Western Boreal Growth and Yield (WESBOGY) Association

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

Experimental Design, Data Collection and Database Maintenance Manual

September 2, 2007

PREFACE to version of August 2007 Version

Restructured to be more chronological
Quick Reference Guide

Update on Veterans and ingress removal

Clearer reference to Map deliverables

Terminology – Installation Establishment and Re-measurement

GPS

Inclusion of History Table as part of the LTS database

Ingress no longer permitted

Site/Soils/Vegetation – schedule and protocol

Aging an installation

HTI
RCD
New Fields (recno,updated,re-measurement,biological age)

Updated treatment flow diagram

Rely on PSP manual and Ecological Land Survey Site Description Manual for technical guidelines

Site index of reserve blocks – need reference manual

FAQ

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Introduction

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

2 Nature of the WESBOGY long-term Research

2.1 Value of Work

This long-term research project is a regional cooperative effort by industrial, federal, provincial, and university researchers to evaluate the dynamics of mixedwood stand development following precommercial thinning. 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 establishment and maintenance of installations throughout the region 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 moderately shade tolerant and 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, Filipescu and Comeau 2007), 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 analyzed separately or in combination with other installations. Each installation has two replications of a series of 15 plots as described in Table 3-1.

Table 3-1: Experimental design for a block of plots

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

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

A number of characteristics (constant conditions) will be considered fixed for this experiment. Microsite weeding and tending will be done annually within a 0.5 m radius of the spruce up to and including year 5. All competing vegetation (trees, shrubs, and grass) will be removed once each year. Grass will be clipped and removed in mid-summer. There will be no fertilization. Repellent for rabbits/deer may be used in problem areas. Initial planting of spruce will be at two densities (2000/ha and 1000/ha) corresponding to the high and low treatment densities for spruce. Local seed sources and nurseries will be used for procurement of seedlings. At year five, spruce and aspen will be thinned to treatment densities; the objective is 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 levels of aspen and spruce. Aspen density will be at five levels -- 0, 200, 500, 1500, and 4000 / ha. Spruce density will be at three levels -- 0, 500, and 1000 / ha. Initial planting of spruce will be at two densities (1000/ha and 2000/ha) corresponding to the low and high treatment densities for spruce. At year five, spruce and aspen will be thinned to treatment densities.

Table 3-2 illustrates the combinations of spruce and aspen densities to be measured, and the plot number associated with each treatment. For example, plot 9 will have a white spruce density of 500 stems per hectare and an aspen density of 500 stems per hectare after thinning. Note that the physical location of treatments (plot numbers) must be randomly assigned.

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

Table 3-2 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 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 Aging an Installation and Determining *Measurement Year*

Many factors are involved in the establishment and planting of an installation. These factors include the year and season the original aspen stand was harvested and the season and stock type of the spruce planted. These factors determine the biological age of the spruce and aspen and influence the schedule upon which treatments and measurements are made.

In order to ensure that all agencies are following a common treatment and measurement schedule, each agency assessed the establishment of their installations and fixed the age of the aspen and spruce relative to the first measurement (1 full growing season after establishment). This standardized year is defined as "Measurement Year 1" which then must be related to calendar year. This process explicitly links calendar year to measurement year and assigns the correct age for the spruce and aspen into the future, ignoring replants and ingress. Note: an establishment survey, carried out at the time of planting, is referred to as "Measurement Year 0". Some agencies did not carry out establishment measurements.

Because this process was not done initially (at the time of planting of the spruce), the age of the aspen and spruce relative to the timing of each treatment varies slightly from agency to agency. Appendix 16-1 presents the results of the assessment process by agency and installation[1]. The table relates calendar year to measurement year considering all factors including year and month of aspen harvesting, year and month of spruce planting as well as stock type (if known). Below is an example of how an installation would have been assessed.

Example demonstrating the aging and measurement year determination

There are 3 important points in time to consider when discussing the establishment and maintenance of an installation. These are the year the aspen was harvested, the year the spruce was planted and the year the spacing to treatment density was carried out. These all have potentially important implications when reporting on growth responses.

To determine biological age of the aspen and spruce factors such as:

1 The aging and setting of the measurement year as done at the 2006 LTS workshop in Dawson Creek, B.C.

- Aw[1] – Summer logging versus winter logging and month. Harvesting before August 1st - is assumed to have completed a full season of growth by the fall measurement. Harvesting after August 1st - is assumed to not have completed a full season of growth by fall the measurement.
- Sw[1] - Stock type and season of planting (spring or summer/fall) should be considered when determining age. August 1st is cutoff date for spruce. Therefore, 1 – 0 stock planted in spring is 2 at the fall measurement, 1 - 0 stock planted in the fall will not be 2 until the next years measurement in the fall, 2 – 0 stock planted in spring is 3 at the fall measurement and 2 - 0 stock planted in the fall will not be 3 until the next years measurement in the fall.

Example:

- **Aspen Harvested** in 07/01/88 – July of 1988 (August 1st is cutoff date for aspen), therefore the October measurement is considered 1 biological growth year for Aw.
- **Spruce Planted** in 08/01/91 – Stock is 1-0 - in the fall of 1991 the spruce has a biological age of 1 after the age is adjusted to include the stock age. (Suggested cutoff date for spruce is August 1st to differentiate between Spring and Summer Stock.
- **Aspen Thinned** in 5/10/96 – during the winter of the 4-5th year of spruce growth

Calendar Year	Month	***Measurement Year***	Action	Species measured			Aspen Age relative to Harvest Year	*Biological Sw Age Inc. stock adjustment
				Sw	Aw 6/12/15	Aw Treated		
1988	July		Aw Harvested				0	
	October						1	
1989							2	
1990							3	
1991	August		Sw Planted					1-0 stock
	October	***0***	Establishment Measurement	X	X		4	1
1992		***1***	**1st measurement**	X	X		5	2
1993		***2***		X	X		6	3
1994		***3***		X	X		7	4
1995	October	***4***	Crop Trees Selected and Measured	X	X	X	8	5
1996	May		Plots Thinned					
	October	***5***	Plot 6/12/15 expanded to 2x2	X	X	X	9	6
1997		***6***		X	X	X	10	7
1998		***7***		X	X	X	11	8
1999		***8***		X	X	X	12	9
2000		***9***		X	X	X	13	10
2001		***10***		X	X	X	14	11
2002		***11***			X		15	12
2003		***12***		X	X	X	16	13
2004		***13***			X		17	14
2005		***14***		X	X	X	18	15
2006		***15***			X		19	16
2007		***16***		X	X	X	20	17

*Ignores re-planting

Figure 4-1 Timing of measurements relative to assessed measurement year

Measurement Year 0
Plot establishment
Establishment Survey, Site and Soils

↓

Measurement Years 1-3
Regular Aw measurements for plots (6,12,15)
Regular Sw measurements

↓

Fall of Measurement Year 4
Regular Aw measurements for plots (6,12,15)
Regular Sw measurements
Aw “crop trees” tagged and measured

↓

Winter of Measurement Year 4 to Spring of Year 5
Thin to treatment density
After thinning verify condition code for both Sw and Aw

↓

Fall of Measurement Year 5
First measurement after thinning for both Sw and Aw
Natural Plots (6/12/15) expanded to 2x2 then measured.

↓

Measurement Years 6 -10
Regular annual measurements for both Sw and Aw
Vegetation in Measurement year 6 and 10

↓

Odd Measurement Years 11, 13, 15…on
Continued annual measurement of only Natural Aw plots (6,12,15)

↓

Even Measurement Years 12, 14, 16 …on
All plots measured every second year i.e. year 12, 14, 16…
Vegetation in Measurement year 16

5 Installation Establishment and Measurements for Measurement Year 0

5.1 Installation Selection

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

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

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

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

Wherever possible, a formal reservation should be placed on the installation area both within the agency and with the corresponding provincial land management agency. Where appropriate, activities should be coordinated with the local provincial managers and with other companies working in the forest management unit to avoid conflict with established reforestation requirements.

5.2 Plot and Buffer Establishment

Treatment plots and buffers are located within each cutblock avoiding landings, skid trails and access roads.

5.2.1 Treatment Plots

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

5.2.2 *Buffer strips*

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. Voicu and Comeau (2006) report that influences on soil moisture and light levels likely to impact on spruce growth, extend over a distance less than 40% of the height of adjacent aspen stands and that influences. 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 use either 5 or 10, not a value between these limits (Table 5-1).

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

Treatments and activities applied to the plot are also to be applied in a buffer around each plot. A buffer is desirable to minimize aboveground and belowground influences 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 tree measurements are NOT to be taken in the buffer. 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. The general rule is that any treatment or activity applied to the plot should also be applied in the buffer.

Table 5-1 Specifications for two alternative buffer zones

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

5.2.3 *Plot numbering*

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

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

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

Locate the plot centre post. With a Staff compass (Brunton Pocket Transit or transit) set up at the plot centre, locate the plot and buffer corner posts using the following azimuths and distances (Table 5-2). 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 5-2 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

5.3 Planting and tree numbering of spruce trees

This is in reference to all plots planted with white spruce (all plots except 13, 14, and 15)

Plant local source (wild seedlot collections) spruce at 2000/ha initial density for the high density plots (1-6). Plant local source spruce at 1000/ha initial density for the low density plots (7-12). Planting lines should be marked prior to planting to ensure that lines fall within the plot boundary. The same stock should be used for each installation. Early planning for acquisition of seedling stock is essential.

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

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 ingress between planted stock (in anticipation of ingress). 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 5-1 and

Figure 5-2). Pigtails or other metal stakes should be placed in the ground on the west side of each tree (again, consistency between agencies is desirable). The first line of spruce is that along the west boundary of the plot. From the time of establishment until year 5 when the thinning is undertaken, only the spruce trees are measured (except aspen in natural plots 6, 12 and 15).

Figure 5-1 Numbering white spruce on high density (plots 1-6)

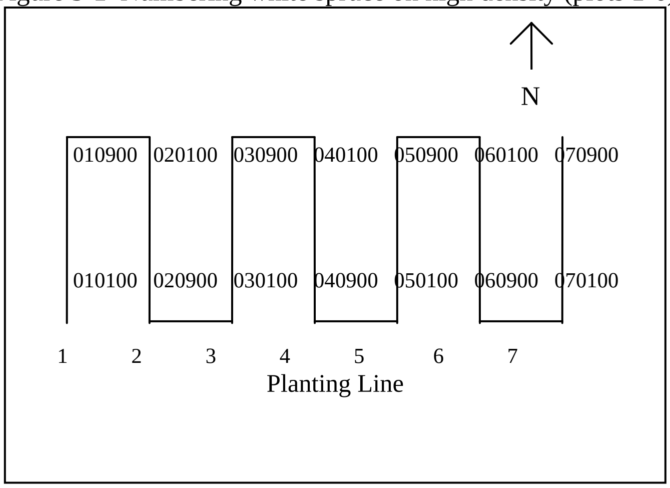
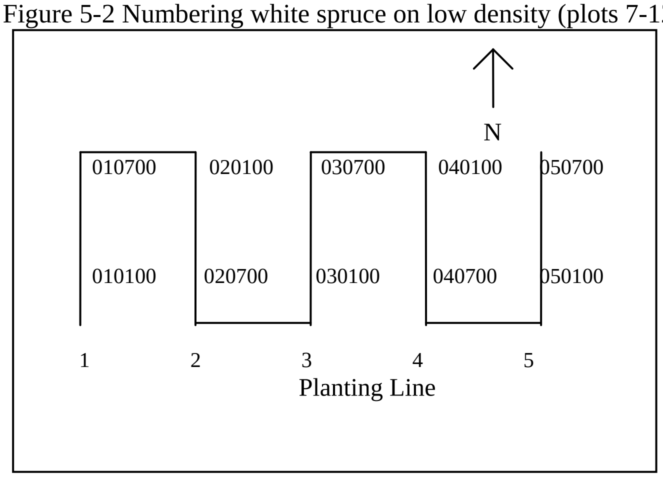


Figure 5-2 Numbering white spruce on low density (plots 7-12)



5.4 White Spruce Plot Establishment Measurements

All spruce are to be measured in the fall (August-October) of the year of plot establishment. This is referred to as the “Establishment Measurement” and only describes the tree characteristics of the growing stock immediately after planting. Note: An “Establishment Measurement” was not done by all Agencies. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables

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

Note: If the study was initiated before 2000, it is important to also read Appendix 16-11 on Natural density aspen subplots established before 2000.

Since aspen 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. Because aspen establishes at high (even excessive) densities and due to the high cost of tree measurements small subplots are required to keep the number of aspen trees measured at an acceptable level. For this reason, up to the time of thinning to treatment density, aspen are only measured in subplots of the natural aspen density plots (6, 12 and 15).

The use of small subplots makes it difficult to describe some stand characteristics (e.g. top height) since the largest trees are not well sampled. As density declines with age, expansion of these subplots up to the full plot size is desirable to better match with the data from the treated plots. A detailed description of plot future expansion methods can be found in Appendix 16-12 and Appendix 16-13.

At plot establishment, the main 20x20m plot is partitioned into four 1x1m subplots in the SW ¼ of the main plot as shown in Figure 5-3. Subplots are numbered 91, 92, 93, and 94. The remaining ¾ of the 20x20m plot is numbered 95. All hardwood trees are consecutively 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) (Figure 3). Record Type is used to indicate the subplot size on the tree data form. Valid Record Types (RTYP) are summarized in Table 5-3.

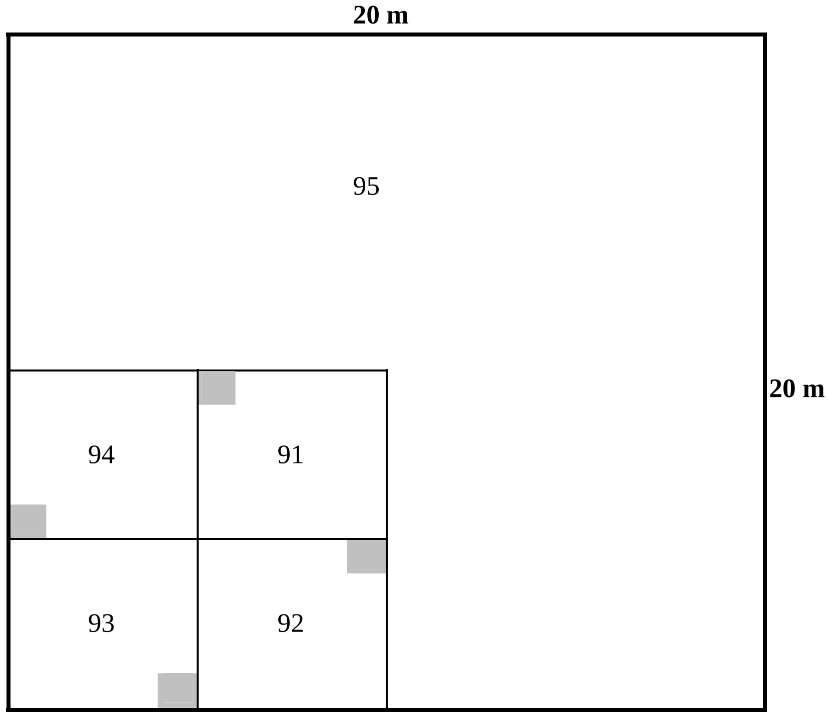
5.6 Aspen Plot Establishment Measurements

All aspen in the 4 – 1x1 subplots established in plot 6, 12 and 15 are to be measured immediately after plot establishment. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

5.7 Plot Tending

Clean and weed the micro-site (0.5 m radius for first 5 years) around each spruce in both plot and buffer until there are no new hardwood sprouts or conifers above the grass/shrub layer. Remove (by cutting) all competing vegetation (trees, shrubs, and grass) in mid-to-late summer (after completion of growth) including removal of dead grass material. Report the approximate number of hardwood trees removed at each visit as well as removal method (hand/brush saw), cost and time. The purpose of the cleaning and weeding is to ensure that planted spruce trees are given the best possible chance to survive over the course of the experiment. This treatment will be applied to all plots (including natural density aspen plots 6 and 12), **EXCEPT** plots with no planted spruce (plots 13 and 14) and the completely untreated plot (plot 15).

Figure 5-3 Un-thinned plots (6, 12, and 15): 1x1 m subplots



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

Table 5-3 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	5-3
5	2x2	.0004=.0003+.0001	22 + 11	8-1
*	5x5	.0025=.0021+.0003+.0001	55 + 22 + 11	
*	20x20	.0400=.03+4*.0021+.0003+.0001	66 + 55 + 22 + 11	
* Not implemented until density declines further (ratified at spring meeting 2003), 2x2 m sub-plots will be used up to at least age 18, pending ongoing review.				
** To indicate that expansion is cumulative. For example, for trees with numbers 92xxxx and Record Type 22, plot size is .0003 ha. Trees with numbers 92xxxx and Record Type 11, are the set of trees found on the 1x1 m (.0001 ha) subplot. The total count of trees in these two sets is the count of trees on the .0004 ha subplot 92.				

5.8 Installation and Plot Location Maps

Location and access should be completely documented using a series of maps of different scales to assist in locating each of the installations and tie points. The maps should be supported by written directions outlining access from a major village/town/city and major tie points. The maps and written descriptions have 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 maps should be digitized.

Three maps are recommended: small scale, medium scale and large scale.

1) A small scale map (approx 1:50,000) showing the relative location of the installation relative to towns/cities with major highways and roads marked (Appendix 16-2). Also include road names and distances to the nearest town or significant tie point.

2) A medium scale map (approx 1:15,000) of the area. 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. Most importantly, tie points used in the large scale map should be clearly identified on this map for reference purposes. Also include road names and distances to the nearest town or significant tie point (Appendix 16-2)

3) A large scale map (approx 1:1500) showing plot locations and their relative position to one another. The map should clearly identify replication and plot number. 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, i.e. culverts or bridges
    - The centre of road junctions
    - Where transmission lines cross roads
    - The point where roads pass into cutblocks

   Tie points with distances and azimuths should be clearly identified on the map (Appendix 16-2) along with written descriptions. The maps initially may be hand drawn but later should be digitized into a GIS.

Aerial photography for reference is desirable, and if possible, they should be recent photos taken after the site was harvested.

5.9 Site and Soils

Site, soil and vegetation information is required to provide descriptive information on the ecological characteristics of each replicate set of treatments. Data collection will use forms and standards presented in the ASRD (2003) "Ecological Land Survey Site Description Manual (2nd Edition)", with modifications as described below. At establishment or soon after, site and soil information should be collected (Unless desired for other purposes, vegetation assessments are completed starting in year 6 as described in section 9,2). It should be noted that prior to 2002, tally sheets site, soils and vegetation were based on a previous version of the Ecological Land Survey Manuals, the previous tally sheets used can be found in Appendix 16-16.

Site Information

For each replication, one site form (Appendix 16-10) should be completed (at the soil pit). The Ecosite to which the replication belongs should be described under "Vegetation Classification" using the field guide that is appropriate for the location of the installation. Be sure to record the field guide that was used. Access (2000) tables templates for Site, Soils and Vegetation will be made available in late 2007. Contact the WESBOGY researcher at the University of Alberta to obtain a copy of the template.

Soils

One soil pit should be established for each replicate. The soil pit should be located in a representative untended area, adjacent to but outside of any of the plots. A full soil description should be completed using the soils form found in Appendix 16-10 . The pit should be filled in and clearly marked for future excavation. Soil samples are not required unless needed to confirm soil classification or soil textures. Access (2000) tables templates for Site, Soils and Vegetation will be made available in late 2007. Contact the WESBOGY researcher at the University of Alberta to obtain a copy of the template.

5.10 Site Index of adjacent reserve blocks

An estimate of site index (SI) from the reserve block should be taken, including documentation on whether top height or site was used in it determination.

5.11 GPS locations

Each plot center and all important tie points must be GPSd. Specifications are UTM NAD83 coordinates with zones specified.

5.12 Plot Maintenance

Any aspen and spruce trees that existed in the stand prior to harvest are considered veterans and should be removed. Any ingress conifers that have naturally regenerated in any of the plots since harvest should also be removed. The only conifers in the plots should be the planted spruce. NOTE: as the installation ages, it may be necessary to accept an ingress spruce or aspen to replace a dead tree.

5.13 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

6 Measurements and Tending during Measurement Years 1, 2, and 3

6.1 Plot Measurements

The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. All spruce and aspen are to be measured after seasonal growth is complete. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables

Table 6-1 summarizes the measurements to be made during re-measurement years 1, 2 and 3.

Table 6-1 Trees to be measured in relation to plot/subplot type and species for years 1, 2 and 3.

	Plot Type	Measured species
	Plots to be treated **(all plots except 6, 12, and 15)**	**Conifer**: All planted Sw **Deciduous**: None
	Untreated - natural plots **(plots 6, 12, and 15)**	**Conifer**: All planted Sw in full (20x20m) plots **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

6.2 Replanting spruce trees

The replanting of spruce is permitted until and including measurement year 4. After measurement year 4 an acceptable natural spruce ingress can be used to replace the dead spruce. The purpose is to maintain densities near to the desired treatment densities. Replacement spruce use the same tree number as the tree being replaced with an appropriate modification to the Establishment and Age fields. The new Establishment field is maintained for the life of the new tree. The replacement stock may come from several sources. Table 6-2 reflects the appropriate stock sources and codes to reflect the status of new tree. If there is a second replacement, the establishment code is modified by adding an additional second identifier, see Table 6-2.

Table 6-2 Acceptable establishment codes for replaced spruce trees

	New Establishment Code	Age	Establishment Code after a second replacement
New Nursery Stock	R	Biological age	RR
Transplants from Buffer	T	Age of transplanted tree	TT
Natural Ingress	I	Assessed in the field	II

6.3 Plot Tending

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 above the grass/shrub layer. Remove all competing vegetation (trees, shrubs, and grass) in mid-to-late summer (after completion of growth) including removal of dead grass material. Report the approximate number of hardwood trees removed at each visit as well as removal method (hand/brush saw), cost and time. The purpose of the cleaning and weeding is to ensure that planted spruce trees are given the best possible chance to survive over the course of the experiment. This treatment will be applied to all plots (including natural density aspen plots 6 and 12), **EXCEPT** plots with no planted spruce (plots 13 and 14) and the completely untreated plot (plot 15).

6.4 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.

6.5 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

7 Measurements and Tending during Measurement Year 4

7.1 Plot Measurements

The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. All spruce and aspen are to be measured after seasonal growth is complete. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

At the time of this measurement, before thinning, aspen crop trees (those that will not removed in the thinning) should be tagged (section 7.2) and measured. Note: In some installations the first measurement of aspen crop trees was deferred to Year 5.

Tree selection should favor potential aspen and spruce crop trees while retaining relatively uniform spacing.

Table 7-1 summarizes the measurements to be made during re-measurement year 4.

Table 7-1 Trees to be measured in relation to plot/subplot type and species in year 4.

	Plot Type	Measured species
	Plots to be treated (all plots except 6, 12, and 15)	**Conifer**: All planted Sw **Deciduous**: All Tagged Aw
	Untreated - natural plots (plots 6, 12, and 15)	**Conifer**: All planted Ss in full (20x20m) plots **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

7.2 Tree numbering of aspen crop trees

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 of any species.

7.3 Replanting spruce trees

The replanting of spruce is permitted until and including measurement year 4. After measurement year 4 an acceptable natural spruce ingress can be used to replace the dead spruce. The purpose is to maintain densities near to the desired treatment densities. Replacement spruce use the same tree number as the tree being replaced with an appropriate modification to the Establishment and Age fields. The new Establishment field is maintained for the life of the new tree. The replacement stock may come from several sources. Table 6-2 reflects the appropriate stock sources and codes to reflect the status of new tree. If there is a second replacement, the establishment code is modified by adding an additional second identifier, see Table 6-2.

7.4 Thinning of Plots

Thinning should be completed before the 5th growing season begins. Aspen trees for all plots, except the natural density aspen plots (6, 12 and 15) should be thinned to the designated treatment densities (Table 3-2). The spruce is thinned to the target densities for all plots.

A complete guide to thinning prepared by Paul Leblanc is provided in Appendix 16-9.

After the thinning has been completed, the condition codes need 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.

7.5 Plot Tending

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

7.6 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.

7.7 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

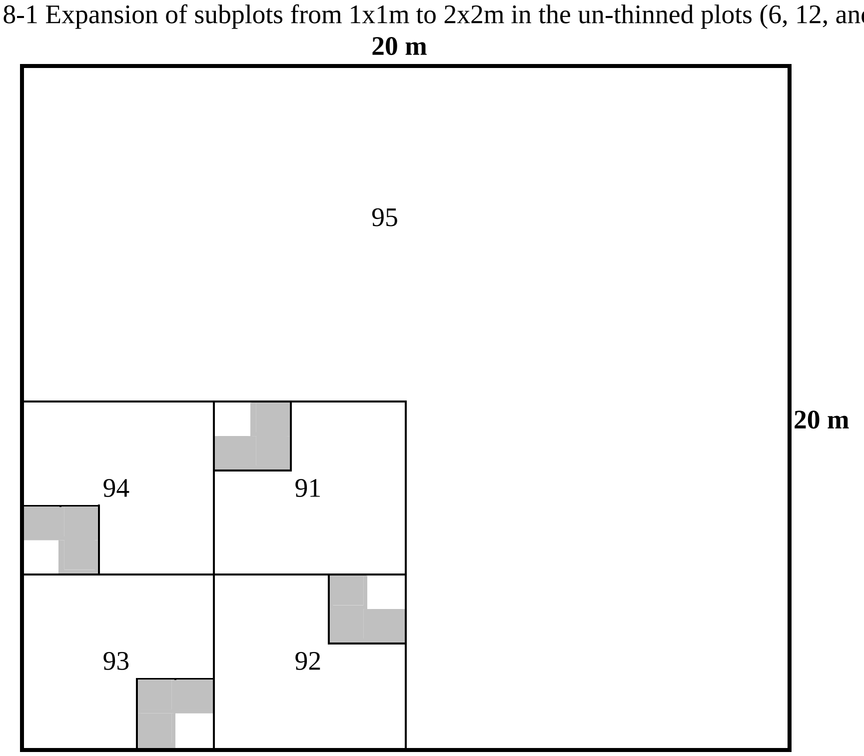
8 Measurements and Tending during Measurement Year 5

8.1 Expansion of natural density aspen Subplots (plots 6, 12, and 15) to 2x2m

Of the 15 plots in the basic treatment combinations, only plots 6, 12, and 15 are maintained at natural levels of aspen density. At plot establishment, the main 20x20m plot was partitioned into four 1x1m subplots in the SW ¼ of the main plot (Figure 5-3). Subplots were numbered 91, 92, 93, and 94. The remaining ¾ of the 20x20m plot was numbered 95. In year 5, the four 1x1m subplots in plots 6, 12 and 15 are expanded to 2x2m keeping the original 1x1m corner posts (Figure 8-1).

A detailed description of plot expansion methods can be found in Appendix 16-12 and Appendix 16-13. Note: If the study was initiated before 2000, it is important to also read the section on Appendix 16-11 on Natural density aspen subplot established before 2000.

Figure 8-1 Expansion of subplots from 1x1m to 2x2m in the un-thinned plots (6, 12, and 15).



Subplots expanded from 1x1m to 2x2 m. New untagged 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.

Tree numbers are consecutive and cumulative as subplots are expanded; see the Figure 8-1 for additional details, and remember that as the subplot size is increased, it is important to continue measuring trees in the smaller subplots. Trees of all hardwood 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). Record

Type is used to indicate the subplot size on the tree data form. Note: The trees located in the original 1x1m plot maintain the RTYP 11 call and the new trees in the 2x2 are marked as 22. Valid Record Types (RTYP) are summarized in Appendix 16-3.

8.2 Plot Measurements

The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. All spruce and aspen are to be measured after seasonal growth is complete. This is the first re-measurement after the thinning and the data file should now show both the Aw and Sw crop trees from all plots. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

Table 8-1 summarizes the measurements to be made during re-measurement year 5.

Table 8-1 Trees to be measured in relation to plot/subplot and species in year 5

	Plot Type	Measured species
	Treated plots **(all plots except 6, 12, and 15)**	**Conifer**: All planted Sw **Deciduous**: All Tagged Aw
	Untreated - natural plots **(plots 6, 12, and 15)**	**Conifer**: All planted Sw in full (20x20m) plots **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

8.3 Plot Tending

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

8.4 Replacement of dead aspen after thinning

The replacement of aspen using natural regeneration, where appropriate, is permitted to maintain treatment densities. This is permitted only after the plots have been treated. The purpose is to maintain densities near to the desired treatment densities. Replacement aspen use the same tree number as the tree being replaced with an appropriate modification to the Establishment and Age fields. The new Establishment field is maintained for the life of the new tree. The replacement tree is considered ingress and given a new Establishment code of "I" for ingress. If there is a second replacement of the tree, the establishment code is modified by adding an additional "I" , i.e. "II".

8.5 Removal of Conifer and Deciduous Ingress

Any conifer or aspen ingress in all plots must be removed before it reaches 1.3m in height. Shrubs are **NOT** removed. Note: where appropriate an aspen or spruce tree can be used to replace a dead aspen or spruce. Appropriate changes to the establishment codes and age are necessary.

8.6 Mapping of tree locations

All tree locations within the plot are to be mapped. However, the trees in the buffers 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 purposes: 1) location of trees at re-measurement time, and 2) evaluation of between-tree competition based on spatial location measures.

Transit and stadia techniques are a reasonable method to map tree locations if completed before aspen get above 2 m or after leaves fall in late summer. Accurate laser survey instruments, with an electronic compass may also be used. Handheld compass cannot be used.

An alternative procedure used by AFS states that "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).

Tree should be mapped from the plot centre or any plot corner as reference points. The use of a single reference point (plot centre) is encouraged.

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

8.7 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.

8.8 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

9 Measurements and Tending during Measurement Year 6

9.1 Plot Measurements

The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. All spruce and aspen are to be measured after seasonal growth is complete The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

Table 9-1 summarizes the measurements to be made during re-measurement year 6.

Table 9-1 Trees to be measured in relation to plot/subplot and species in year 6.

	Plot Type	Measured species
	Treated plots **(all plots except 6, 12, and 15)**	**Conifer**: All planted Sw **Deciduous**: All Tagged Aw
	Untreated - natural plots **(plots 6, 12, and 15)**	**Conifer**: All planted SW in full (20x20m) plots **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

9.2 Vegetation Assessment

Vegetation information is required to provide descriptive information on the ecological characteristics of each replicate set of treatments. Data collection will use forms and standards presented in the ASRD (2003) "Ecological Land Survey Site Description Manual (2nd Edition)", with modifications as described below.). It should be noted that prior to 2002, tally sheets for site, soils and vegetation were based on a previous versions of the Ecological Land Survey Manuals, the previous tally sheets used can be found in Appendix 16-16. Access (2000) tables templates for Site, Soils and Vegetation will be made available in late 2007. Contact the WESBOGY researcher at the University of Alberta to obtain a copy of the template.

Vegetation
Vegetation data will be collected to provide basic descriptive information on the dominant species present on the site using the form found in Appendix 16-10. To provide reasonable sampling of each replication and to obtain a representative sample across the treatment densities – data will be collected within the 20 m x 20 m measurement plots in treatment plots 1, 4, 6, 7, 10, 12, 13 and 15 (0, 1500 and natural aspen density plots). Measurements are to be taken in year 6, 10, and 16, from mid-July to mid-August. Exhaustive and complete species lists within the measurement plots are not needed for this purpose. For each stratum, record cover of the dominant species (all tree species, up to 5 shrubs, and up to 10 herbs, and any bryophytes with greater than 5 % cover). Sedges, willows or other problematic species only have to be identified to genus. Distribution and vigor do not need to be recorded. Total cover and average height is also recorded for each stratum (bottom of front of form).

9.3 Removal of Conifer and Deciduous Ingress

Any conifer or aspen ingress in all plots must be removed before it reaches 1.3m in height. Shrubs are NOT removed. Note: where appropriate an aspen or spruce tree can be used to replace a dead aspen or spruce. Appropriate changes to the establishment codes and age is necessary.

9.4 Installation and plot maintenance

The following items are to be checked at each visit:

1) Check the condition of tags on all the posts, centre and corners. Replace and retag where necessary.
2) Replace any missing tree tags.
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.

9.5 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

10 Measurements and Tending during Measurement Year 7, 8 and 9

10.1 Plot Measurements

The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. All spruce and aspen are to be measured after seasonal growth is complete. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

Table 10-1 summarizes the measurements to be made during re-measurement years 7, 8, and 9.

Table 10-1 Trees to be measured in relation to plot/subplot and species for years 7, 8 and 9.

	Plot Type	Measured species
	Treated plots **(all plots except 6, 12, and 15)**	**Conifer**: All planted Sw **Deciduous**: All Tagged Aw
	Untreated - natural plots **(plots 6, 12, and 15)**	**Conifer**: All planted Sw in full (20x20m) plots **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

10.2 Removal of Conifer and Deciduous Ingress

Any conifer or aspen ingress in all plots must be removed before it reaches 1.3m in height. Shrubs are NOT removed. Note: where appropriate an aspen or spruce tree can be used to replace a dead aspen or spruce. Appropriate changes to the establishment codes and age is necessary.

10.3 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.

10.4 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

11 Measurements and Tending during Measurement Year 10

11.1 Plot Measurements

The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. All spruce and aspen are to be measured after seasonal growth is complete. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

Table 11-1 summarizes the measurements to be made during re-measurement year 10.

Table 11-1 Trees to be measured in relation to plot/subplot and species for year 10

	Plot Type	Measured species
	Treated plots (all plots except 6, 12, and 15)	**Conifer**: All planted Sw **Deciduous**: All Tagged Aw
	Untreated - natural plots (plots 6, 12, and 15)	**Conifer**: All planted Sw in full (20x20m) plots **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

11.2 Vegetation Assessment

Vegetation information is required to provide descriptive information on the ecological characteristics of each replicate set of treatments. Data collection will use forms and standards presented in the ASRD (2003) “Ecological Land Survey Site Description Manual (2^{nd} Edition)”, with modifications as described below. Access (2000) tables templates for Site, Soils and Vegetation will be made available in late 2007. Contact the WESBOGY researcher at the University of Alberta to obtain a copy of the template.

Vegetation
Vegetation data will be collected to provide basic descriptive information on the dominant species present on the site using the form found in Appendix 16-10. To provide reasonable sampling of each replication and to obtain a representative sample across the treatment densities – data will be collected within the 20 m x 20 m measurement plots in treatment plots 1, 4, 6, 7, 10, 12, 13 and 15 (0, 1500 and natural aspen density plots). Measurements are to be taken in year 6, 10, and 16, from mid-July to mid-August. Exhaustive and complete species lists within the measurement plots are not needed for this purpose. For each stratum, record cover of the dominant species (all tree species, up to 5 shrubs, and up to 10 herbs, and any bryophytes with greater than 5 % cover). (Sedges, willows or other problematic species only have to be identified to genus). (Distribution and vigor do not need to be recorded). Total cover and average height is also recorded for each stratum (bottom of front of form).

11.3 Removal of Conifer and Deciduous Ingress

Any conifer or aspen ingress in all plots must be removed before it reaches 1.3m in height. Shrubs are **NOT** removed. Note: where appropriate an aspen or spruce tree can be used to replace a dead aspen or spruce. Appropriate changes to the establishment codes and age is necessary.

11.4 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.

11.5 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

12 Measurements and tending during Odd Measurement Years 11,13,15…

12.1 Plot Measurements

Measurement of aspen in the natural un-thinned sub-plots (6\12\15) will continue annually. Planted spruce is not measured in these plots during the odd years. There is no measurement of spruce or aspen in the thinned plots during the odd years. The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

The natural density aspen plots (6, 12, and 15) will be measured in the odd years 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 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.

Table 12-1summarizes the measurements to be made during re-measurement years 11, 13, 15,. ...

Table 12-1 Trees to be measured in relation to plot/subplot, species for odd numbered years from age 11 onwards

	Plot Type	Measured species
	Treated plots **(all plots except 6, 12, and 15)**	**Conifer**: None **Deciduous**: None
	Untreated - natural plots **(plots 6, 12, and 15)**	**Conifer**: None **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

12.2 Removal of Conifer and Deciduous Ingress

Any conifer or aspen ingress in all plots must be removed before it reaches 1.3m in height. Shrubs are NOT removed. Note: where appropriate an aspen or spruce tree can be used to replace a dead aspen or spruce. Appropriate changes to the establishment codes and age is necessary.

12.3 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.

12.4 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

13 Measurements and Tending during Even Measurement Years 12, 14, 16…

13.1 Plot Measurements

Complete measurement of both spruce and aspen in both the thinned and un-thinned plots will occur during the even years beginning in year 12. The normal measurement time is late summer or fall, but could be as late as the following early spring before growth begins. The LTS data dictionary (Appendix 16-3) describes the tree measurement and related variables.

Table 13-1 summarizes the measurements to be made during re-measurement years 12, 14, 16, …..

Table 13-1 Trees to be measured in relation to plot/subplot, for even numbered years from age 12 onwards.

	Plot Type	Measured species
	Treated plots **(all plots except 6, 12, and 15)**	**Conifer**: All planted Sw **Deciduous**: All Tagged Aw
	Untreated - natural plots **(plots 6, 12, and 15)**	**Conifer**: All planted SW in full (20x20m) plots **Deciduous in subplots 91, 92, 93, and 94**: All deciduous species.

13.2 Removal of Conifer and Deciduous Ingress

Any conifer or aspen ingress in all plots must be removed before it reaches 1.3m in height. Shrubs are NOT removed. Note: where appropriate an aspen or spruce tree can be used to replace a dead aspen or spruce. Appropriate changes to the establishment codes and age is necessary.

13.3 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.

13.4 Maintenance of a Field Journal

A journal should be maintained for all visits and other events affecting the installation.
The plot history table (Appendix 16-6) should be maintained and submitted annually with the LTS data.

14 Data processing and maintenance protocols

14.1 Data processing procedures

Annually collected data will follow the process outlined in Figure 4-1. The flow diagram outlines the 8 steps involved in managing WESBOGY LTS data.

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

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

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

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

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

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

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

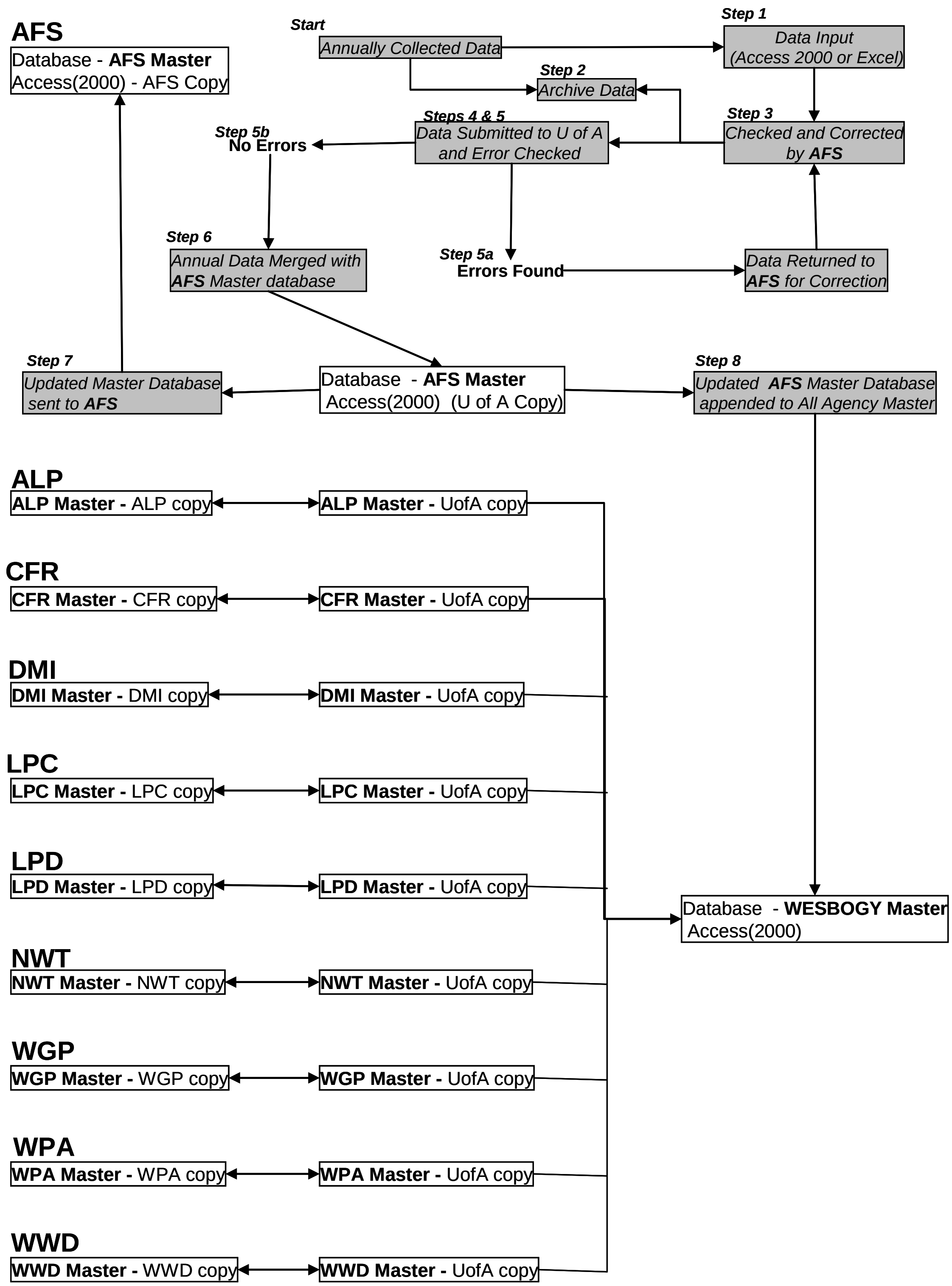
Step 5b: If No Errors Found - If no errors are found proceed to step 6.

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

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

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

Figure 14-1 Flow diagram describing the steps involved in processing data



14.2 Microsoft Access Database Structure

Appendix 16-5 outlines the data structure (field names, type and size) for the Microsoft Access 2000 database.

14.3 Data Error Checking Procedures

The objective of the data error checking procedures is to create a consistent and error-free databases for all agencies which would facilitate efficient data management and analysis. A description and discussion of common errors made can be found in Appendix 16-7.
The criteria used to error check the database is provided in Appendix 16-8.

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

1. DATA FORMAT: Ensured that the database structure, naming conventions and field parameters were consistent over all agencies. This section also deals with the presence of extraneous fields. This is a requirement when all individual databases are appended to one another to create the WESBOGY master database. Appendix 16-5 describes the approved database structure, naming conventions and field attributes.

2. DATA CODING: Ensured that only permitted field codes and abbreviations were used within a particular field. Appendix 16-3 and Appendix 16-4 describes the permitted field codes for each of the discrete fields within the database.

3. UNITS of MEASURE: Ensured that the units of measure were consistent within each agency over all measurement years. Appendix 16-3 summarizes the units of measure for each of the continuous fields within the database.

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

5. Tree Numbers and Measurements: Errors caused by incorrect tree numbers can disrupt the annual measurement schedule. Error in tree numbering can either create duplicates in records or drop measurements. This process ensures that a tree has correct tree numbers and that remeasurements over time are complete.

14.4 Error Checking Database

The error checking process requires that any changes made to the database are methodically and carefully made. In order to facilitate this process, within the main database, additional fields are added. Appendix 16-8 lists the new fields created, their type and size. The fields are followed by an "_O" represent the "original values" for comparison and checking purposes. The "ERRXXX" fields are error fields that will be populated with either an Err, Err0, Err1 or Err2. The following are the definitions for these errors.

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

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

Where

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

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

15 References

WESBOGY Publications

Mike Bokalo, Philip G. Comeau, Stephen J. Titus. **2007.** Early development of tended mixtures of aspen and spruce in western Canadian boreal forests For. Ecol. Manage. 242, 175-184.

Cosmin N. Filipescu, and Philip G. Comeau, **2007**. Aspen competition effects light and white spruce growth across several boreal sites in western Canada (in press CJFR).

Voicu, M. and P.G. Comeau. **2006.** Microclimatic and spruce growth gradients adjacent to young aspen stands. Forest Ecol. Manage. 221: 13-26.

Comeau, P., Bokalo, M. and Titus. S. **2004.** Early dynamics of tended mixedwood stands. Enhanced Forest Management Research Note, Department of Renewable Resources, Note 06/2004

Reference Material

Berry, A.B. 1987. Plantation white spruce variable density volume and biomass yield tables to age 60 at the Petawawa National Forestry Int. Can. For. Serv. Info. Rep P1-X-71.

Day, R.F. and Bell, F.W. 1988. Development of crop plans for hardwood and conifer stands on boreal mixedwood sits. In Samoil J.K. (Ed.). Management and Utilization of northern mixedwoods. Forestry Canada Info. Rep. NOR-X-296. pp. 87-98.

Drew, J.J. 1988. Managing white spruce in Alberta's mixedwood forest: the dilemma. In J.K. Samoil (Ed.) Management and utilization of northern mixedwood. Forestry Canada Inf. Rep. NOR-X-296. pp. 35-40.

Fowells, H.A. 1965. Silvics of forest trees of the United States. USDA For. Serv. Handbook No. 271.

Gibson, I.A.S. and Jones, T. 1977. Monocultures as the origin of major forest pests and diseases. In origins of pests, parasite, disease and weed problems. J.M. Cherrett and G.R. Sagar (Eds.) Blackwell Scientific Pub. Oxford. Pp. 139-16.

Kabzems A., Kosawan, A.L. and Harris W.c. 1986. Mixedwood section in an ecological perspective: Saskatchewan. Can. For. Serv. and Sask. Parks Renew. Res., For. Div. Tech. Bull. 8, Second Edition.

Kelty, M.J. 1989. Productivity of New England hemlock/hardwood stands as affected by species composition and canopy structure. For. Ecol. Manage. 28: 237-257.

Munn-Kristoff, M.J., D. Kuhnake, G.B. Maier. 1988. A comparison of permanent plot procedures of various forestry agencies in western Canada. Internal repot for Alberta Growth and Yield Co-op.

Savill, P.S. and Evans, J. 1986. Plantation silviculture in temperate regions. Clarendon Press. Oxford.

Schier, G.A. 1981. Physiological research on adventitious shoot development in aspen roots. USDA For. Serv. Gen. Tech. Rep. INT 107.

Strong and LaRoi. 1983. CJFR 13:1164-1173.

Valentine, K.W.G., Sprout, R.N., Baker, T.E., and L.M. Lavkulich. (Eds.). 1978. The soil landscapes of British Columbia. B.C. Min. Environ., Resource Anal. Br., Victoria, B.C.

Vandermeer, J. 1989. The ecology of intercropping. Cambridge University Press. New York.

Oliver, C.D. and B.C. Larson. 1996. Forest Stand Dynamics. McGraw-Hill, New York. 520p.

Smith, D.M., B.C. Larson, M.J. Kelty, and P.M.S. Ashton. 1997. The practice of Silviculture: Applied Forest Ecology, 9th ed. Wiley and Sons, New York. 537p.

16 Appendices

Appendix 16-1 Results of the installation age assessment process by agency and installation

ALP	**Date Aspen**	**Date Spruce**								**Thinned July of 00**
	Harvested	**Planted**	**Calendar Year**	1994	1995	1996	1997	1998	1999	2000
	Dec-93	Jun-94	**Measurement Year**	**0 and 1**	**2**	**3**	**4**	**5**	**6**	**7**
Aw Age at 1	1		**Aspen Age**	no	2	3	4	5	6	7
Sw Age at 1		2	**Spruce Age**	no	3	4	5	6	7	8
	Date Aspen	**Date Spruce**								**Thinned July of 06**
	Harvested	**Planted**	**Calendar Year**	2001	2002	2003	2004	2005	2006	2007
	Jan-01	Jul-01	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	2		**Aspen Age**	yes	2	3	4	5	6	7
Sw Age at 1		2	**Spruce Age**	yes	2	3	4	5	6	7

CFR	**Date Aspen**	**Date Spruce**								**Thinning Sept of 05**
	Harvested	**Planted**	**Calendar Year**	2000	2001	2002	2003	2004	2005	2006
	Jun-98	Jul-00	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	4		**Aspen Age**	yes	4	5	6	7	8	9
Sw Age at 1		3	**Spruce Age**	yes	3	4	5	6	7	8
	Date Aspen	**Date Spruce**								**Thinning Sept of 06**
	Harvested	**Planted**	**Calendar Year**	2001	2002	2003	2004	2005	2006	2007
	Jun-98	Jul-01	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	5		**Aspen Age**	yes	5	6	7	8	9	10
Sw Age at 1		3	**Spruce Age**	yes	3	4	5	6	7	8

DMI	**Date Aspen**	**Date Spruce**								**Thinned July of 98**
	Harvested	**Planted**	**Calendar Year**	1992	1993	1994	1995	1996	1997	1998
	Oct-91	Jul-92	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	2		**Aspen Age**	yes	2	3	4	5	6	7
Sw Age at 1		2	**Spruce Age**	yes	2	3	4	5	6	7

LPDC	**Date Aspen**	**Date Spruce**								**Thinned Aug of 05**
	Harvested	**Planted**	**Calendar Year**	2001	2001	2002	2003	2004	2005	2006
med	Jan-01	May-01	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	1		**Aspen Age**	no	1	2	3	4	5	6
Sw Age at 1		2	**Spruce Age**	no	2	3	4	5	6	7
	Date Aspen	**Date Spruce**								
	Harvested	**Planted**	**Calendar Year**	2004	2004	2005	2006	2007		
sup	Feb-04	May-04	**Measurement Year**	**0**	**1**	**2**	**3**	**4**		
Aw Age at 1	1		**Aspen Age**	no	1	2	3	4		
Sw Age at 1		3	**Spruce Age**	no	3	4	5	6		

LPSR	**Date Aspen**	**Date Spruce**								**Thinning May of 04**
	Harvested	**Planted**	**Calendar Year**	1998	1999	2000	2001	2002	2003	2004
	Aug-96	Sep-98	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	3		**Aspen Age**	yes	3	4	5	6	7	8
Sw Age at 1		2	**Spruce Age**	yes	2	3	4	5	6	7

NWT	**Date Aspen**	**Date Spruce**							**Thinned May of 98**	
	Burned	**Planted**	**Calendar Year**	1993	1994	1995	1996	1997	1998	1999
	Apr-92	Jul-93	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	3		**Aspen Age**	yes	3	4	5	6	7	8
Sw Age at 1		3	**Spruce Age**	yes	3	4	5	6	7	8

SRD	**Date Aspen**	**Date Spruce**								**Thinned Oct of 97**
	Harvested	**Planted**	**Calendar Year**	1992	1993	1994	1995	1996	1997	1998
	Jun-91	Aug-92	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	2		**Aspen Age**	yes	2	3	4	5	6	7
Sw Age at 1		2	**Spruce Age**	yes	2	3	4	5	6	7

WBR	**Date Aspen**	**Date Spruce**							**Thinning Fall of 96**	
	Harvested	**Planted**	**Calendar Year**	1992	1993	1994	1995	1996	1997	1998
	Jun-92	Fall 92	**Measurement Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	1		**Aspen Age**	yes	1	2	3	4	5	6
Sw Age at 1		2	**Spruce Age**	yes	2	3	4	5	6	7

continued on next page….

WFR	Date Aspen	Date Spruce							Thinning Aug of 96	
	Harvested	Planted	Calendar Year	*1993*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
med	1989	Jun-93	Measurement Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	4		Aspen Age	yes	4	5	6	7	8	9
Sw Age at 1		*2*	Spruce Age	yes	*2*	*3*	*4*	*5*	*6*	7

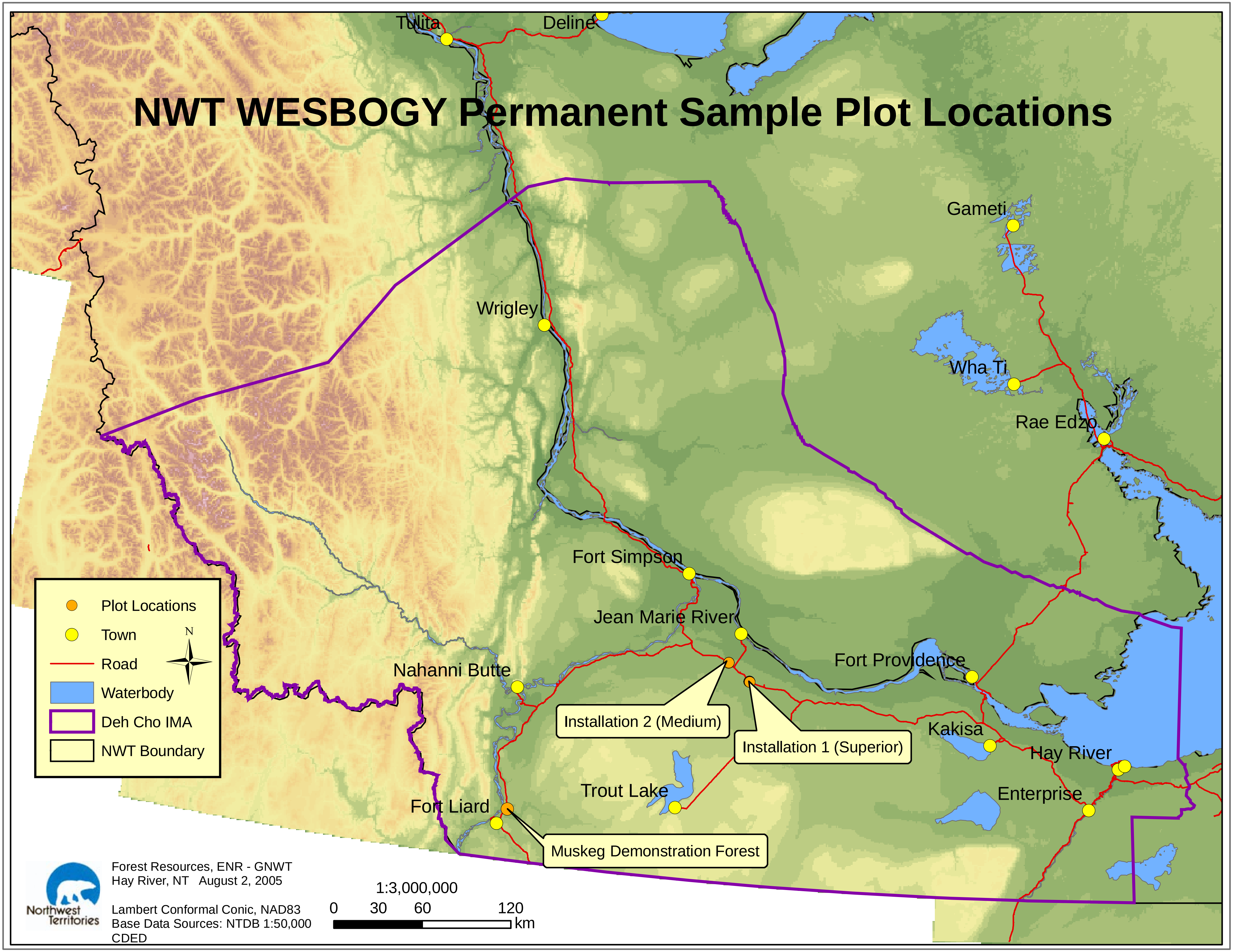
	Date Aspen	Date Spruce							Thinning Aug of 96	
	Harvested	Planted	Calendar Year	*1993*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
sup1	1987	Jun-93	Measurement Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	6		Aspen Age	yes	6	7	8	9	10	11
Sw Age at 1		*2*	Spruce Age	yes	*2*	*3*	*4*	*5*	*6*	7

	Date Aspen	Date Spruce							Thinning July of 97	
	Harvested	Planted	Calendar Year	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
sup2	1988	Jun-94	Measurement Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	7		Aspen Age	no	7	8	9	10	11	12
Sw Age at 1		*2*	Spruce Age	no	*2*	*3*	*4*	*5*	*6*	7

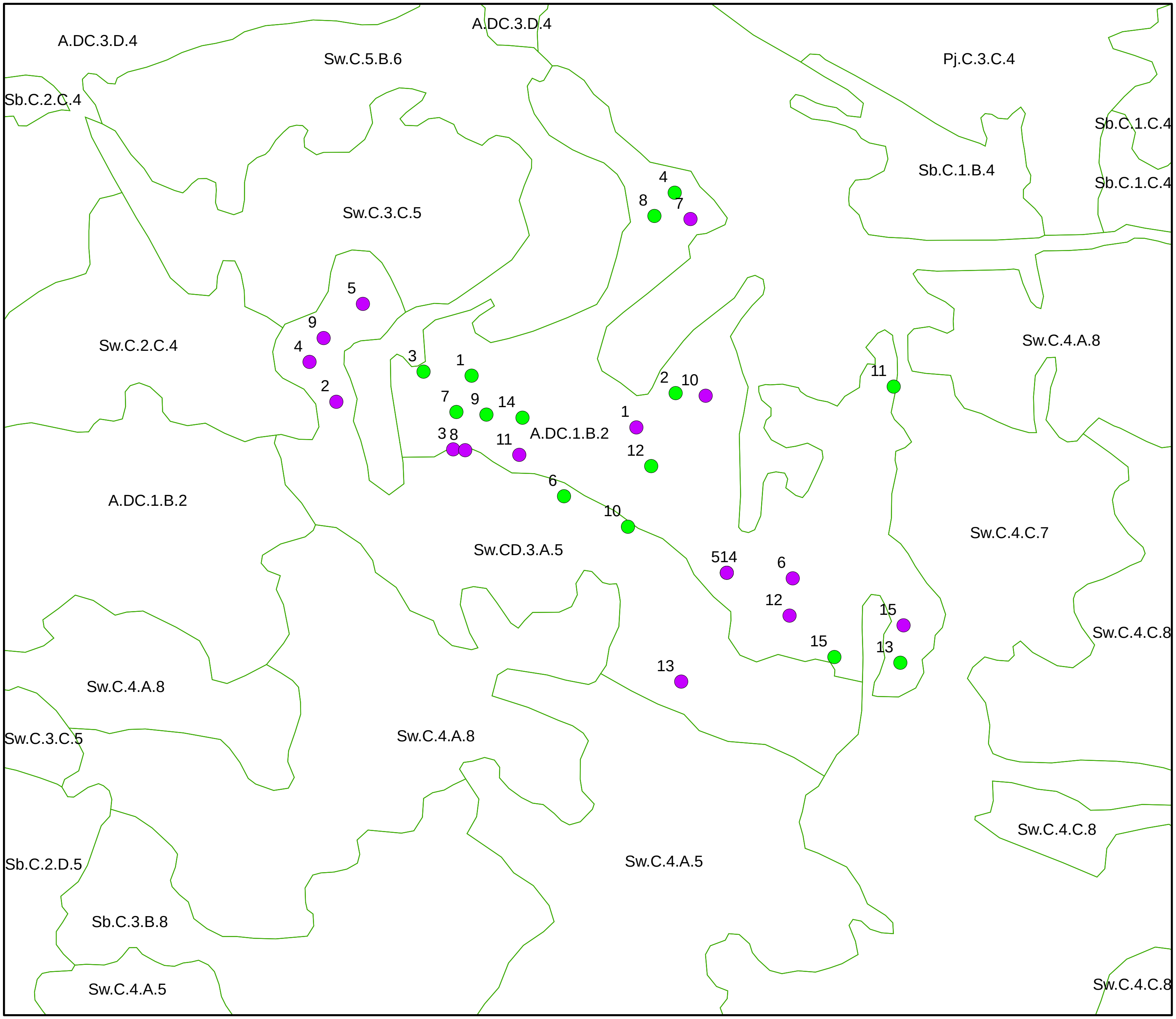
WGP	Date Aspen	Date Spruce							Thinning May of 96	
	Harvested	Planted	Calendar Year	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
	Jul-88	*Aug-91*	Measurement Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	*5*		Aspen Age	yes	5	6	7	8	9	10
Sw Age at 1		*2*	Spruce Age	yes	*2*	*3*	*4*	*5*	*6*	7

WPA	Date Aspen	Date Spruce							Thinning Summer of 95	
	Harvested	Planted	Calendar Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
	Jun-90	Fall 90	Measurement Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Aw Age at 1	1		Aspen Age	yes	1	2	3	4	5	6
Sw Age at 1		*2*	Spruce Age	yes	*2*	*3*	*4*	*5*	*6*	7

Appendix 16-2 Example installation and plot location maps


NWT WESBOGY Permanent Sample Plot Locations
Tulita
Deline
Gameti
Wrigley
Wha Ti
Rae Edzo
Fort Simpson
Jean Marie River
Fort Providence
Nahanni Butte
Installation 2 (Medium)
Installation 1 (Superior)
Kakisa
Hay River
Trout Lake
Enterprise
Fort Liard
Muskeg Demonstration Forest
Plot Locations
Town
Road
Waterbody
Deh Cho IMA
NWT Boundary
N
Forest Resources, ENR - GNWT
Hay River, NT August 2, 2005
Lambert Conformal Conic, NAD83
Base Data Sources: NTDB 1:50,000
CDED
1:3,000,000
0 30 60 120
km
Northwest Territories

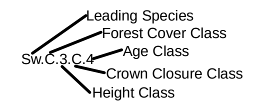
NWT WESBOGY Permanent Sample Plot Locations
Installation 1 (Superior)



Legend

- Replicate A
- Replicate B
- Forested
- Vegetated Non-Forested
- Water
- Non-Vegetated

Forest Cover Label



Forest Cover Composition	Forest Cover Class
80 - 100% Coniferous	C
30 - 70% Coniferous, Coniferous Leading	CD
30 - 70% Deciduous, Deciduous Leading	DC
80 - 100% Deciduous	D

Age (yrs)	Age Class
0 - 20	1
21 - 40	2
41 - 60	3
61 - 80	4
81 - 100	5
101 - 120	6
121 - 150	7
151 - 180	8
181 +	9

Height (m)	Height Class
0.01 - 2.5	0
2.51 - 7.5	1
7.51 - 12.5	2
12.51 - 17.5	3
17.51 - 22.5	4
22.51 - 27.5	5
27.51 - 32.5	6
32.5+	7

Crown Closure (%)	Crown Closure Class
0 - 30	A
31 - 50	B
51 - 70	C
71 - 100	D

Leading Species	
Sw	White spruce
Sb	Black spruce
Pl	Lodgepole pine
Pj	Jack pine
F	Alpine fir
L	Tamarack
A	Trembling aspen
Po	Balsam poplar
Bw	White birch

N

1:5,000

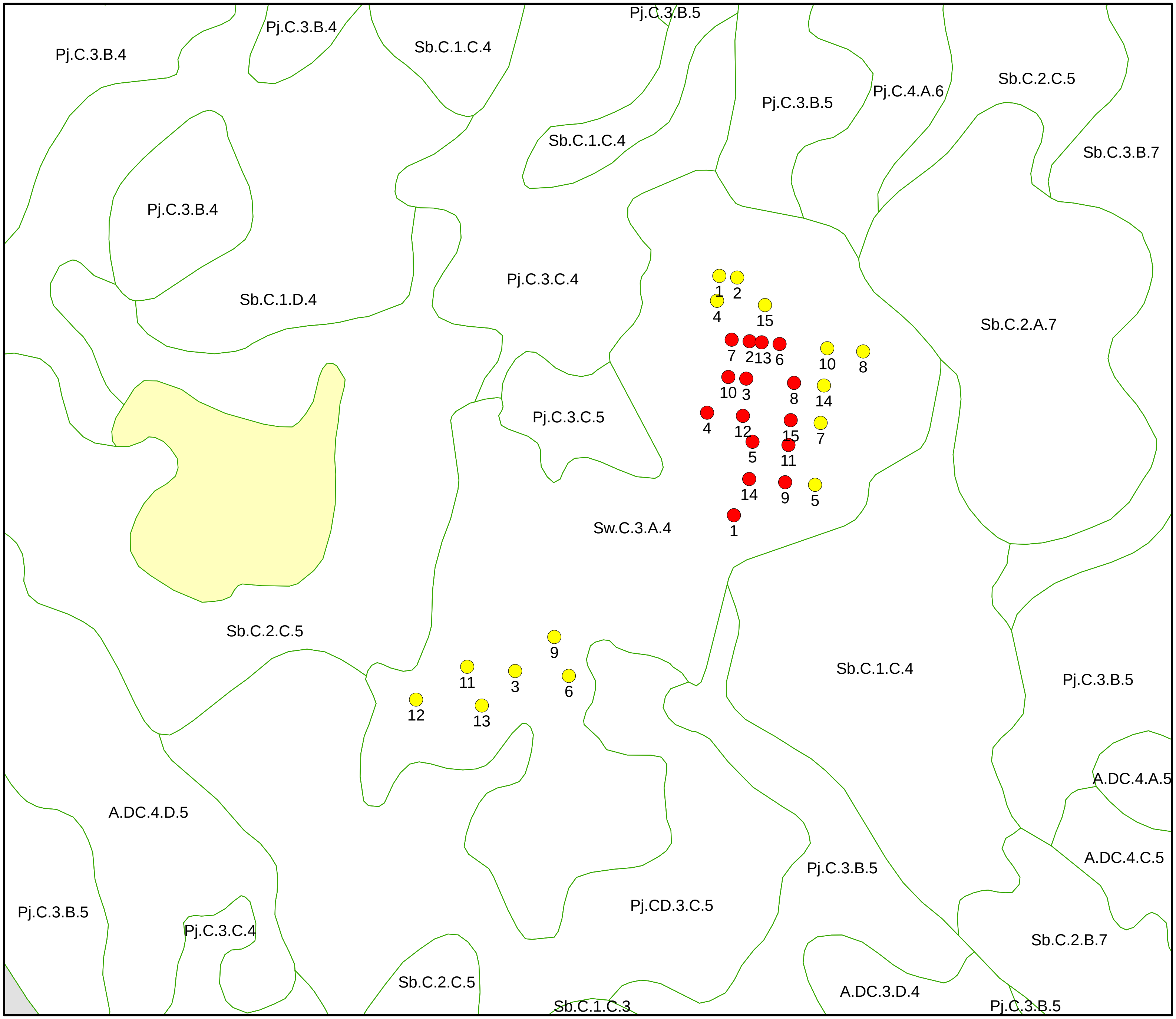
0 25 50 100 150 200 m

Northwest Territories

Forest Resources, ENR - GNWT
Hay River, NT August 2, 2005

Lambert Conformal Conic, NAD83
Base Data Sources: NTDB 1:50,000
CDED

NWT WESBOGY Permanent Sample Plot Locations
Installation 2 (Medium)



Legend

- Replicate C
- Replicate D
- Forested
- Vegetated Non-Forested
- Water
- Non-Vegetated

Forest Cover Label

Sw.C.3.C.4
- Leading Species
- Forest Cover Class
- Age Class
- Crown Closure Class
- Height Class

Forest Cover Composition	Forest Cover Class
80 - 100% Coniferous	C
30 - 70% Coniferous, Coniferous Leading	CD
30 - 70% Deciduous, Deciduous Leading	DC
80 - 100% Deciduous	D

Age (yrs)	Age Class
0 - 20	1
21 - 40	2
41 - 60	3
61 - 80	4
81 - 100	5
101 - 120	6
121 - 150	7
151 - 180	8
181 +	9

Height (m)	Height Class
0.01 - 2.5	0
2.51 - 7.5	1
7.51 - 12.5	2
12.51 - 17.5	3
17.51 - 22.5	4
22.51 - 27.5	5
27.51 - 32.5	6
32.5+	7

Crown Closure (%)	Crown Closure Class
0 - 30	A
31 - 50	B
51 - 70	C
71 - 100	D

Leading Species

Sw	White spruce
Sb	Black spruce
Pl	Lodgepole pine
Pj	Jack pine
F	Alpine fir
L	Tamarack
A	Trembling aspen
Po	Balsam poplar
Bw	White birch

N

1:5,000

0 25 50 100 150 200 m

Northwest Territories

Forest Resources, ENR - GNWT
Hay River, NT August 2, 2005

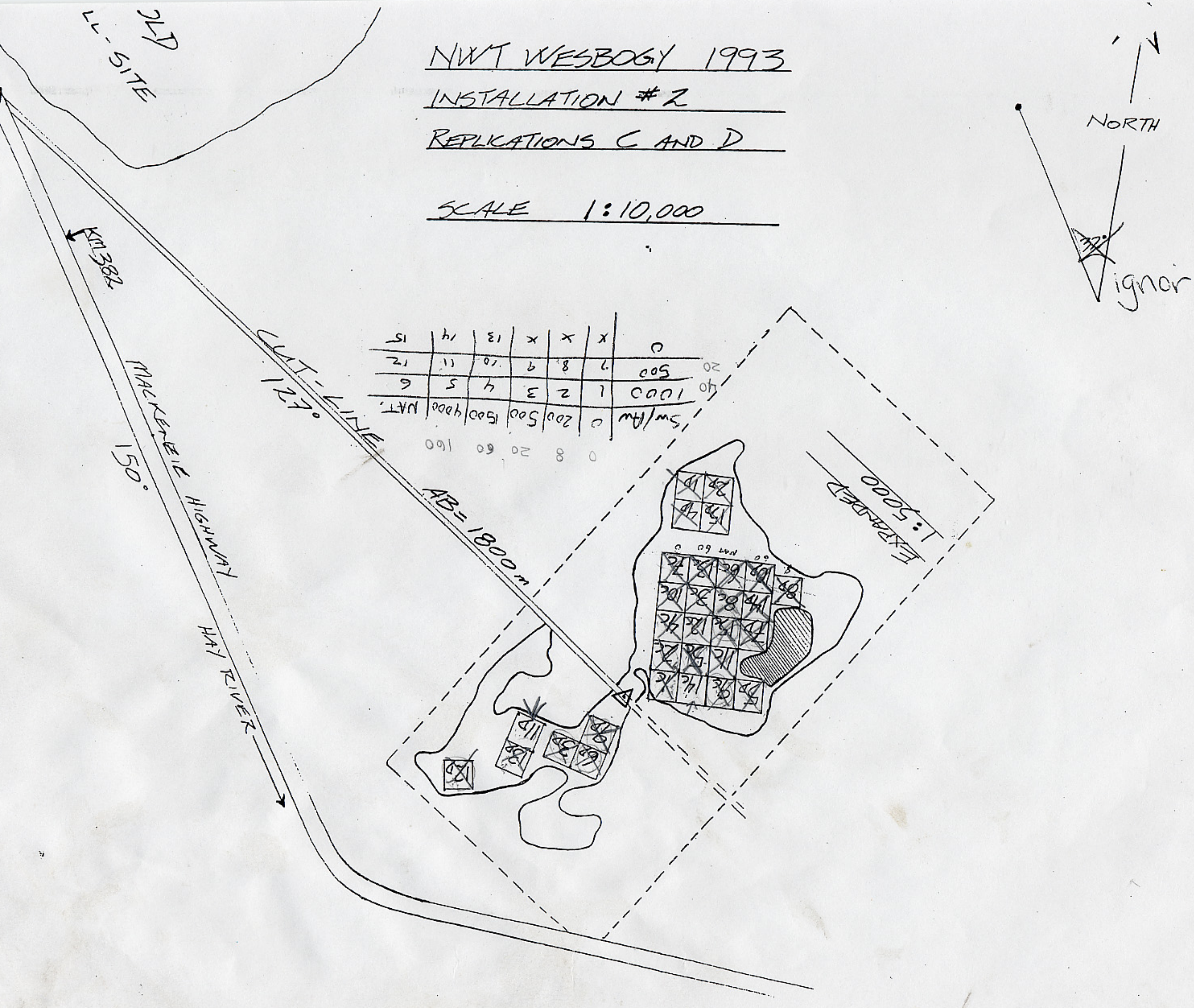
Lambert Conformal Conic, NAD83
Base Data Sources: NTDB 1:50,000
CDED

NWT WESBOGY 1993

INSTALLATION #2

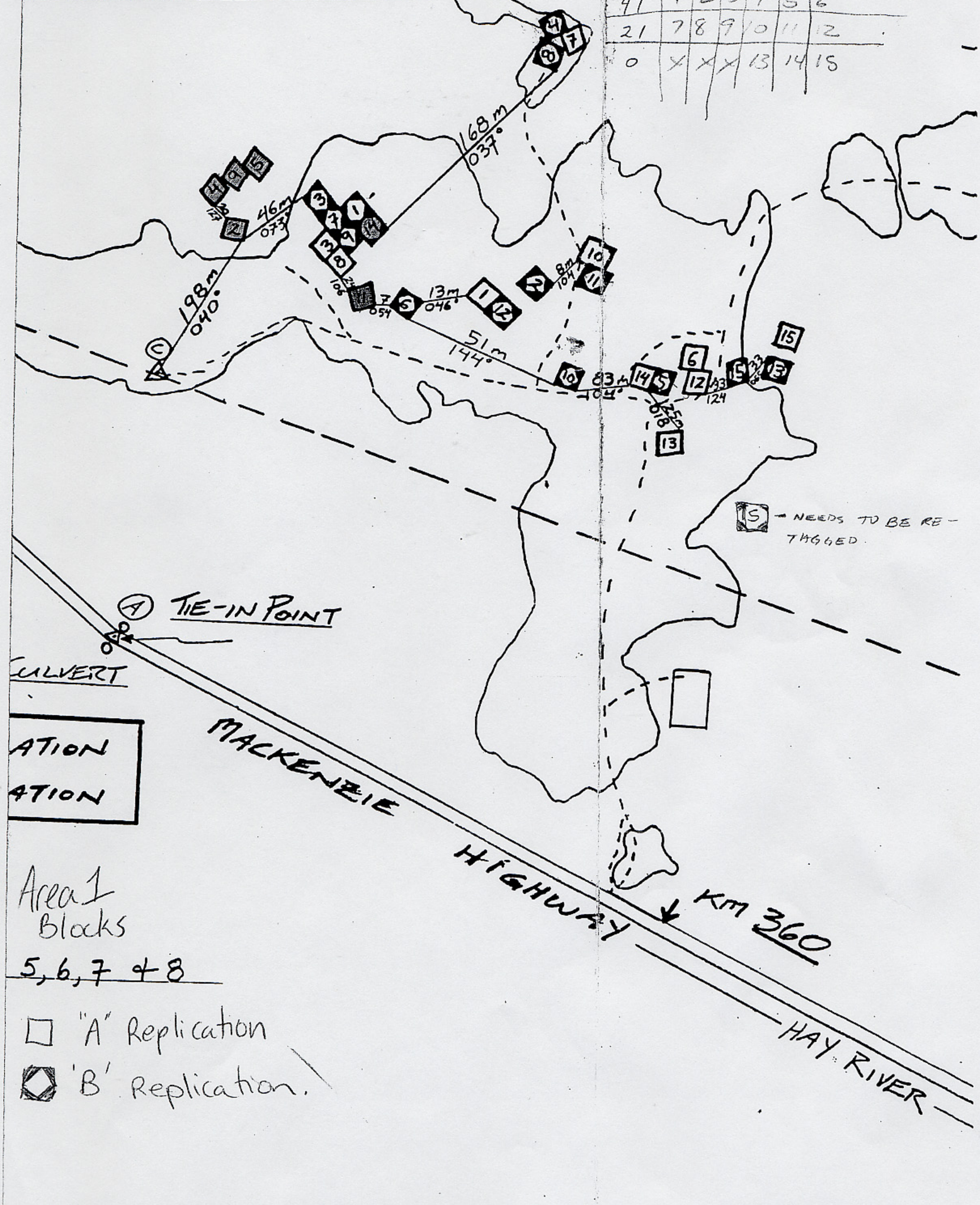
REPLICATIONS C AND D

SCALE 1:10,000



Sw/Aw	0	200	500	1500	4000	NAT.
	0	8	20	60	160	
1000 (40)	1	2	3	4	5	6
500 (20)	7	8	9	10	11	12
0	x	x	x	13	14	15

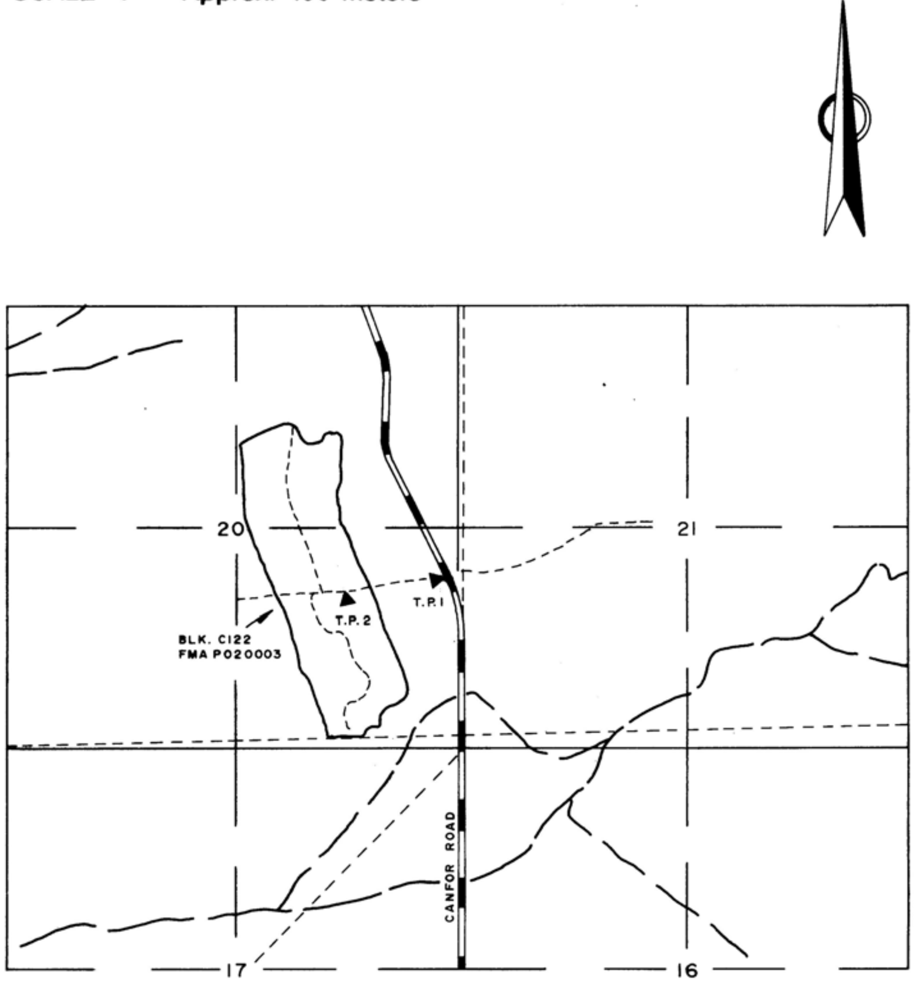
INSTALLATION #1



	0	8	20'	60	160	NAT.
41	1	2	3	4	5	6
21	7	8	9	10	11	12
0	X	X	X	13	14	15

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

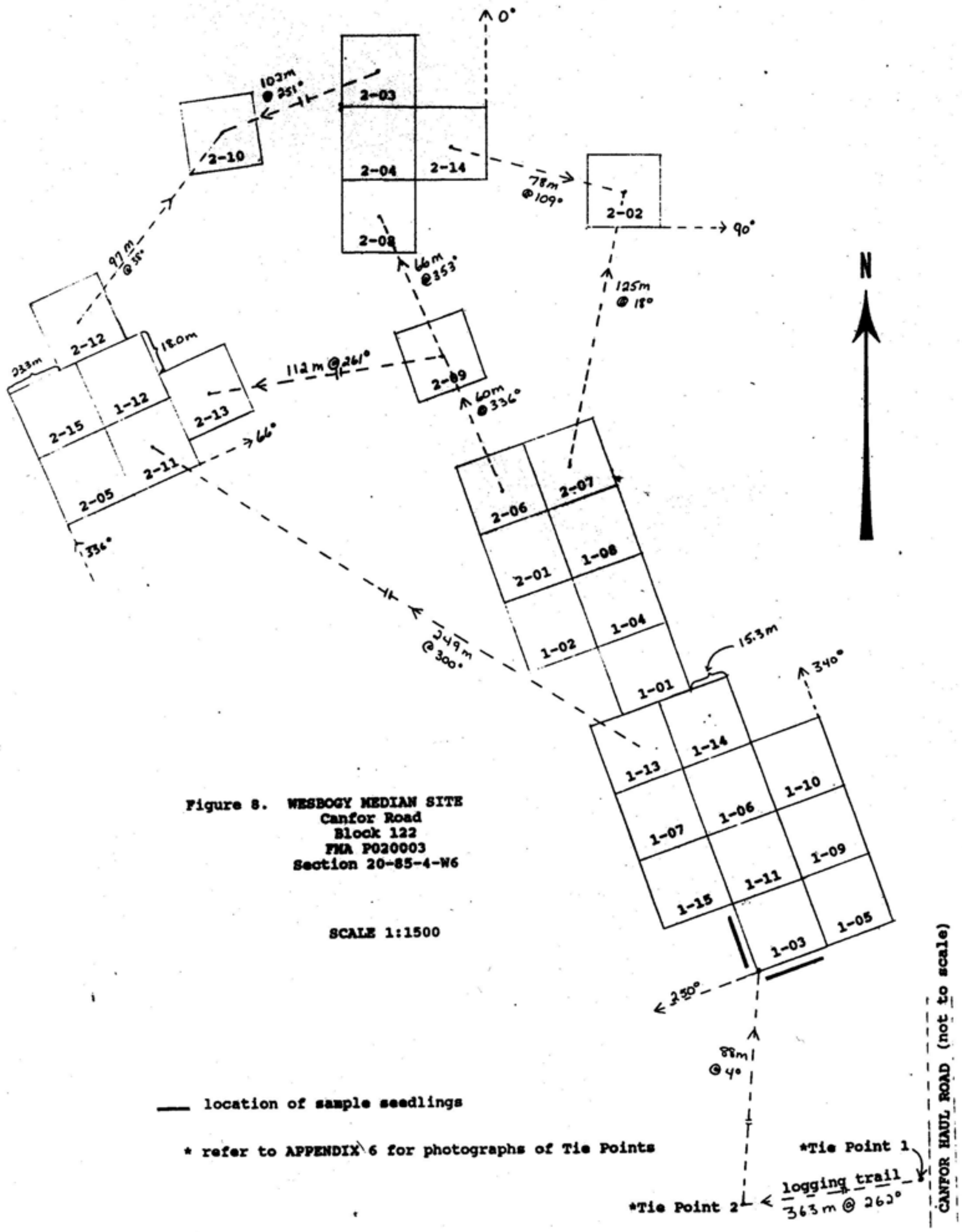


Figure 8. WESBOGY MEDIAN SITE
Canfor Road
Block 122
FMA P020003
Section 20-85-4-W6

SCALE 1:1500

— location of sample seedlings

* refer to APPENDIX 6 for photographs of Tie Points

Appendix 16-3 Tree Data Form and Dictionary

Criteria for selecting trees to be measured are found in the section on trees and measurement schedule.

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DIGITS	UNITS	DESCRIPTION
RTYP *	RECORD TYPE	Numeric	2	NA	NA	Record Type is a two-digit field that identifies the type of data being portrayed. The benefit of these codes is that they provide an easy way to separate data before and after thinning to treatment density as well as other types of data and conditions. This will help to study the tree growth responses due to thinning treatment, and it will be particularly useful when the data from several agencies are combined in analysis. Record Type 09 indicates the trees before thinning. This code is only for white spruce because we do not tag aspen in treated plots before the thinning. Record Type10 indicates the trees after thinning and includes both spruce and aspen. For the natural density aspen plots (6, 12 and 15), subplot size is also identified by Record Type. For example, trees recorded in a 2x2 m subplot the Record Type will be “22”. Other codes identify site, soil, and other vegetation data. Allowable codes: 01 Site Description (Form 2002 - 1) 02 Soils data (Form 2002 - 2) 05 Vegetation data (Form 2002 - 3) 09 **Spruce Tree data before thinning 10 **Spruce and aspen Tree data after thinning 11 *Tree data (all species) from 1x1 m sub-plots 22 *Tree data (all species) from 2x2 m sub-plots (all tree species) 55 *Tree data (all species) from 5x5 m sub-plots (all tree species) 66 *Tree data from final expansion (20x20 m excluding the 10x10 area in subplots) (All tree species) -------- *Natural density aspen plots (6, 12, and 15) ** All other plots
AGCY *	AGENCY	Character	6			This field contains up to 6 alpha-characters to denote the agency or company responsible for this particular block of plots. Allowable codes: AFS Alberta SRD, PLFD Division, Edmonton ALP Alberta-Pacific Forest Industries Inc Boyle CFR Canadian Forest Products Ltd, Alberta Operations Grande Prairie DMI Daishowa-Marubeni Int. Ltd. Peace River Pulp Div. LPSR Louisiana-Pacific Canada Swan River, Manitoba LPDC Louisiana-Pacific Canada Dawson Creek, B.C. NWT Northwest Territories, Renewable Resources

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DIGITS	UNITS	DESCRIPTION
						WFR Alberta Plywood Ltd, Slave Lake WBR Weyerhaeuser Canada, Saskatchewan Division Prince Alberta WGP Weyerhaeuser Canada Ltd, Alberta Division Grande Prairie WPA Weyerhaeuser Canada, Saskatchewan Division Prince Alberta
BLK *	BLOCK	Numeric	2			Each company or agency will set up and maintain one or more blocks. Enter a 2-digit number. For the first block, the entry will be "01". Allowable codes: 0-24
INST *	INSTALLATION	Character	3			Each block consists of two installations; one on a superior site and one on a median site. This field will contain 3 characters in uppercase: Allowable codes: SUP Superior site installation MED Median site installation
REPL *	REPLICATION	Numeric	2			Each installation consists of two replicates of a series of 15 plots. Therefore, this two digit, numeric field will be either 01 or 02. Allowable codes: 01 Replication number 1 02 Replication number 2
PLOT *	PLOT	Numeric	2			This is a two-digit number ranging from 01 to 15. Each plot must begin on a new tally sheet. Plot numbers are specified by treatment density according to Table 3-2. Allowable codes: 01 to 15
DATE *	DATE	Numeric	8			Measurement date is recorded as year/month/day, without any separator characters. For example October 9th, 1990 is entered as "19901009". Allowable codes: yyyymmdd
TRNO *	TREE NUMBER	Numeric	7			A six-digit code is assigned all trees in both treatment and natural density plots. Refer to Section 5.3 for a full description of methods for tree numbering on the different plots. For treatment plots (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 5.3 and 7.2 for a complete description of methods for tree numbering on treatment plots. For the natural density aspen plots (6, 12, and 15), the six-digit code consists of the subplot number (2 digits) and tree number (4 digits). Refer to Section 5.5 for a complete description of methods for tree numbering on natural density aspen plots. Allowable codes: 0-999999
SPP *	SPECIES	Character	2			Denotes tree species Allowable codes:

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DIGITS	UNITS	DESCRIPTION
						FA Alpine fir FB Balsam fir FD Douglas-fir LA Alpine larch LT Tamarack LW Western larch PF Limber pine PJ Jack pine PL Lodgepole pine PW Whitebark pine SB Black spruce SE Engelmann spruce SW White spruce AW Aspen PB Balsam poplar BW Paper birch
EST *	ESTABLISHMENT TYPE	Character	5			Denotes the origin of both aspen and white spruce. Allowable codes: 'S' indicates that the aspen seedling is of sucker origin 'D' indicates the seedling (aspen or spruce) is of seed origin 'P' is the planted spruce 'R' is any spruce that have been replanted due to mortality 'T' is any spruce that have been replanted using a tree from the buffer. 'I' is any aspen that have been used to replace a dead aspen and spruce If a second replant, transplant or ingress tree is used the code is modified by placing an additional code with the existing, for example "RR" – replanted twice "II "– second ingress tree used "TT" – second transplant The establishment field can be modified to represent 3, 4 or 5 tree replacements.
RCD	ROOT COLLAR DIAMETER	Numeric		1	cm	RCD is measured just above the butt swelling, using small calipers. Record the measurement to 0.1 cm. When the tree passes 1.3 m height a both RCD and DBH will be recorded. RCD is then measured until **all** trees of that species in the **installation** are above 1.3 meters. Allowable codes: 0.0-5.0
DBH	DBH	Numeric		1	cm	After a tree reaches a height of 1.3 m, record its diameter at 1.3 m height. At the 1.3 m height, the measurement height point should be painted on the tree. To prevent damage to the tree, do not use nails. DBH measurements are recorded to the nearest 0.1-cm. The following measurement protocol is taken from the Alberta SRD/PLFD PSP manual: "Breast height is 1.3 metres from the point of germination. Breast height is determined

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DIGITS	UNITS	DESCRIPTION
						using a straight stick 1.3 m long. Using a metal diameter tape, measure the tree's diameter to the nearest 0.1 cm making sure the tape is perpendicular to the stem. Diameters are always taken at 1.3 m unless there are large branches or swellings right at breast height. These defects are to be avoided and the diameter is taken immediately above or below the distortion and a comment noting the problem is made on the tally sheet in the shaded comments section (e.g. DBH taken above swell)." (PSP Manual Section 2.1.4.3) Allowable codes: 0.0-100.0
HT	TOTAL HEIGHT	Numeric		2	m	Total heights (stem length) should be measured to the nearest centimetre (0.01 m) for all live trees using a telescoping range pole. These poles are available to a maximum of 15 m. When use of a range pole becomes impractical other height measurement instruments may be used. Trees taller than 3 m should be measured to the nearest 0.1 m. Total height is the distance from the root collar (not the ground) to the tallest live point of the terminal leader. Measurement using a height pole continues until tree are 6m – 11m in height. Then a hypsometer should be used to measure height. Allowable codes: 0.00-100.00
HTI	HEIGHT INCREMENT	Numeric		0	cm	Record height increment (current leader length) to the nearest centimeter (0.01 m). This measurement is required <u>in addition to total height</u> so that actual growth can be summarized. Current height increment is measured at each re-measurement until tree height makes direct measurement impractical. Height increment is recorded to the nearest centimeter. Total height may decline if there is top kill or dieback, while the new terminal bud recovers and grows. Direct measurement of height increment gives a check on the total height and reduces the variation in total height which may occur from one measurement to the next. HTI is measured until trees are 3 meters. For trees taller than 3 m it is left blank and will be calculated by subtraction. Allowable codes: 0.00-200.00
CRN	NORTH CROWN RADIUS	Numeric		1	m	Measure the crown radius for all trees > 1.3 m height. Record the measurement to the nearest 0.1 m horizontally along the north direction from the centre of the tree. Allowable codes: 0.0-30.0
CRW	WEST CROWN RADIUS	Numeric		1	m	Measure the crown radius for all trees > 1.3 m height. Record the measurement to the nearest 0.1 m horizontally along the west direction from the centre of the tree. Allowable codes: 0.0-30.0
HTLC	HEIGHT TO LIVE	Numeric		1	m	The height from the root collar to the base of the live crown is recorded for all trees that

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DIGITS	UNITS	DESCRIPTION
	CROWN					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. Allowable codes: 0.0-100.0
CC1 * CC2 CC3	CONDITION CODES	Numeric	2			In 2004 new condition codes were adopted based on the ASRD codes. They are listed and described in Appendix 16-4. Old condition codes and there descriptions for measurements taken between 1990 – 2003 are listed in Appendix 16-14. The preface to Appendix 16-4 discusses the adoption of the new condition codes and highlights the differences. In Appendix 16-15 a correspondence table between the old and new condition codes is listed. Up to a maximum of 3 condition codes can be recorded for each tree. Each tree should have at least one condition code, i.e. the field of condition code 1 must be filled. For a normal, healthy tree, enter 0. If root collar diameter and total height are omitted, the tree condition code must be given to show the condition (e.g. dead and down, missing) of the tree. As long as there is a condition code describing the status of a tree, the information should be recorded as a standard condition code instead of including comments. Multiple codes should be recorded in the order of priority based on effect on tree. In some cases a new condition code may be needed to describe special tree conditions. New condition codes should not be used without prior discussion and approval. If dead tree is coded dead on the first tree code, the second condition code should explain the cause of death. Three separate fields. The first condition code is mandatory, while the second and third condition codes are optional. Up to a maximum of 3 condition codes can be recorded for each tree.
AZ	AZIMUTH	Numeric	3	0	Degrees	A staff compass and a metric tape are used to determine the azimuth and distance to the centre of each tree, at breast height, from the plot centre. Azimuths are recorded from 1-360 degrees and distances are measured to the nearest 0.1 m. Ensure that the compass has the correct declination and record this on the top of the tally sheet. For all plots except 6, 12 and 15 subplots, tree locations are to be mapped after thinning to treatment density. All hardwood and softwood ingress is removed before it reaches 1.3m. In the instances were an aspen or spruce tree is being used to replace a dead tree an azimuth and distance should be recorded and the proper EST and AGE fields updated. For plots 6, 12, and 15, the azimuth and distance should be recorded for every tree that reaches 1.3 m height.

VARIABLE *required	FULL NAME	FIELD TYPE	FIELD WIDTH	# of DIGITS	UNITS	DESCRIPTION
						Allowable codes: 0-360
DIS	DISTANCE	Numeric		1	m	Distance from plot centre to a tree is measured to the nearest 0.1 m using a metric tape. Allowable codes: 0.0-28.0
AGE	AGE	Numeric	3	0		This is field age. Age is required for all planted spruce trees (all plots except 13, 14 and 15) and ingress 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 ingress white spruce can be determined by counting branch whorls. For deciduous trees it can be estimated by counting nodes. Age is a required entry for each tree initially <u>and</u> at each re-measurement, previous years age assessments should be used as a guide to estimate current years age. Allowable codes: 0-200
Measnum	Measurement Number	Numeric	3	0		This is a calculated field – do not fill in this field, it will be set during the installation aging and assessment procedure. This field links calendar year to the first measurement of spruce, after 1 full growing season. From this all other activities and treatments including assessment of sw and aw age are made.
AWAGE	Biological Aw Age	Numeric	3	0		This is a calculated field – do not fill in this field, it will be set during the installation aging and assessment procedure. This field takes into consideration year of harvest and corresponds to measurement year (measnum) and calendar year.
SWAGE	Biological Sw Age	Numeric	3	0		This is a calculated field – do not fill in this field, it will be set during the installation aging and assessment procedure. This field takes into consideration year of harvest and corresponds to measurement year (measnum) and calendar year.

Appendix 16-4 2004 WESBOGY LTS Tree Condition Codes (based on ASRD/LFD tree condition codes)

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

In Appendix 16-4 a table of the new 2004 codes is presented as well as a table with their description.

In Appendix 16-14 a table of the codes that were used between 1990 and 2003 (including 2003).

In Appendix 16-15 a correspondence table that represents how the new codes relate to the old codes and a more detailed comparison of the similarities and differences is presented. This should provide field crews with guidance on how to make the necessary adjustments to the new codes. For the data that has already been gathered and stored digitally, the correspondence table will be used to convert all old data to represent the new codes. This will ensure that only one data coding system will exist. The conversion of old to the new codes will be handled by the U of A and should be transparent to the participating agencies.

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

Please note:

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

2004 WESBOGY LTS Condition Codes and Descriptions

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

Notes: No CC means no crown class.

2004 WESBOGY LTS Condition Codes and Descriptions

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

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

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

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

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

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

Appendix 16-5 Database Structure (Microsoft Access 2000)

Columns

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

Appendix 16-6 History Table Template

Med Installation	Replication 1	Plot	Aw Harvested	Sw Planted	Stock Sowed	Stock Type	Seedlot	RePlanted	New or from buffer	Stock Sowed	Stock Type	Seedlot	Thinned	Spatial SW	Spatial AT	Vegetation
WGP		1	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		2	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		3	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		4	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		5	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		6	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		7	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		8	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		9	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		10	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		11	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		12	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		13	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		14	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91
		15	07-01-88	08-01-91	01-01-91	Styro 313	6-066-06-SW-79	08-24-93	New	01-01-93	Styro 415	6-066-06-SW-79	05-10-96	08-12-91	09-20-95	07-24-91

					Measurements													
Site Index (residual stand)	Establishment ecosite assessment	Soil	2nd Ecosite Assessment	Plot GPS's	1	2	3	4	5	6	7	8	9	10	11	12	13	14
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04
07-24-91	07-24-91	07-24-91	07-14-04	07-14-04	08-12-91	08-04-92	08-24-93	09-26-94	09-20-95	08-27-96	10-16-97	10-16-98	09-01-89	08-01-00	09-01-01	09-27-02	09-01-03	09-01-04

Appendix 16-7 Examples and discussion of common errors in data collection and input

The following table lists examples of common mistakes and unsuitable formats of data entry. The corresponding corrections are shown. 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 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 with common Errors

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 with 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

Appendix 16-8 Additional Fields used in error checking and the criteria/conditions

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

Error type:

"ErrRtyp" Record type is not allowed (RTYP is not 1, 2, 5, 9, 10, 11, 22, 55, 99, or is null)

"ErrBlk" Block number is not allowed (BLK is not 1, 2, or is null)

"ErrInst" Installation number is not allowed (INST is not SUP, MED, or is null)

"ErrRepl" Replication number is not allowed (REPL is not 1, 2, or is null)

"ErrPlot" Plot number is not allowed (REPL is out of the range 1-15, or is null)

"ErrSpp" Species code is not allowed (SPP is not FA, FB, FD, LA, LT, LW, PF, PJ, PL, PW, SB, SE, SW, AW, PB, BW, or is null)

"ErrEst" Establishment type is not allowed (EST is not S, D, P, R, or is null)

"ErrRcd0"
(1) RCD <= 0
(2) Null and ((HT>0 and HT<=1.3) or (HT > 1.3 and DBH=null))

"ErrRcd1" RCD unreasonably large by age and specie due to measurement errors or wrong units

<u>RCD upper ranges by age and species (cm)</u>

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

"ErrDbh0"
(1) DBH <= 0
(2) Null when HT > 1.3 m

"ErrDbh1" DBH unreasonably large by age and specie due to measurement errors or wrong units

<u>DBH upper ranges by age and species (cm)</u>

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

"ErrRcdDbh" DBH >= RCD

"ErrHt"
(1) HT < 0.01 m
(2) HT unreasonably large by specie

<u>HT upper limit by species (m)</u>

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

"ErrHti"
(1) HTI <0 And (CC1, CC2, CC3<>7, 24, 18, 19, 42)
(2) HTI >=HT*0.8
(3) HTI unreasonably large by specie
(4) HTI=NULL and (HT>0.3 and <> 25, 26, 27, 29, 88, 99)

The upper limit of HTI by species (cm)

Species	SW	AW
Limit	80	200

"ErrHtDbh" HT/DBH ratio > 10

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

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

Crown upper limit (m) by species and age

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

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

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

The upper limit of HTI by species (m)

Species	SW	AW
Limit	1	15

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

"ErrCc2" Health code is not allowed in CC2

"ErrCc3" Health code is not allowed in CC3

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

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

"ErrDis" DIS > 28.3 m

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

"ErrDate0" DATE field is null

"ErrDate6" Wrong date format of 6 digits

"ErrDate7" Wrong date format of 7 digits

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

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

"ErrTrNo0" Tree number field is null

ErrHTLC	HTLC>=HT
ErrRcd0	0
ErrRcd1	> upper limit
ErrRcdDbh	DBH >= RCD
ErrREPL	3

Appendix 16-9 Paul Leblanc's Thinning Manual

WESBOGY THINNING METHODOLOGY

Paul LeBlanc
(written in 1995, updated in 2005)

OVERVIEW

A WESBOGY installation is a replicated experiment of various densities of white spruce and trembling aspen. In the fall of year five (early September), WESBOGY experimental plots need to be thinned to treatment densities. Both the white spruce and aspen require thinning. Table 1 shows the combinations of treatment densities for the 15 plots within one replication.

Of course, you should be measuring all the white spruce trees and all the aspen sub-plot trees <u>before</u> you start thinning. Usually these measurements are done in mid to late August, after the white spruce are done growing for the season.

Table 1. White spruce and aspen densities by plot number.

initial planted density	thinned density at year 5	aspen (0/ha)	aspen (200/ha)	aspen (500/ha)	aspen (1500/ha)	aspen (4000/ha)	aspen (natural density)
White spruce 2000/ha	white spruce 1000/ha	plot # 1	plot # 2	plot # 3	plot # 4	plot # 5	plot # 6
White spruce 1000/ha	white spruce 500/ha	plot # 7	plot # 8	plot # 9	plot # 10	plot # 11	plot # 12
White spruce 0/ha	white spruce (0/ha)	n/a	n/a	n/a	plot # 13	plot # 14	plot # 15

Thinning of a WESBOGY replicated mixedwood experiment consists of six phases (in order):

Phase 1 - thinning the white spruce;

Phase 2 - selecting aspen crop trees;

Phase 3 - tagging and measuring aspen crop trees;

Phase 4 - thin (clean or space) out the remaining non-crop tree aspen;

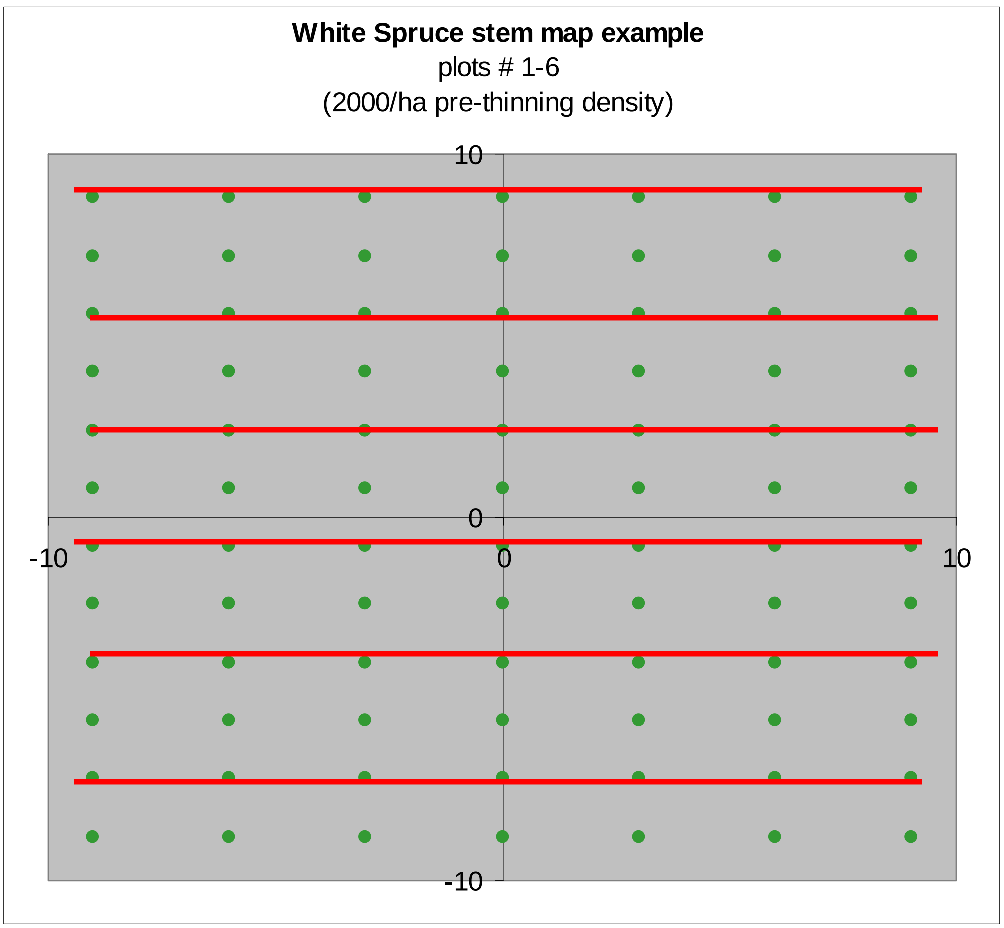
Phase 5 - expand the aspen subplots from 1 X 1 m to 2 X 2 m; and

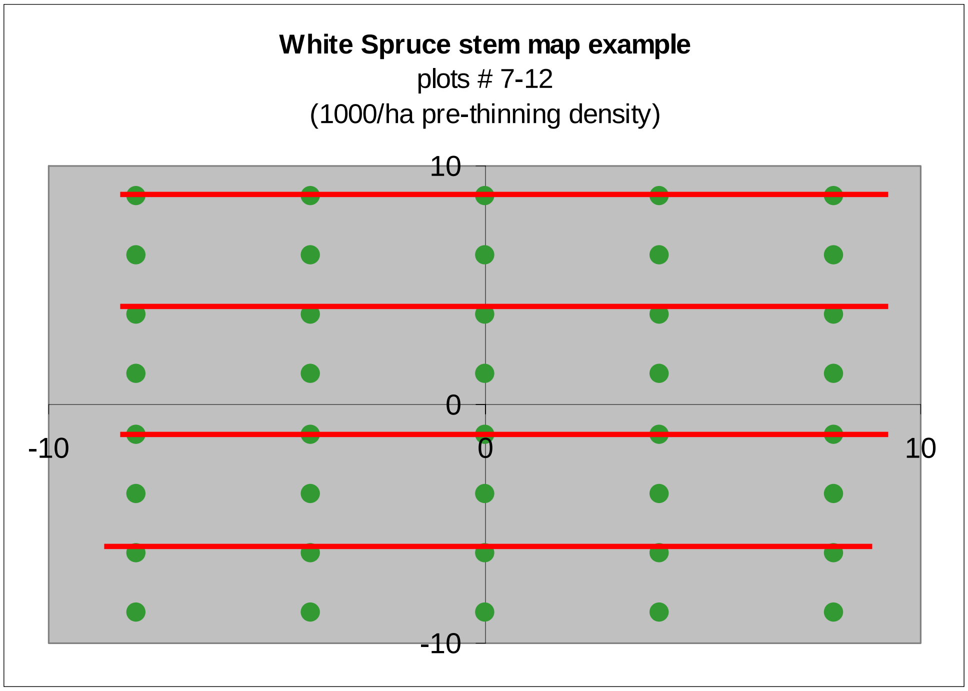
Phase 6 - stem mapping the aspen crop trees; white spruce crop trees; and aspen sub-plots

PHASE ONE: Thinning the White Spruce

WESBOGY plots were planted with 2,000 (high density) and 1,000 (low density) white spruce per hectare. These plots (and their plot buffers) need to be thinned to treatment densities of 1,000 and 500 stems per hectare (42 and 20 trees per plot, respectively). The plots are planted at a higher than necessary initial density to allow for some mortality, and still maintain the target density at year five.

The white spruce are planted in rows oriented north-south. Our method was thin **across** the rows, east-west. Therefore, we would start at row # 1 tree # 1 and leave all the trees east and west across the rows. Then we would move up row # 1 to tree # 2, and remove (thin) all the spruce trees in row #2, indicated by the red line.





In theory, we should be able to simply remove every second spruce tree to achieve the proper density (assuming 100% survival or 0% mortality). However, mortality may have occurred within each plot. Sometimes white spruce may have died in the row you plan to leave. Simply substitute a live healthy tree in the removal row (red line) to compensate for the dead tree. Ensure that there are 42 white spruce trees inside each plot (plots 1-6) and 20 white spruce trees inside each plot (plots 7-12).

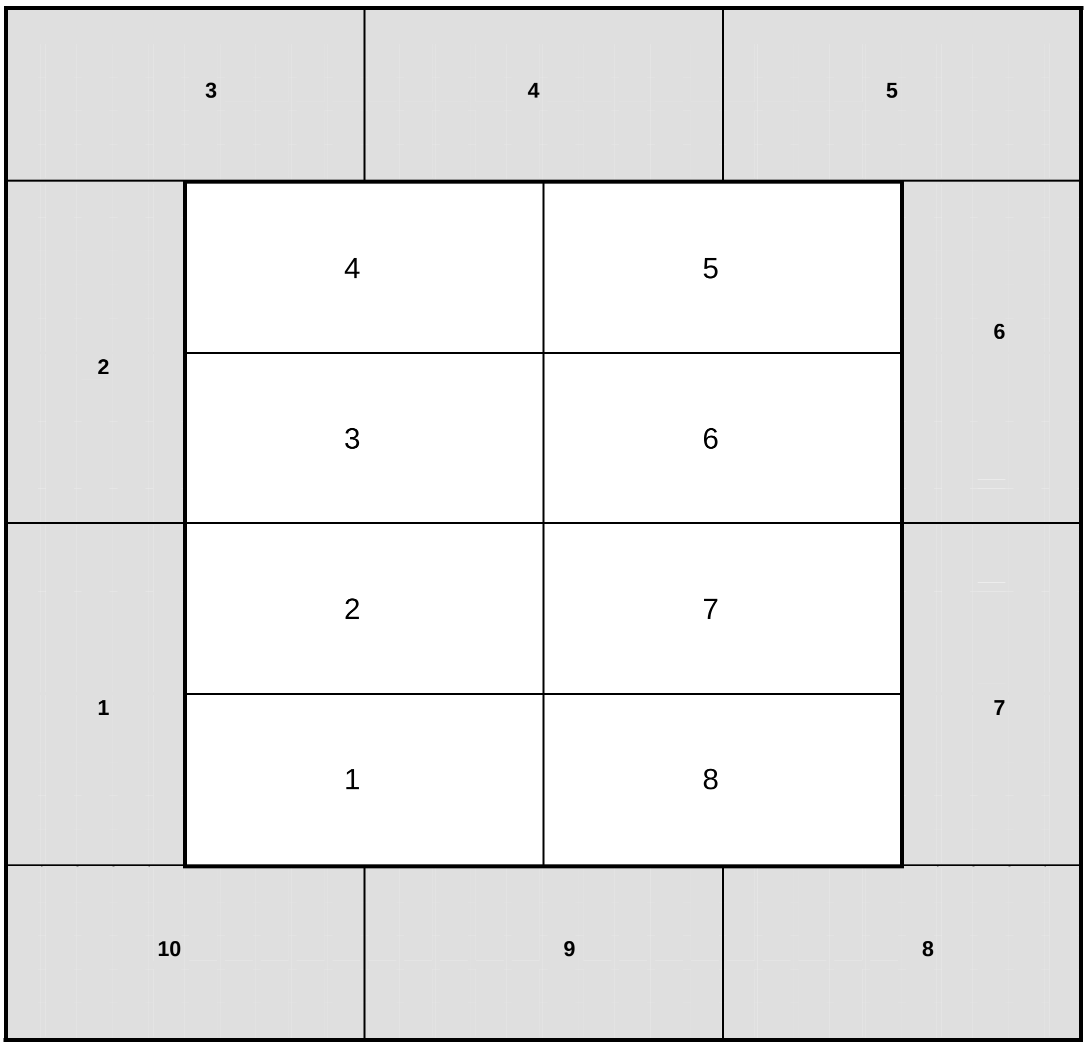
PHASE TWO: Selecting Aspen Crop Trees

We deemed it important to select the crop trees first, then measure them, and finally thin the 'extra' aspen. This sequence prevents the accidental thinning below target density. The aspen are thinned to a variety of densities, as outlined below:

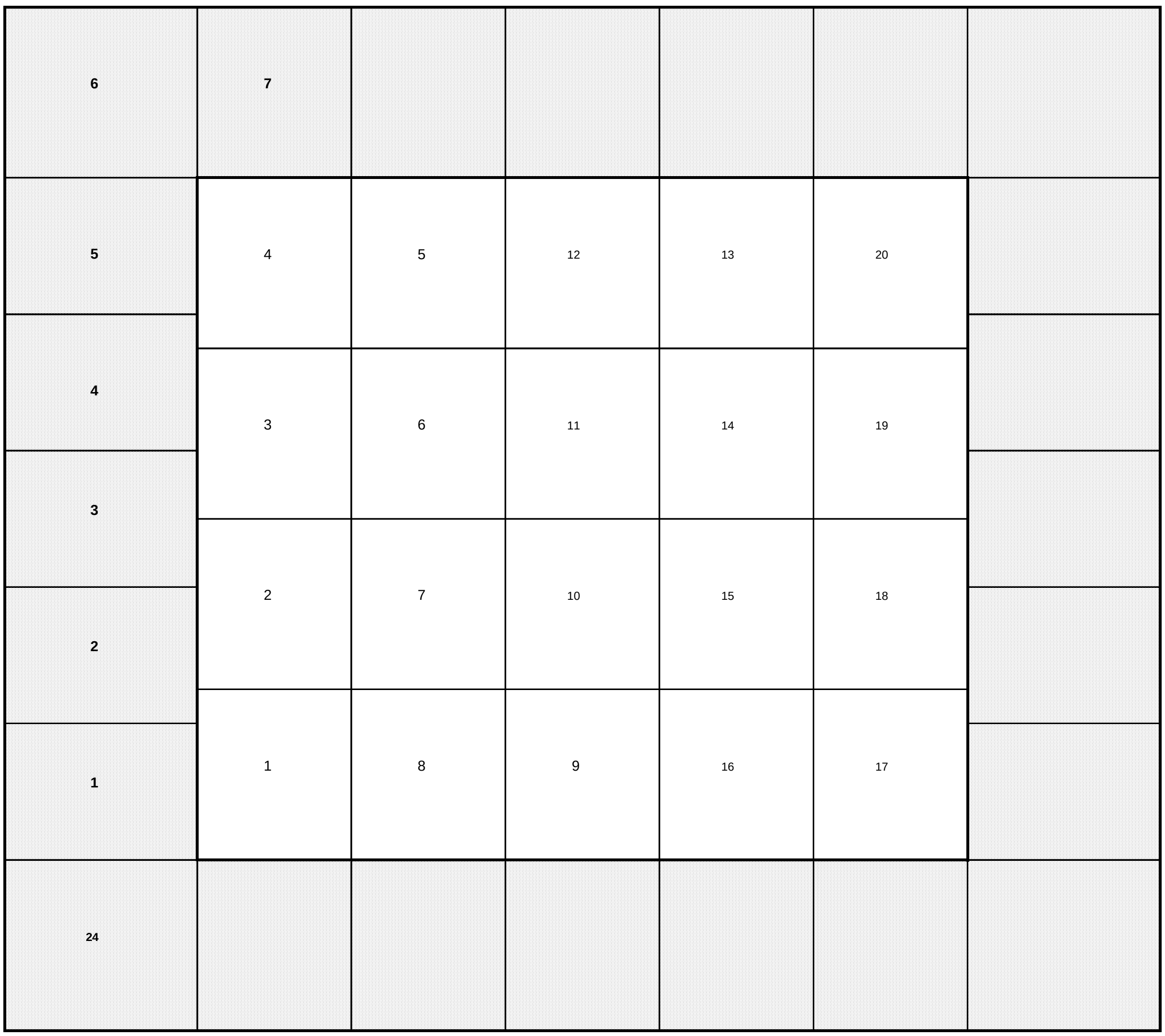
Plot	Target Density # Stems / ha	# of Aspen in Plot	# of Aspen in Buffer (5 m)
plots 1 & 7	0	0	0
plots 2 & 8	200	8 (1 aspen per 5 X 10 m cell)	10
plots 3 & 9	500	20 (1 aspen per 5 X 4m cell)	25
plots 4, 10, & 13	1,500	60 (3 aspen per 5 X 4m cell)	75
plots 5, 11, & 14	4,000	160 (8 aspen per 5 X 4m cell)	200
plots 6, 12, & 15 (sub-plots)	natural	natural	natural

Obviously, plots 1 & 7 require no effort for selecting crop trees. The selection of aspen crop trees must be distributed over the plot. The best way to accomplish this is to use ropes as part of a 'grid' system.

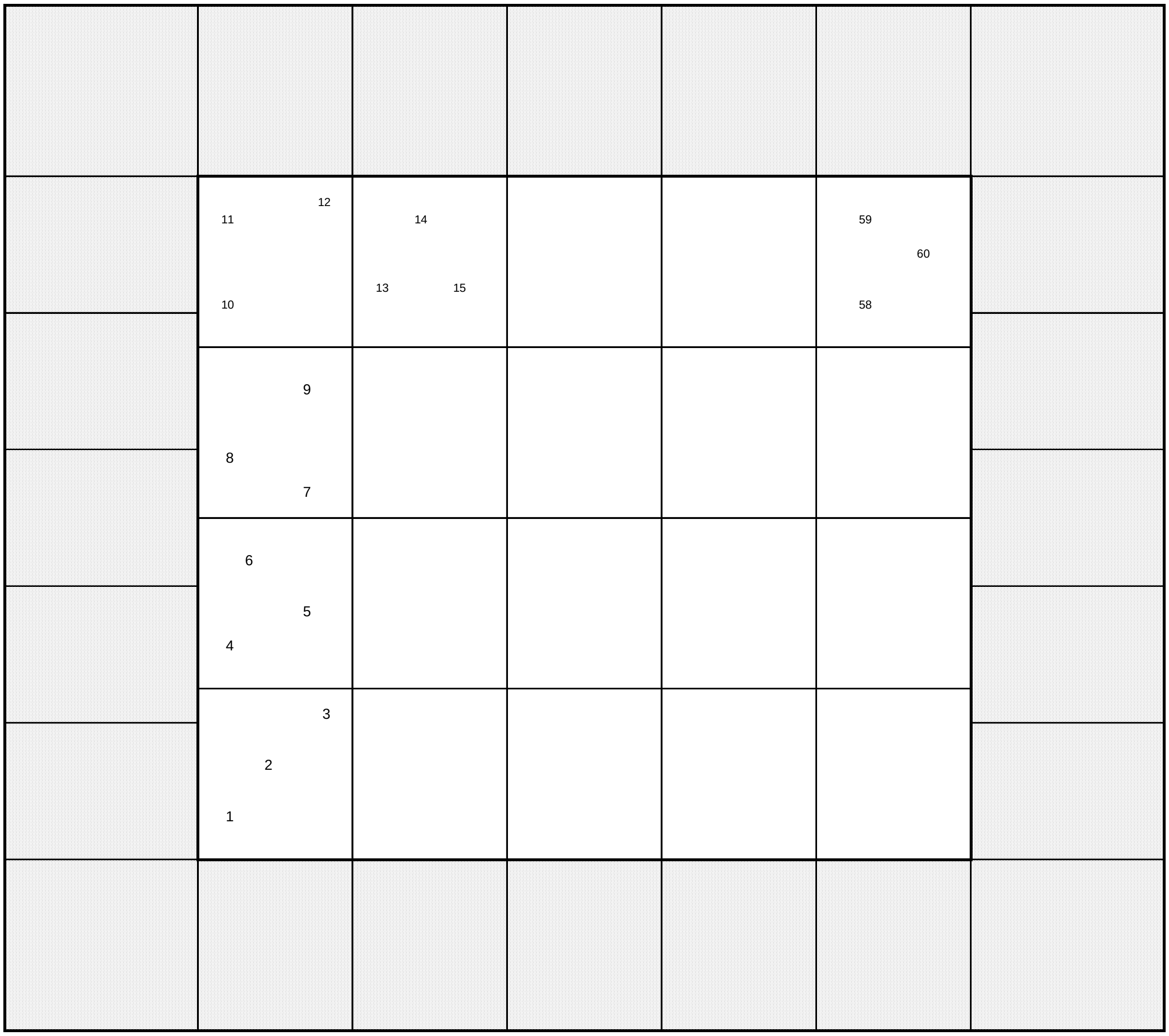
Plots 2 and 8 utilize a 5 X 10 m grid system, which makes eight grids with the 20 X 20 m plot. Simply choose **one** crop tree within each of the eight grids. The buffer area is similarly gridded, and 10 aspen crop trees chosen. We used orange spray paint to mark the aspen crop trees within the plot. Paint the base of the tree, and just above dbh.



All remaining plots utilize a <u>5 X 4 m grid</u>, but the number of aspen crop trees chosen within each grid varies. Plots 3 and 9 choose **one** tree per grid, to have 20 crop trees within the plot, and 25 trees in the buffer.

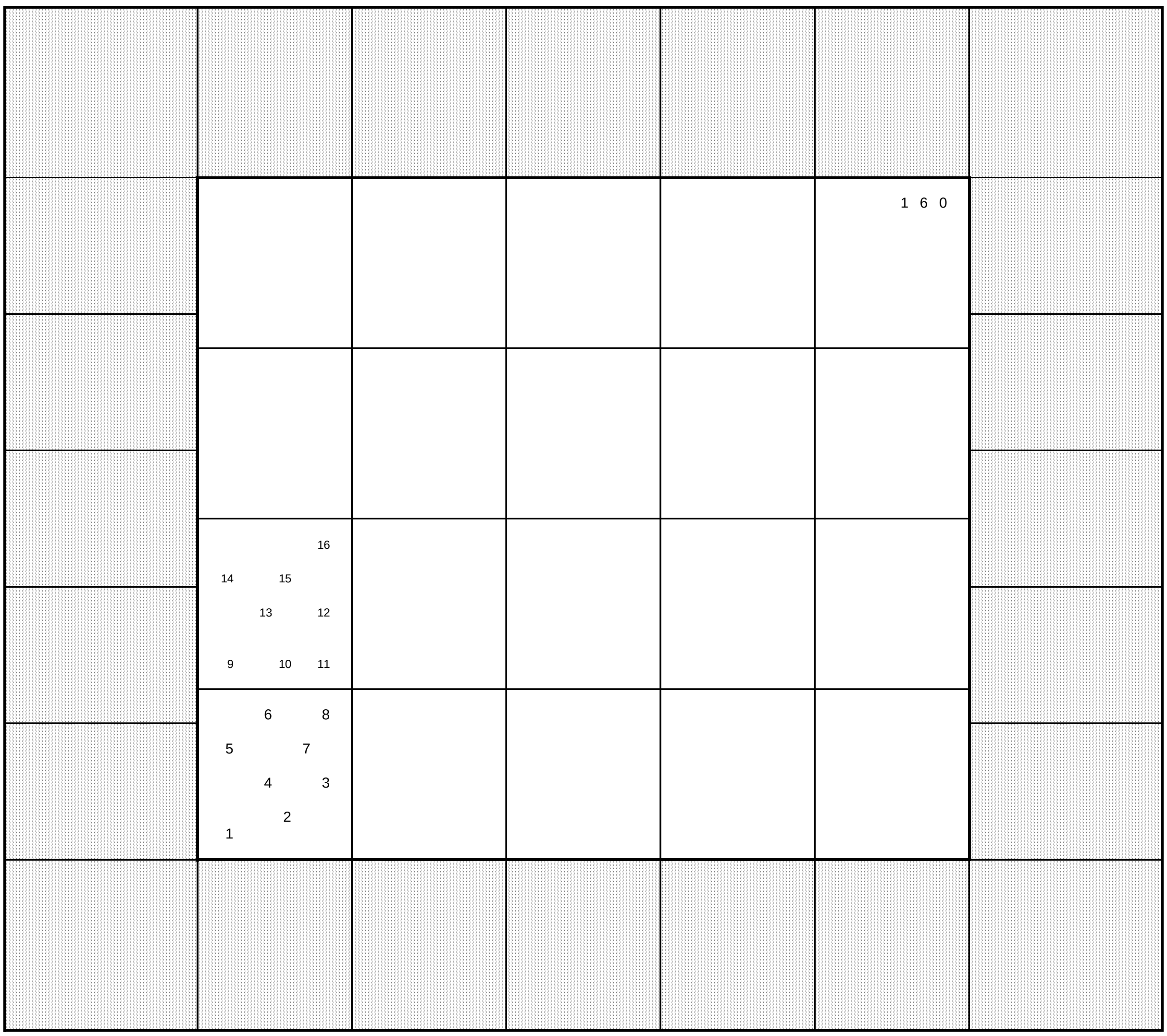


Plots 4, 10 and 13 choose **three** trees per 5 X 4m grid, to have 60 crop trees within the plot, and 75 trees in the buffer.



Plots 5, 11, and 14 choose **eight** trees per grid, to have 160 crop trees within the plot, and 200 trees in the buffer.

NOTE: Corners in buffer are 5 m X 5 m and each get 10 trees each instead of eight.



PHASE THREE: Tagging and Measuring Aspen Crop Trees

Each crop tree in each plot needs to be tagged and measured. Push a pigtail pin in the ground north of the base of each aspen crop tree. Attach an aluminum tag with the tree number. Using a 1.30 m stick, mark a DBH line on the tree with paint or a black permanent marker. Measure RCD, DBH, total height with a height pole, crown radius, and record any condition codes applicable.

PHASE FOUR: Thinning the Remaining Non-crop Aspen

Now that the aspen crop trees are selected and measured, the remaining aspen need to be removed. An important point in the WESBOGY experimental design is that brush species are **not** considered competition to the crop trees, therefore the brush (*e.g.* hazel, alder, willow) is not removed.

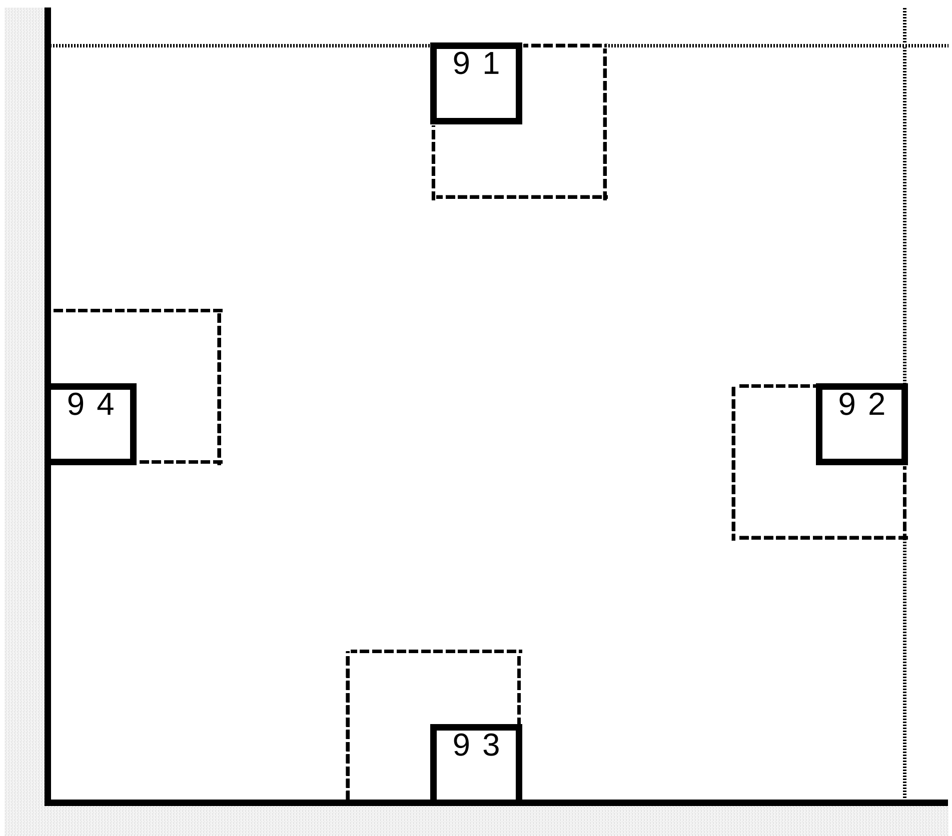
A second caution is to avoid 'nicking' the crop trees with the brush saw as the unwanted aspen are removed. The purpose of painting the crop tree's base or root collar is so the brush saw operator can avoid the crop trees, even with his head down working. It is also advisable to pay the brush saw operator(s) and hourly or daily rate, rather than production-based.

A potential safety hazard is the operator hitting the metal pigtail pins with the brush saw. The pins are pulled out of the ground and are violently flung away at random angles. We used pigtail pins dipped in white paint to make them high-visibility, and regularly reminded the operator about this specific hazard.

The white spruce trees should not be 'buried' by aspen slash. Felled aspen may have to be repositioned off of white spruce trees, especially in plots 1 & 7 where all aspen are removed.

PHASE FIVE: Expanding Aspen Subplots

Plots 6, 12, and 15 do not require thinning, since they are natural density aspen (control). However, the 1 X 1 m subplots need expanding to 2 X 2 m (4 m^2). Additional corner posts are established, and the new trees tagged and measured. If the original subplot has 12 trees, the new trees in the expanded subplots would start with tree number 13. This avoids the problem of having two tree # 1's within the same subplot.

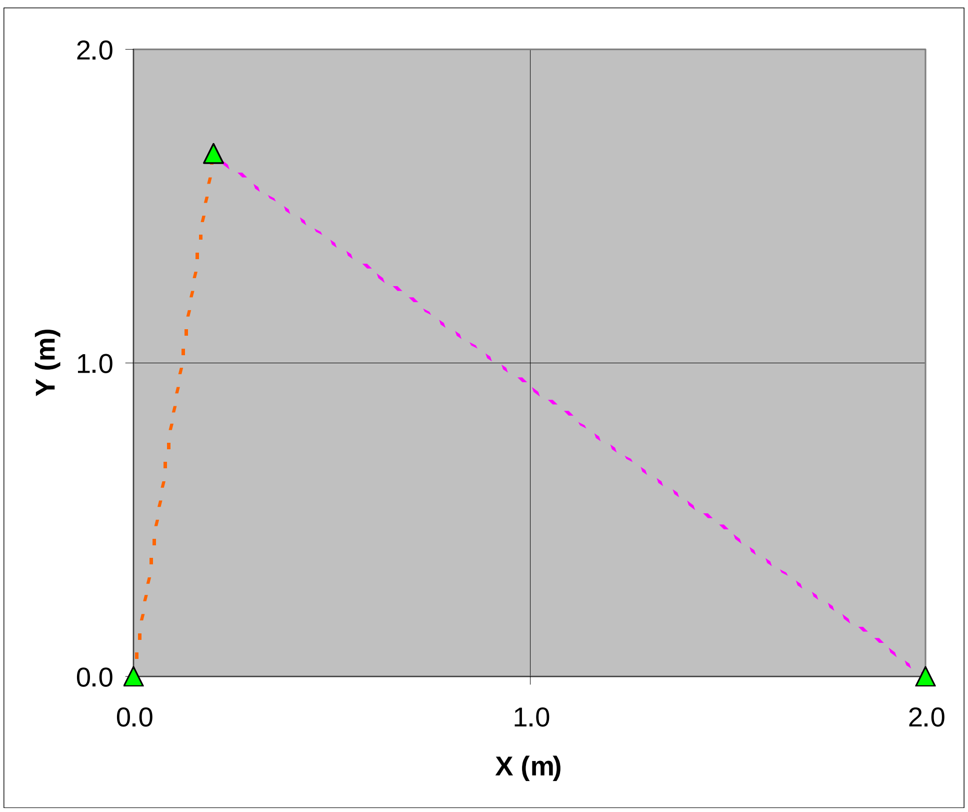


PHASE SIX: Stem Mapping

We completed phases 1-5 between early September and snowfall in November. Therefore, we left the stem mapping until the following spring. Generally, its easier to map the aspen in a leaf-off condition, so when field work began in May we stem mapped the aspen first (plots 2-5; 8-11; and 13 & 14). Then we stem mapped the white spruce (plots 1-12). Finally, we stem mapped the newly expanded aspen sub-plots.

Aspen crop trees and white spruce crop trees were stem mapped using the azimuth-distance method. A compass and laser were set up at plot centre, and the azimuth of each tree was recorded from the compass. The distance was measured with the laser. The 2nd crew member stood by each tree with a reflective target for the laser.

Aspen subplots were stem mapped using the distance-distance method. For a given tree, measure distance1 (distance of SW subplot post to tree) and distance2 (distance of SE subplot post to tree). There is a formula to convert distance-distance into X,Y coordinates, therefore the end result is the same.

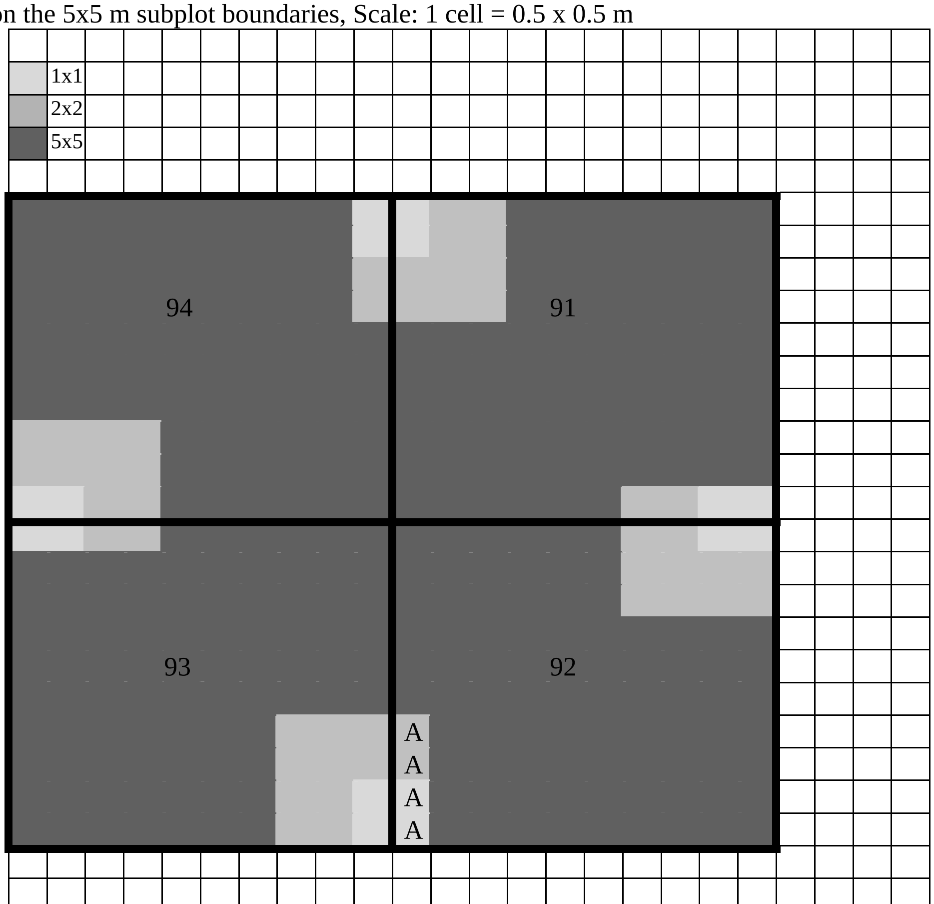


Appendix 16-10 Site, Soil and Vegetation Tally Sheets

Appendix 16-11 Natural density aspen Subplots (plots 6, 12, and 15) established before 2000

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 16-1). The expansion of subplots for this layout follows the general approach outlined for installations established after 2000. However, there is a small difference that is outlined in Figure 16-1 that must be handled correctly to avoid double counting of some trees.

Figure 16-1 SW 5x5m subplot layout for installations set out prior to 2000 with subplots centred on the 5x5 m subplot boundaries, Scale: 1 cell = 0.5 x 0.5 m



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

Appendix 16-12 Pilot Study at Year 10 to determine feasibility of moving to 5x5m subplot sizes

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 has been 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. This will be reviewed annually with the goal of keeping the number of trees on a 5x5 m plot at something less than 30 trees (12000/ha).

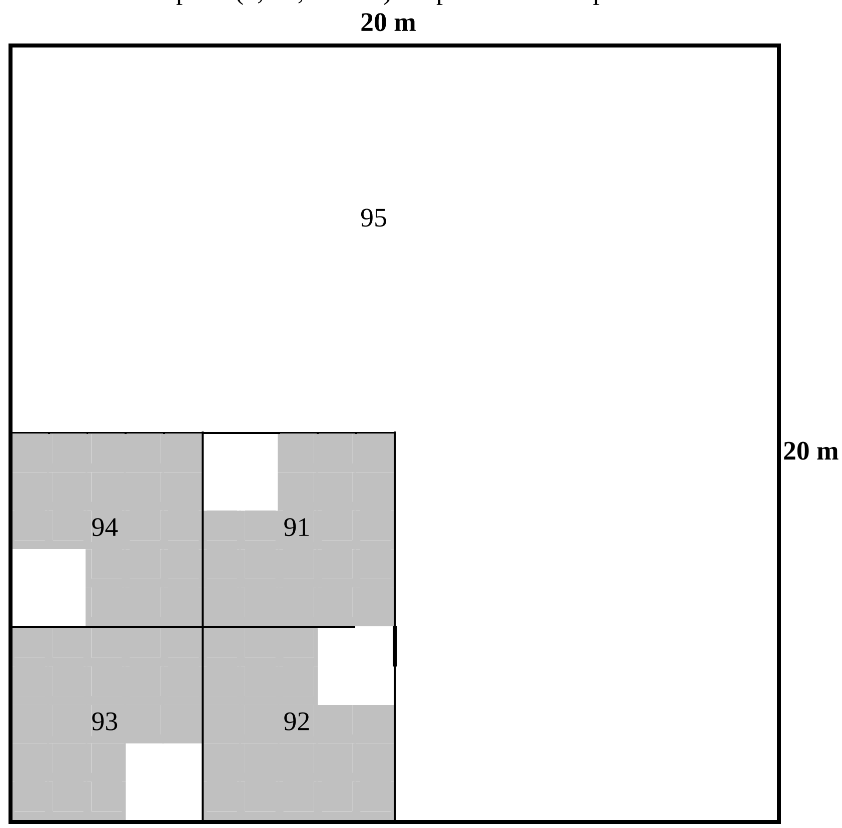
Until plots are expanded to 20x20 m, it will not be possible to estimate top heights that are comparable to those of the treated plots. Attempts to estimate top height using plot sizes smaller than 20x20 m will be biased (underestimating top height). The amount of bias increases as plot size decreases.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

Appendix 16-13 Future Expansion of Natural density aspen Subplots (plots 6, 12, and 15)

In the future these subplots will be expanded from 1x1 m, to 2x2 m (at year 5) to 5x5 m (expansion year not yet determined) then to the full 20x20 m size. 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 inTable 16-1. Graphic summaries of the area coverage (to avoid potential overlap and double counting) are shown in Figure 5-3, Figure 8-1 , Figure 16-2 and .

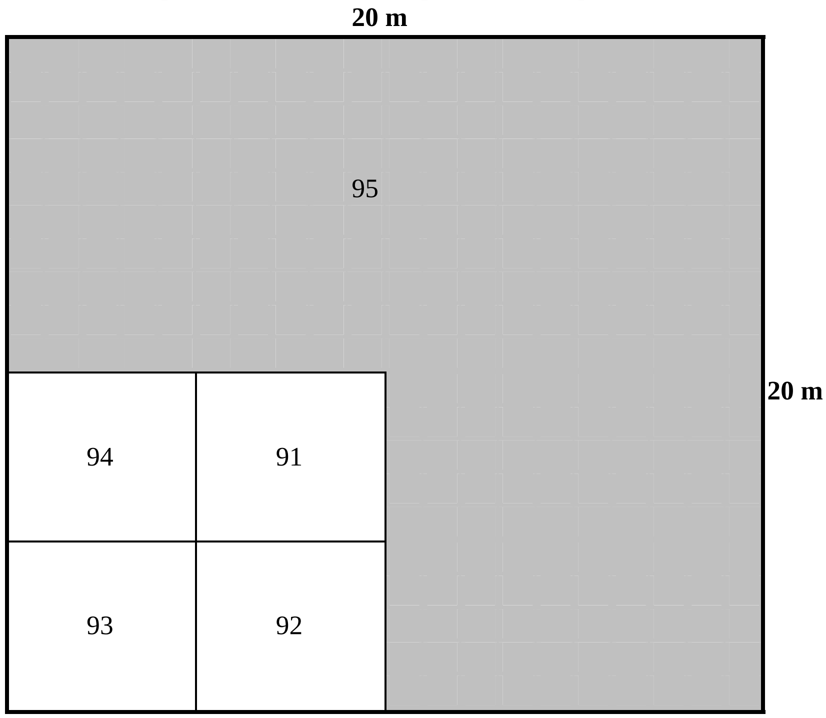
Tree numbers are consecutive and cumulative as subplots are expanded; see the figures below for additional details, and remember that as the sub-plot size is increased, it is important to continue measuring trees in the smaller sub-plots.

Figure 16-2 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 16-3 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.

Table 16-1 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	
5	2x2	.0004=.0003+.0001	22 + 11	
*	5x5	.0025=.0021+.0003+.0001	55 + 22 + 11	
*	20x20	.0400=.03+4*.0021+.0003+.0001	66 + 55 + 22 + 11	
* Not implemented until density declines further (ratified at spring meeting 2003), 2x2 m sub-plots will be used up to at least age 18, pending ongoing review.				
** To indicate that expansion is cumulative. For example, for trees with numbers 92xxxx and Record Type 22, plot size is .0003 ha. Trees with numbers 92xxxx and Record Type 11, are the set of trees found on the 1x1 m (.0001 ha) subplot. The total count of trees in these two sets is the count of trees on the .0004 ha subplot 92.				

Additional details and examples for the subplot expansion are provided in Table 16-2. 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 16-2 Subplot expansion areas and factors with example estimates of tree/ha

RTYP	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

Appendix 16-14 Historic Reference to 1990 - 2003 condition codes

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

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

Table 16-3 Description of 1990 - 2003 WESBOGY LTS tree condition codes

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

	Forks tend to be V-shaped and will only be recorded when above 1.3 m (dbh level). Forks below this point are recorded as trees having the same stump (category code 28). Natural forking on deciduous trees is not to be recorded.
14 Pronounced Crook-	Pronounced crook develops from the death or breaking-off of one of the leaders of a forked tree. It may also develop if the leader is broken off and a lateral branch becomes the new leader. A pronounced crook is more of a bend than a V-shape.
15 Sweep/Bend -	Sweep or bend is the gradual bowing or curving of the main tree stem. It has no decay significance. This is recorded when the sweep or bend is severe enough to cause a loss in sawlog volume.
16 Spiral Grain -	Spiral grain is the twisting of the grain seen in exposed wood or in the direction of the bark fissures. Spiralling frost cracks and scars also indicate the presence of spiral grain.
17 Dying -	A tree is considered to be dying when the amount of sound wood produced is less than the amount of sound wood lost on a yearly basis.
18 Dead Top -	Dead tops are those tops dead at least a year (versus top killing), obviously weathered and without any green foliage.
19 Broken Top -	Broken tops are breaks t hat occur above 10 cm dib (they are not used to indicate decay).
20 Animal or Mechanical Damage -	Woodpeckers and other birds frequently scar trees by making holes in the stems, providing an entry point for wood rotting fungi. Bear, deer, elk and moose can cause extensive damage by removing bark and cambium from the tree trunk. Rodents, including porcupines and beavers, can also damage trees. Mechanical damage refers to damage done to the tree by equipment and machinery such as trucks, skidders or bulldozers.
21 Insect Attacks -	Insects, specific to the genus, can attack any part of the tree, and in general are only recorded when t he actual insect is seen (not if only the symptoms of infestation are present). Insect attacks include infestations by sawyer beetles (a major problem in the slavage of fire killed timber), weevils, aphids, budworm, moths, etc. The forest tent caterpillar, *Malacosoma disstria*, causes severe defoliation in aspen stands in Alberta, resulting in a significant reduction in annual growth.
22 Limby -	A tree having long, heavy, low-limbed branches, is recorded as limby. Usually, limby trees are open-grown or older, dominant veterans.
23 Leaning -	To be recorded as leaning, a tree must have a noticeable angle from the vertical versus t he rest of the stand.
24 Broken Stem -	A broken stem is recorded if the tree bole is severed at a point below 10 cm dib (as distinct from a broken top).

Appendix 16-15 Correspondence between 1990-2003 and 2004 condition codes

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