tree condition codes (in priority order; * indicates new codes)

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 17, Correspondence table for existing (WESBOGY) and proposed (ASRD/LFD) tree condition codes

New	Old	Old description	Comment relating old to new codes
00	00	*Normal, healthy tree.	identical
51	01	Conks/Blind Conks	identical
67	02	Scars	Closed scars (DBH > 9.1cm)
63	03	Stem Cankers	Stem disease
02-9x	04	Mistletoe	Second CC 91-96 Hawksworth Mistletoe Rating System
20	05	Root rot	Armillaria
63	06	Rotten branches	Stem disease
16? 27	07	Dieback	27=dieback with NEW leader
02, 65	08	Foliar disease Condition Code 2 should identify pathogen species Condition Code 3 should indicate severity (1=light, 2=moderate, 3=severe)	Second CC identifies pathogen
01-62	09	Bark beetles	Second CC identifies species
48	10	Frost crack	Identical
08	11	Wind shake (windthrow)	Windthrow
53	12	Burls and Galls	DBH > 9.1cm
54	13	Fork	Fork (DIB>7.0cm 2.5 m past crook)
55	14	Pronounced crook	DIB>7.0cm 2.5 m past crook
46	15	Sweep/Bend	Sweep/bow
	16	Spiral grain	
49	17	Dying	Identical
16	18	Dead top	Dead top/dieback
59?	19	Broken top (above 10 cm top dib)	Broken Stem (DIB >=10cm at break)
03,41,42,43	20	Animal or mechanical damage	Second CC identifies agent
01-64	21	Insect attack Condition	Second cc identifies species
57	22	Limby	DBH>9.1cm
35, 58	23	Leaning	Leaning (DBH>9.cm)
56	24	Broken stem (below 10 cm top dib)	DIB<=10cm at break
25	25	Standing Dead On first coding, Condition Code 2 should indicate cause of death. List may be desirable here...	
15	26	Missing	Identical
61	27	Dead and Down	DBH>9.1cm
28	28	Sucker(s) from old stump (forked below dbh)	Almost identical
29	29	Cut down	Identical
30	30	*White pine weevil	Terminal Weevil
27	31	*Spruce bud midge	Dead top with new leader
01-82	32	*Yellow-headed spruce sawfly	Identical
39	39	DBH taken on new leader	Identical
13	40	*Frost heaving	Identical
22	41	Bushy top (multiple leaders)	Identical
27	42	Dead top, lateral branch has become dominant leader	New leader?
16?	51	*Frost damage.	Dead top/dieback? Frost heaving (13)
06	71	Fire damage	Identical
10	72	Flooding damage	Identical
11	73	Poor Planting	Identical
14	74	Erosion	Identical
12	75	Suppression	Identical
17	77	Poor Seedbed	Identical
18	78	Herbicide	Identical
23	79	Poor Form	Identical
29	88	Removed (Thinned)	Cut down
Delete	99	Dead/Down 2nd time	

The following tree condition codes are those adopted for the ASRD, LDF PSP measurement manual. They are more comprehensive than the one we currently use and may be a more "standard" improvement. Codes are listed in numeric order. Priority in specifying the code should be by order of influence on growth of the tree. An alternative list is provided below based on LFD PSP measurement manual (2002). Additional descriptions are found in Table 20; however, the published manual includes some additional details and diagrams that we may try to incorporate in our manual.

"Condition codes are recorded in the following priority (i.e. a tree may have 5 conditions yet there is only room to record 3, so the codes are recorded in order of priority). Record the remaining codes in the comments section on the tally sheet."

Table 18, 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
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 (DIB>7.0cm-2.5m past fork)
07	Mechanical		55	Pronounced Crook (DIB 7.0cm-2.5m past crook)
08	Windthrow		56	Broken Top (<=10cm DIB at Break)(NO CC)
09	Climate		57	Limby (DBH>9.1cm)
10	Flooding		58	Leaning (DBH>9.1cm + if sever NO CC)
11	Poor Planting		59	Broken Stem (>+10cm DIB at Break)(NO CC)
12	Suppression		60	Generic woodpecker feeding
13	Frost Heaving		61	Dead and Down (NO CC) DBH>9.1cm)
14	Erosion		62	Stem Insects
15	Missing		63	Stem Disease
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 (DBH 9.1cm)
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/Vegetation press		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		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/Bend		99	Do not look for tree

Notes:
No CC means no crown class.

9.3 Description of tree condition codes

Table 19, Description of current 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).

Table 20, ASRD Condition Code Descriptions (Their section 4.6)

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.

Condition Code	Description
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 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	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

Condition Code	Description
	(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 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.
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. Open scars are illustrated in Figure 4.4. 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. A burl is illustrated in Figure 4.5. 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. Figure 4.6 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 as shown in Figure 4.7. 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 (see Figure 4.8). 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)	Figure 4.17 also indicates feeding by woodpeckers. 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 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

Condition Code	Description
	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 (Figure 6.10). 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 (see Figure 4.10), 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 (see Figure 4.11). 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 Stem Form Defects DBH ≥ 9.1 cm	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. 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.

Condition Code	Description
	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 only 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 (as indicated in the figures below) are thought to occur towards the base of the tree (Rangen and Roy 1997). Excavated holes indicate subcambial penetration (holes penetrate beneath the bark and into the sapwood) and

Condition Code	Description
	large wood chips can be associated with excavations. Excavated feeding holes can be large (Figure 4.20). 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 such as that indicated in Figure 4.20. 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 (i.e. restricted, such as in Figure 4.20).
85 Yellow-bellied sapsucker feeding	Figure 4.18 illustrates the 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)	Figure 4.19 is an example of feeding by hare on small saplings. In this case the bark was bitten off. 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 in a manner similar to that in Figures 4.19; 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 (Figure 4.21), 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 (see Figure 4.22 for an example). 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. Figure 4.13 illustrates the effect resulting from mistletoe infestations and the individual flowering plant. The Hawksworth Rating System for mistletoe is used to determine the severity of mistletoe infestation on individual trees. Figure 6.15 outlines instructions and gives an example of the use of the 6-class mistletoe rating systems (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	

9.4 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 **Error! Reference source not found.**

9.4.1 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 9-1 attached as Appendix A).

9.4.2 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 9-2 attached as Appendix A). 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.

9.4.3 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 may be collected with the first measurement

Form 9–1 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

SURFACE EXP.

TEXTURE

SOIL CLASS/

SLOPE/ASPECT

SOIL DRAINAGE

General Comments On Site Characteristics

Form 9–2 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

DEPTH (CM)

1

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

1. Form 9–3 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	