

Foothills Growth and Yield Association
Lodgepole Pine Regeneration Project

**MANUAL
FOR FIELD MEASUREMENTS**

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1 General

This document is intended for use by FGYA technical representatives and contractors engaged in ongoing measurement of the trial, as a replacement to the full field manual (version 2.1, July 2003) and the subsequent supplementary manual for field measurements (version 1.3, June 2005). Documentation in the earlier full manual not directly relevant to field mensuration (or no longer required as dictated by the stage in the trial) has been removed. Version 2.0 addresses requirements identified for the 2007 field season following review and analysis of data collected for the first 5 years of the trial. For the most part, measurement procedures remain as described in the previous version (June 2005). However, a number of clarifications and changes have been made. The most important of these are highlighted in Appendix 3 as well as being incorporated in the rest of the manual. Please refer to Appendix 2 “Delivery File Structure Specification” for clarification of data loading and submission requirements.

Sections 1.1 through 1.5 below contain tables, lists, and figures which summarize planting densities, treatment plot descriptions, installation layout, referencing and numbering conventions, and scheduling of required measurements. Further details of plot establishment are provided in the Project Establishment Report (Dempster, W.R, and R.J.T. McPherson, April 2003). Detailed measurement schedules will be provided annually.

1.1 Installation Planting Densities

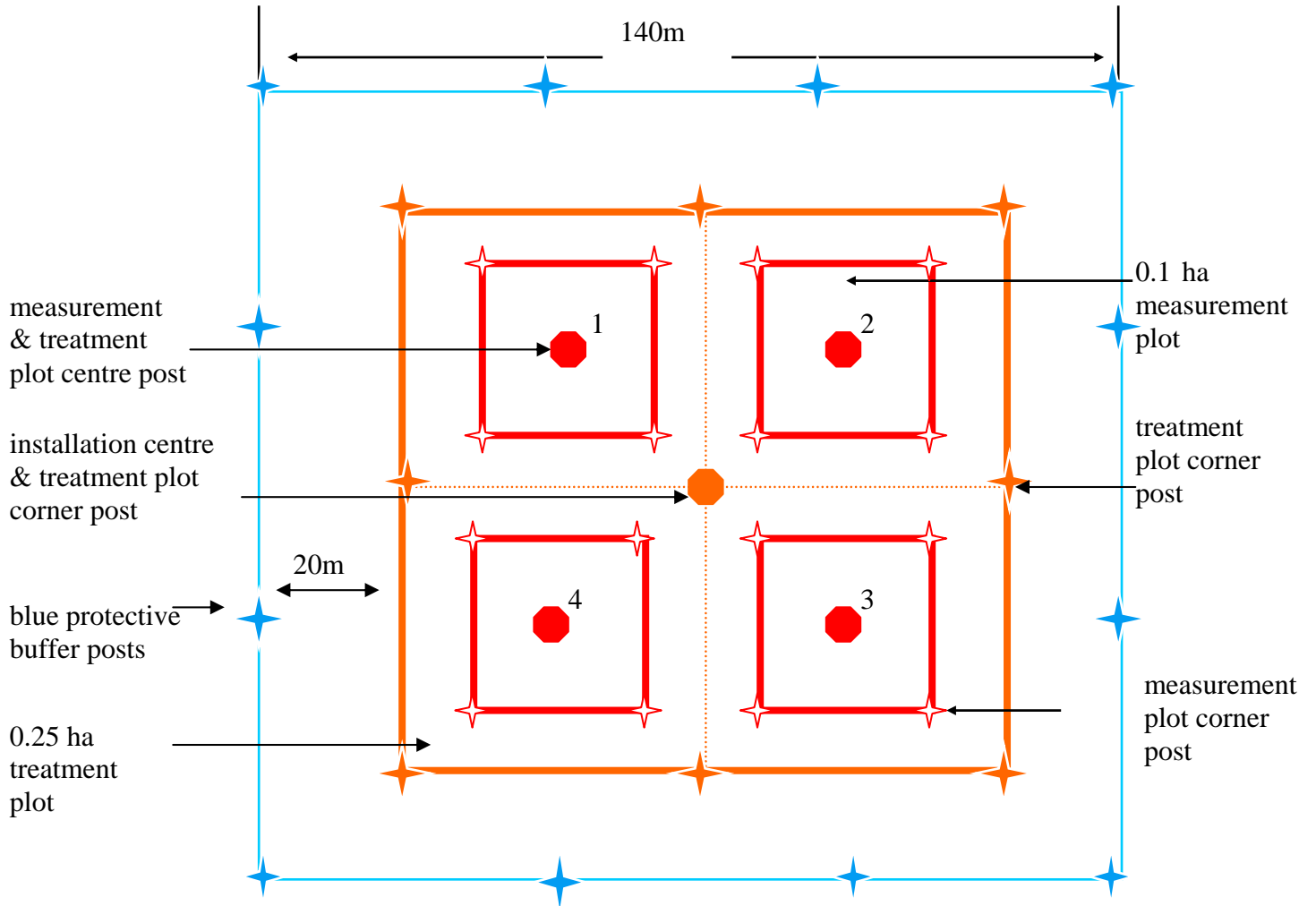
Spacing # Code	Spacing (m ²)	Target Density (stems/ha)	Target Trees/plot (0.25/0.1 ha)
1	Control	0	0
2	3.5	816	204/082
3	3.0	1111	278/111
4	2.5	1600	400/160
5	2.0	2500	625/250
6	1.5	4444	1111/444

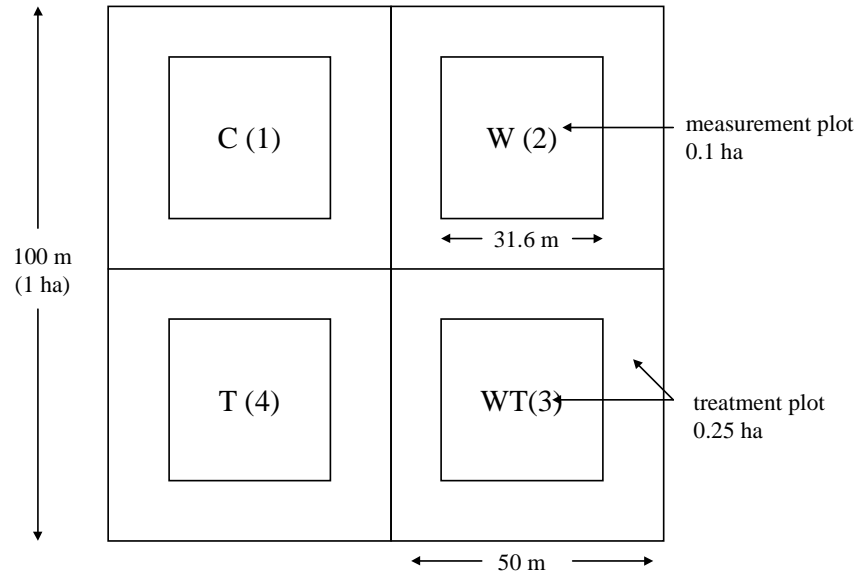
1.2 Plot Vegetation Management Treatments

T.P. #	Treatment	Treatment Description
1	C: Control	No vegetation management treatments
2	W: Weeding	Remove competing vegetation
3	WT: Weeding & Thinning	Treatments 2 & 4
4	T: Thinning	Pre-commercially thin to target density

The two diagrams below portray “typical”, non-split installations. Many installations have been split. Before carrying out any mensuration or treatment on any given plot, treatment plot post demarcation and field notes should be checked and verified.

1.3 Installation Diagrams





Treatment Plot 1 = C: Control
 Treatment Plot 2 = W: Weeding
 Treatment Plot 3 = WT: Weeding & Thinning
 Treatment Plot 4 = T: Thinning

1.4 Referencing and Numbering Conventions

Each installation is uniquely referenced by a 3-digit numeric code:

1. Ecosite category (valid codes 1 – 5).
2. Group number (valid codes 1 –5, expandable if additional replications added).
3. Spacing (valid codes 1 – 6: 1 = no planting, 2 = 3.5m/816spha, 3 = 3.0m/1111spha, 4 = 2.5m/1600spha, 5 = 2.0m/2500spha, 6 = 1.5m/4444spha)

1.5 Timing of Required Measurements

Measurement Category	End of Growing Season:				
	6	7	8	9	10
Coniferous density / ingress		x		x	
Competition – shrubs and herbs		x		x	
Competition – deciduous trees		x		x	
Size and growth		x		x	
Vigour	x	x	x	x	x
Health		x		x	
Photographs		x		x	

2 Measurements

Section 1.5 identifies when measurements are required during the second five years of the trial. Timing of measurements is expressed in growing seasons completed after planting. Measurements alternate annually between a basic check of tagged trees for vigour and mortality one year and full measurements the next. Because establishment and planting of installations was spread over a 3 year period, and to accommodate possible amendments to the default schedule in Section 1.5, a detailed annual schedule of measurements will be prepared and approved each year. A unique and sequential measurement number will be assigned by the database manager to each scheduled measurement of a treatment plot. Scheduled measurements should be made at the end of the growing season, following terminal bud set, between July 15 and September 15.

Full measurements (measurement type “FM”) include ingress, competition, sample tree size and growth, vigour, health, and photographs.

Vigour measurements (measurement type “V”) include assignment of a valid vigour code to all tagged trees, plus a valid “health” code for any tagged tree that has died since the last measurement.

Pinning and numbering of trees will be checked and maintained at each measurement. All seedlings planted within measurement plots, plus naturally regenerated trees designated as sample or crop trees (see below), should be pinned and numbered, using 9-gauge 45 cm painted wire pins, aluminum tags and wires. Numbering within an installation should be consecutive and continuous, i.e.; If measurement plot #1 had seedlings numbered 1-444, measurement plot #2 seedling numbering would start at 445 NOT 1. Pins should be consistently placed 20 cm North of seedlings to reduce confusion with ingress.

Any tagged tree within 1.78 m of a regeneration plot centre stake must be correctly assigned to that regeneration plot. Do NOT assign regeneration plot numbers to trees that are outside the regeneration plot.

For each tree in the database (i.e.: all tagged trees within measurement plots), a sample type must be correctly assigned. Valid sample types are shown below.

Tree Sample Type

Code	Sample Type
C	Crop Tree
S	Sample Tree
B	Crop Tree & Sample Tree
N	Neither ¹

Procedures for selecting sample trees are described below. Procedures for identifying crop trees are described in Section 2.5.

Sample Tree Selection - Planted Installations

The selection and tagging of sample trees provides the basis for tracking an unbiased sample of approximately 50 trees individually on each treatment plot. The selection of sample trees is only carried out once per installation; after their initial selection they will remain the same year to year. (Exception: during a fill plant, a dead sample tree could be replaced, given a unique number, and assessed as a new sample tree). Other than in a fill-planting situation, sample trees are not to be replaced. Where mortality of sample trees has occurred and no fill-plant has taken place there will be less than 50 sample trees.

To select the sample trees in planted installations, start by selecting all tagged trees within each regeneration plot until 50 sample trees have been selected. On lower density installations, you may not have 50 trees within the 16 regeneration plots, in this case, go back to the first plot and select the closest pine outside the regeneration plot, go to the next plot and do the same, continue doing this until you've achieved the required 50. Sample trees must be flagged on their respective pigtailed with BLUE ribbon (alternatively, pigtailed may be painted blue)

Note: The above procedure should have been followed in previous measurements for all planted installations.

Sample Tree Selection - Non-Planted “0 density” Installations

To select “Sample Trees” from ingress in non-planted installations, implement the following procedure:

For each treatment plot, start in regeneration plot # 1, measure out one metre, due North, from the regeneration plot center, and at this location, tag and number the closest lodgepole pine volunteer > 10 cm in height, within the 1.78 metre radius regeneration plot. Next, in the same regeneration plot, follow the same procedure twice more but measuring out one metre due East and then one metre due South, from the regeneration plot center, tagging and numbering the closest lodgepole pine volunteer > 10 cm in height. Once you have selected the three sample

¹ Trees tagged and assessed for health and vigour, which are neither crop or sample trees, are assigned the code “N”.

trees in regeneration plot #1 as noted above, move to the next regeneration plot and follow the same procedure starting with your first tree being the closest lodgepole pine volunteer > 10 cm in height as measured from a point 1 metre due West from the regeneration plot centre. If three sample trees are located at each regeneration plot (16), two extra sample trees will have to be selected to achieve a total of 50, these can be located in any regeneration plot. As you proceed with the selection process, alternate the selection location in order from N to E to W to S, this will result in an unbiased selection method. The regeneration plots need not be divided into theoretical quadrants for the selection process, simply select the lodgepole pine volunteer > 10 cm in height which is closest to the 1 metre point in the particular cardinal direction that you are using. By doing this instead of using a “quadrant”, we can select two or more sample trees which are located right next to each other in the same cardinal direction where clumping of trees is occurring. A maximum of 4 sample trees per regeneration plot, and 50 sample trees per measurement plot may be selected. Unlike on the planted plots, it is NOT necessary to look outside the regeneration plot if less than 50 trees are located within the 16 regeneration plots. Where this situation occurs, additional sample trees will be tagged if and when further ingress occurs.

The plot measurement type and tree sample type define what tree measurements are required as follows:

- V (vigour) measurement type:
 - Valid vigour code required for all tagged trees, regardless of sample type.
 - If tree has died since last measurement, a health code is also required to explain cause of death if known.
- FM (full) measurement type:
 - If sample type = S or B: all tree size and growth information, plus vigour and health, must be recorded;
 - If sample type = C: vigour and health codes are required, plus height is recorded in the regeneration plot table;
 - If sample type = N: vigour and health codes only are required.

Details of required measurements are provided below.

2.1 Density of Coniferous Natural Regeneration

- Required for FM (Full Measurements) only.
- In each 1.78 meter radius regeneration plot (16), record the number of live naturally regenerated coniferous trees >10.0 cm in height, by species & origin.
- Partition the counts by height into <30cm and 30cm+.

For trees 30cm+:

If the count is less than or equal to 10, the exact number of trees should be recorded. However, if the stem count exceeds 10, an estimate (accurate to +/- 10%) is acceptable.

For trees <30cm:

If the count is less than or equal to 10, the number of trees should be recorded to a required accuracy of +/- 2 trees . However, if the stem count exceeds 10, an estimate (accurate to +/- 20%) is acceptable.

2.2 Size & Growth (Sample Trees)

- Required for Sample trees in Full Measurements.

For each Sample Tree measure/collect the following information during scheduled FM (full measurements):

2.2.1 Tree Height:

- For each sample tree, record the tree height from tree stem ground level to the base of the bud. Leaning trees are to be measured from the base of the bud plumb to the ground level. E.g.; If a tree had an extreme lean of about 45° you would measure from the base of the terminal bud straight down to the ground, in other words, you do not measure the *length* of the tree, only the *height* above ground level.
- Precision: record to nearest 0.1cm on trees < 2 m tall, trees over 2 m are recorded to nearest cm. Accuracy required to within +/- 1 cm for trees < 3 m, +/- 10 cm for trees > 3 m.

2.2.2 Ground Line Diameter / Stump Diameter / Breast-Height Diameter:

- For each sample tree, record stem diameter in cm at ground level (GLD). Be careful not to damage trees with the calipers when taking measurements.
- Tree diameter is measured at ground line only until the sample tree has reached 2.0m in height. Once a tree has reached 2.0m in height, diameter will also be measured at 1.3m (DBH) and 0.3m (DSH).
- For one measurement only all 3 diameters will be required (GLD, DSH, DBH); thereafter GLD can be dropped.
- Precision: record all diameters to the nearest 0.1cm, accurate to within +/- 0.2cm.

2.2.3 Crown Diameter:

- For each sample tree, record the crown diameter at the widest point. Disregard “rogue” branches which would give a false assessment of crown diameter.
- Precision: record to the nearest cm. Accuracy required to within +/- 1 cm for trees < 3 m, +/- 10 cm for trees > 3 m.

2.2.4 Crown Length:

- For each sample tree, record the crown length in cm. Start at the bottom where the live crown starts and measure up to the tip of the terminal bud. Disregard “rogue” branches which would give a false assessment of crown length.

- Precision: record to the nearest cm. Accuracy required to within +/- 1 cm for trees < 3 m, +/- 10 cm for trees > 3 m.

Any trees which have “shrunk” significantly in height since the last measurement should have a valid health code or comment explaining shrinkage. Contractors should have previous measurements available in data collectors or on tally forms to assist in identifying these trees.

2.2.5 Last Three Internode Lengths:

- Internodal measurements capture one or more previous year’s measurements when plots are not visited annually. The database is set up to accept internode measurements # 1, 2, & 3. #1 being the previous year, # 2 being the year before that, etc.
- Under the current measurement schedule and interval, only the first (highest) 2 internodes need normally be measured.
- Precision: Record to 0.1cm accuracy on trees < 2 m tall, trees over 2 m are recorded to nearest cm. Accuracy required to within +/- 1 cm for trees < 3 m, +/- 10 cm for trees > 3 m.

2.3 Health

- Health assessments are required on all tagged trees during full (FM) measurements). They are also required during vigour (V) measurements for any tagged tree that has died since the last measurement.
- For each tagged tree within the measurement plot, record up to two health codes from the acceptable list of codes below, if applicable.
- Pay particular attention to the codes listed below that are bolded. These are factors that are known or expected to be significant causes of mortality in young lodgepole pine growing in west-central Alberta, and differentiation of which might lead to different management interpretations. Identification aids for these “key” factors are provided under separate cover.²
- If a condition is observed which is not listed in the Health Table, please record as a comment and notify the Field Coordinator of the additional health code requirement.

Code	Description	Code	Description	Code	Description
A	Abiotic injuries	DSB	White Pine Blister Rust	IMD	Coneworms
AB	Fire	DSC	Comandra Blister Rust	IME	Eastern Pine Seedworm
AC	Chemical Pollutants (not pesticides)	DSD	Sphaeropsis (Diplodia) Blight	IMK	Cone Midges
AD	Drought	DSF	Sweet Fern Blister Rust	IMM	Spruce Seed Chalcid/Midge
AE	Winter Damage	DSG	Scleroderris Canker	IMP	European Fruit Lecanium
AES	Snow or Ice	DSH	Hypoxylon Canker	IMS	Cone Maggots
AEW	Winter Desiccation	DSN	Aspen/Poplar Cankers General	IP	Pitch Blister Moths

² Identification of Key Health and Mortality Factors for the Foothills Growth and Yield Association Regenerated Lodgepole Pine Trial (Extracts from: *Field Guide to Forest Damage in British Columbia*, March 2001, Second Edition, MOF/CFS Joint Publication Number 17, Edited by John Henigman, Tim Ebata, Eric Allen, Joan Westfall, and Adriane Pollard. www.for.gov.bc.ca/hfp/forsite/pest_field_guide)

Code	Description	Code	Description	Code	Description
AF	Frost	DSR	Diplodia Gall and Rough Bark	IR	Wood Borers
AFC	Frost Crack	DSS	Stalactiform Blister Rust	IRA	Carpenter Ant
AFH	Frost Heaved	DSW	Western Gall Rust	IRB	Poplar Borer
AFK	Shoot/Bud Frost Damage	DT	Burls	IRC	Poplar and Willow Borer
AH	Hail	I	Insects	IRF	Flathead Borers
AL	Lightening	IA	Aphids, Adelgids and Scale Insects	IRM	Clearwing Moth
AO	Flooding	IAG	Gall Forming Aphids	IRT	Spruce Borers
AR	Redbelt	IAO	Open feeding Aphids and Adelgids	IRW	White Spotted Sawyer Beetle
AS	Slide	IAP	Pine Needle Scale	IRY	Northeastern Sawyer Beetle
AW	Windthrow	IB	Bark Beetles	IS	Seedling Insects
AWS	Soil Failure	IBA	Ambrosia Beetles	ISO	Strawberry Root Weevil
AWT	Treatment or Harvesting Related	IBD	Douglas Fir Beetle	IST	Crane Flies
AX	Scarring/Rubbing	IBE	Eastern Larch Beetle	IT	Terminal Weevils
CL	Condition - Leaning	IBH	Ash Bark Beetles	ITS	White Pine Weevil
CDT	Dead Top	IBL	Lodgepole Pine Beetle	ITT	Lodgepole Terminal Weevil
CFT	Fork Top	IBM	Mountain Pine Beetle	IW	Root Weevils
CNL	New Leader	IBR	Spruce Beetle	IWA	Northern Pine Weevil
CSM	Settling Mound (microsite)	IC	Defoliators – Coniferous	IWP	Couper Collar Weevil
D	Disease	ICA	Needle Miners General	IWS	Yosemite Bark Weevil
DB	Broom Rusts	ICB	Budworms General	IWW	Warren Root Collar Weevil
DBC	Yellow Witches Broom of Spruce	ICC	Spruce Budworm	T	Treatment Injuries
DBM	Witches Broom Rust of Fir	ICG	Black Army Cutworm	TC	Chemical
DC	Spruce Cone Rust	ICN	Sawflies General	TL	Logging
DD	Stem Decays	ICP	Yellowheaded Spruce Sawfly	TM	Mechanical
DDA	Aspen/Poplar Decays and Stains	ICZ	Budmoths General	TP	Planting
DDP	Red Ring Rot	ID	Defoliators – Deciduous	TPJ	J Root
DE	Seedling Diseases	IDA	Aspen Leaf Beetle	TPM	Poor Planting Microsite
DED	Damping off Disease	IDB	Birch Skeltonizer	UNS	Seedling Shrinkage – Unexplained
DEG	Grey Mold	IDC	Cankerworms General	V	Vegetation Problems
DEM	Powdery Mildew	IDF	Leafminers General	VP	Vegetation Press
DES	Storage Mold	IDG	Grey Willow Leaf Beetle	W	Wildlife
DF	Needle Diseases	IDL	Large Aspen Tortrix	WA	Bear
DFB	Needle Cast General	IDM	Forest Tent Caterpillar	WB	Browsing Damage
DFD	Elytroderma Needle Cast	IDO	Bruce Spanworm	WBC	Cows or Horses
DFE	Needle Rusts General	IDP	Aspen Leafroller	WBH	Hare or Rabbit
DL	Leaf Diseases	IDS	Satin Moth	WBU	Ungulates (Deer, Elk, Moose)
DLR	Leaf Rusts General	IE	Engravers/IPS	WM	Mice or Voles
DLS	Leaf Spot Diseases	IF	Spruce Bud Midge	WP	Porcupine
DLV	Aspen and Poplar Leaf and Twig Blight	IM	Seed and Cone Insects	WS	Squirrel
DM	Lodgepole Pine Dwarf	IMC	Spruce Seed Moth	WV	Beaver

Code	Description	Code	Description	Code	Description
	Mistletoe				
DR	Root Diseases			WY	Sapsuckers
DRA	Armillaria Root Disease				
DRI	Tomentosus Root Rot				
DS	Stem Diseases				
DSA	Atropellis Canker				

2.4 Vigour

Assessment of vigour is required in all scheduled measurements (measurement types FM, V).

For each tagged tree within the measurement plot, record one of the four following vigour codes:

Code	Vigour Class
AL	Alive and likely to survive
AU	Alive but unlikely to survive
D	Dead
M	Missing*

* Trees recorded as missing for three years, can be assigned as Dead

2.5 Competition and Crop Tree Assessment

Competition and crop tree assessments are required to be recorded during full measurements.

A “crop tree” is defined as the coniferous tree with the best overall height, ground line diameter, and health within each (1.78 m radius) regeneration plot. Each treatment plot will have a maximum of 16 crop trees. Initially, on planted installations, the crop tree should be a planted pine. However, if a naturally regenerated conifer in a regeneration plot exceeds the height and diameter of an existing crop tree, and is at least as healthy and vigorous as the crop tree, then that natural is to be tagged, numbered and considered to be the new crop tree. Moreover, any *planted* pine in a regeneration plot, which exceeds the height, diameter, and health of an existing crop tree will also replace the existing crop tree. (It will be tagged and numbered already so just record that number as the new crop tree). Crop trees will continue to be replaced by better candidates throughout the life of the plots, often more than once. Once a crop tree has been replaced by a better candidate, the replaced crop tree is no longer measured for any size and growth measurements (unless it is a “Sample Tree”).

Crop trees must have their respective pigtailed flagged with GREEN ribbon. Once a crop tree has been replaced with a better candidate the ribbon must be removed and placed on the new crop tree.

Shrub and herb competition (shrub/herb & deciduous) is assessed using the crop tree as theoretical plot centre. If no crop tree exists within a particular regeneration plot then competition is to be assessed using the regeneration plot centre. This holds true for control (non-planted) plots, i.e.: competition must still be assessed regardless of the presence (or absence) of a crop tree. In control plots, the best natural coniferous (ingress) seedling within each regeneration plot is selected as the crop tree (minimum 10cm height). This “natural” crop tree must be tagged and given a unique number.

Where competition is assessed as part of a regularly scheduled measurement, all size and growth measurements must be recorded for each crop tree. i.e. The “crop tree” will have the exact same variables collected as a “Sample” tree.

At each regeneration plot, measure/collect the following information:

2.5.1 Crop Tree Number

- Record the crop tree # used for assessments.

2.5.2 Tree Species Code

- Record the tree species code of the crop tree.

Code	Species
Fa	Sub-alpine Fir
Fb	Balsam Fir
Lt	Tamarack (Larch)
Pj	Jack pine
Pl	Lodgepole Pine
Sb	Black Spruce
Se	Englemann Spruce
Sw	White Spruce

2.5.3 Tree Source

- Record whether the crop tree is planted *or* from natural regeneration.

Example: Pl (planted)

Code	Definition
P	Planted
N	Natural

2.5.4 Tree Height

- As for sample trees (see Section 2.2.1).

2.5.5 Last Three Internode Lengths

As for sample trees (see Section 2.2.5).

2.5.6 Deciduous Competition

This information will be collected during full measurements and recorded in a separate deciduous data table.

2.5.6.1 # Stems >30cm in Height, by Species

- Record for each deciduous species the # of stems 30cm+ in height within 1.78 m of the regeneration plot centre.
- If the number of deciduous trees in the plot is less than or equal to 10, the exact number of trees should be recorded. However, if the stem count exceeds 10, an estimate (+/- 10%) is acceptable. This may be obtained by estimation from a representative segment of the circular plot (e.g. counting trees in a ¼ segment, and multiplying by 4 to obtain the estimate for the plot).

Suckered deciduous stems are counted as individuals if the suckering has occurred under ground and is not visible. A “group” of stems visibly suckered and/or originating above ground may be counted as a single stem.

2.5.6.2 Height and Diameter for Deciduous Species

- In the 1.78 m radius regeneration plots, record the modal height and modal ground-line diameter for each deciduous species. Modal height or diameter is the most frequently occurring height or diameter in a plot, not necessarily the average.
- Also record the species, height, ground-line diameter and (for trees over 2m in height) DBH of the tallest deciduous tree over 30 cm height.
- Precision: record heights to the nearest cm and diameters to the nearest 0.1cm. Required accuracies:
 - Modal height: +/- 2 cm on trees < 1 m tall, auditor’s discretion on trees > 1 m tall
 - Diameters: +/- 0.2 cm.
 - Height of tallest deciduous: +/- 1 cm for trees < 3 m, +/- 10 cm for trees > 3 m.

2.5.7 Shrub & Herb Competition:

2.5.7.1 Percent Cover and Modal Height for Top Five Shrub and Herb Species

- For up to five herb and shrub species competing with the crop tree, record the percent cover for each species along with the modal height of each in a 1.0 m radius plot centered on the crop tree. Competition is assessed on plot center when no crop tree is present. When using plot center as the theoretical crop tree, portray plot center as being of average height of the actual crop trees occurring (in cm) within the installation. It is the assessor’s decision as to whether or not a given species is competing with the crop tree and is based on the volume of vegetation and it’s proximity to the crop tree within the 1 m cylinder. Where two or more species are encountered with overlapping foliage covering the same ground area, the species with the tallest average height for that given area is assigned the percent cover (for that area).

E.g.: In a 1m radius plot you have two species, Loniinv @ 50% cover with a 60cm avg ht., and Corncan @ 10% cover with a 8cm avg ht.. 5% of the Corncan is overtopped by the Loniinv. Therefore, you would record Loniinv @ 50% cover and Corncan at 5% cover (the other 5% Corncan is overtopped by the Loniinv and is not counted.)
By doing this, shrub and herb competition percent cover will never exceed 100% for any given regeneration plot.

2.6 Photographs

Photographs are to be taken every two years at full measurements (more frequently if a vegetation treatment has been completed or the site is highly dynamic). Photographs may be taken digitally or conventional photographs may be collected and converted to digital format.

Photograph Collection Methodology:

- At each treatment plot center (4 per installation), take one landscape orientated photo toward each treatment plot corner. This will give us four photos per treatment plot and therefore 16 photos per installation. Photographs should be labelled accurately. Contractors will confirm the photograph submission format & protocol with the database manager prior to any collection of data.

Appendix 1. Comparison Chart for Visual Estimation of Percent Cover

