

BC MINISTRY OF FORESTS

MANUAL BRUSHING QUALITY INSPECTION SYSTEM

For use with specifications for manual brushing contained in:

- ministry contract forms - FS717A, FS717B,
- standards agreement forms - saFS717A and saFS717B, or
- a Sustainable Forest Management Plan (for publicly-funded work)

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Introduction

This booklet constitutes the Ministry of Forests' *Manual Brushing Quality Inspection System*. This system shall be used to determine the performance quality for manual brushing work funded by the Province of British Columbia and performed in accordance with the specifications contained in a ministry contract, a standards agreement, or a sustainable forest management plan.¹

The inspection system determines within a statistically valid level of precision how closely the manual brushing conforms to the standards stated in the agreement. Briefly, the system requires the collection of performance data from inspection plots as well as other data/observations from outside the plots and mathematically translates this information into a measure of performance quality.

This inspection system is consistent with the following fundamental principles:

- achievement of an adequate number of appropriately brushed trees;
- minimal damage to crop trees;
- encourage efficiency (and lower cost) by allowing some variability across a treatment unit, requiring less brushing where appropriate; and
- maintain biological diversity within openings.

The system is designed to accommodate a variety of brushing situations, such as:

- recent plantations, having no natural regeneration or few naturals;
- fill-planted areas, having acceptable naturals or acceptable previously-planted trees;
- older plantations where it may be difficult to distinguish naturals from previously-planted trees, and crop trees are possibly up to an average 3 m tall;
- a wide range of treatment types, such as cutting, girdling, breaking or bending, brush matting, etc; and
- a wide range of target vegetation, from herbaceous plants to broadleaf trees.

This inspection system is specifically designed to be used in conjunction with revised ministry manual brushing contract forms 717A and 717B, dated 02/03 or later. However, it may be adapted for use with most agreements covering manual brushing activities on Crown land, provided an agreement specifies the following essential elements:

- an inspection plot radius;
- criteria for the selection of crop trees;
- the number of crop trees within a plot to be brushed (treated);
- target vegetation species to be brushed around crop trees within a treatment circle radius;
- treatment standards, including a definition of crop tree damage;
- plot errors, defined as either reworkable or non-reworkable, that correspond with the specifications of the agreement;
- non-plot faults that correspond with specifications of the agreement and that are not suited for examination solely through inspection plots.²

¹ For ease of reading, the term 'agreement' is used to collectively refer to these documents.

² To aid in the distinction between those aspects of performance that are evaluated only within plots vs those evaluated anywhere on a treatment unit (both in and outside plots), infractions evaluated solely within plots are termed 'errors' and those evaluated both in or outside plots are termed 'faults.'

Statistical Objective

The methodology described in this booklet will result in an estimate of manual brushing performance quality for plot errors that is statistically valid within $\pm 5\%$, 19 times out of 20.

Survey Design

To meet the statistical objective an inspection survey must:

1. uniformly and systematically sample the treated area;
2. be free of bias; and
3. have a sufficient number of inspection plots of an appropriate size so that the bulk of the variation in a population is accounted for in the sampling.

Starting with the last requirement first, experience has shown that a plot containing 7-10 crop trees, a plot intensity of one plot/ha, and a minimum of 10 plots will usually deliver the required statistical precision for an individual treatment unit. Thus, a survey design should normally start with these criteria. However, it cannot be known for certain ahead of actually collecting the plot data whether or not the number of plots will be adequate for statistical purposes. Consequently, during the survey design stage an experienced inspector can vary the number of plots up or down in accordance with the observed variability within the particular areas to be inspected. The greater the variation in the consistency of the work, the more plots that may be needed, and vice versa.

Using a 100 m distance both between strip lines and between plots on a strip line will give a sampling intensity of one plot/ha. If such a grid is suited to the particular treatment unit to be inspected, lay it out on a project map so that the area will be uniformly sampled. Where treatment unit shapes do not lend themselves to such a grid, change strip lines as needed to ensure plots are well-distributed and the treatment unit is evenly sampled. When there are multiple treatment units in an opening having different brushing requirements, each treatment unit must be sampled to the 10 plot minimum criterion.

The distance between plots should be evenly spaced on a strip line (in this case, 100 m apart) but the distance from the start of the strip to the first plot may be varied to between 10 and 110 m. Predetermining plot locations on the project map avoids the risk of bias.

Once the basic grid is laid out, add the points of commencement and termination. Also add any other tie points necessary to ensure the grid is accurately established in the field. These should be tied into features indicated on the project map or on an air photo. Examples of good tie points are road junctions, road crossings over creeks, creek junctions, or points where block/road boundaries change direction. If sufficient tie points are not available, one or more survey base lines may have to be installed.

The above systematic method is only one of several possible methodologies. Any method that produces a non-biased, systematic, uniform and complete sampling of a treatment unit is acceptable.

Choosing a Plot Radius

All inspection plots in a treatment unit must use the same plot radius. For statistical purposes, an average of 7 – 10 crop trees within each plot is optimum. Thus, as stand density decreases plot size must correspondingly increase to capture the desired 7-10 crop trees, and vice versa.

The following table shows different stocking density ranges and the corresponding plot radii and multipliers. A 3.99 m radius is typically used in the BC interior while a 5.64 m radius is common on the coast. However, if crop tree densities are lower, as they can be in heavy brush situations, a larger than normal plot may be appropriate.

Crop Tree Density Range ³ (trees/ha)	Plot Radius for 7 to 10 Crop Trees (m)	Plot Multiplier ^a
3500 – 5000	2.52	500
1400 – 2000	3.99	200
700 – 1000	5.64	100
350 – 500	7.98	50
140 – 200	11.28	20

^a # trees in a plot X plot multiplier = # trees/ha

Reworkable Plot Errors

Reworkable plot errors are errors found within an inspection plot that **can** be corrected. There are nine reworkable plot errors for all manual brushing treatment types except brush matting for which there are three. This section describes the nine standard reworkable errors. Brush matting errors are described on page 5.

Errors R3 through R9 are purposely similar to those used in the juvenile spacing quality inspection so as to minimize the potential for confusion.

Excess Trees

An *excess tree* is a brushed tree within an inspection plot that is in excess of the agreement M Value.⁴ In an inspection plot having excess trees as well as plot errors, a reworkable error can be attributed to an excess tree, provided all other requirements can be met in the plot.

³ Note that the density ranges are for crop trees but there may also be additional non-crop trees in a plot. Although not always the case, most areas scheduled for manual brushing will have few naturals and therefore most or all trees will be crop trees.

⁴ “**M Value**” or “**M**” means both the number of crop trees required to be brushed in a plot and the maximum number of brushed crop trees that will be credited in an inspection plot. This value is subject to adjustment on a plot by plot basis – see “Recording the Plot,” page 6.

R1 – Improper Crop Tree Selection

Error R1 – Improper Crop Tree Selection is assigned only when the crop tree that should have been selected remains undamaged (otherwise the error is NR1 – Crop Tree Damage). As specified in an agreement, the best trees of the highest ordered preferred crop tree species that are not within the minimum inter-tree distance of each other should have been brushed.

R2 – Target Vegetation Not Treated

Error R2 – Target Vegetation Not Treated is assigned when more than 10% of the area within a treatment circle, measured on a ground cover basis, has not been treated or is improperly treated.

Error R2 is also assigned when a treatment circle has not been shifted uphill on a steep slope where required under an agreement.

R3 – Target Vegetation Leaning on Crop Tree

Error R3 – Target Vegetation Leaning on Crop Tree is assigned when target vegetation is leaning against or has the potential to fall back on a crop tree.

R4 – Live Branches

Error R4 – Live Branches is assigned when all live branches on the stump of target vegetation have not been cut or broken as per agreement requirements.

R5 – Stump Cut Angle

Error R5 – Stump Cut Angle is assigned when the stump angle on any woody-stemmed target vegetation exceeds 30 degrees from horizontal.

R6 – High Point of Treatment

Error R6 – High Point of Treatment is assigned when the point of treatment on a stem of the target vegetation is greater than 30 cm above the point of germination, or the height specified in an agreement.

R7 – Target Vegetation Not Cut Through

Error R6 – Target Vegetation Not Cut Through is assigned when target vegetation that is required to be completely cut is not completely cut through.

R8 – High Slash

Error R8 – High Slash is assigned when the height of the slash exceeds the maximum permissible height specified in an agreement. The slash height specification does not apply to brush matting.

R9 – Other

Error R9 – Other is assigned for any other reworkable error. This would normally be an error arising from not meeting an additional non-standard requirement specified in a particular agreement.

Non-Reworkable Plot Errors

Non-reworkable plot errors are errors found within an inspection plot that cannot be corrected. There are three non-reworkable errors for all treatment types.

NR1 – Crop Tree Damage

Error NR1 – Crop Tree Damage is assigned when crop tree damage results from treatment. The criteria for crop tree damage must be stated in an agreement.

NR2 – Improper Cutting

Error NR2 – Improper Cutting is assigned when more than 25% of the stems of the target vegetation within a treatment circle that are required to be left partially attached have been completely cut or broken off.

NR3 – Other

Error NR3 – Other is assigned for any other non-reworkable error. This would normally be an error arising from not meeting an additional non-standard requirement specified in a particular agreement.

Brush Mat Installation Errors

The following reworkable error codes apply solely to brush mat installation. Other than this, the NR error codes, plot procedures and performance quality calculations for brush mat installation are the same as for any other treatment type.

R1 – Insecure Installation

Error R1– Insecure Installation is assigned when a brush mat has not been securely fastened down.

R2 – Crop Tree Damage Potential

Error R2 – Crop Tree Damage Potential is assigned when a brush mat has been installed in a manner that does not prevent potential weather and/or animal damage to the crop tree.

R3 – Vegetation Not Treated

Error R3– Vegetation Not Treated is assigned when vegetation that prevents the proper installation of the brush mat has not been cut, pulled or otherwise removed.

Recording the Plot

The following is the recommended procedure for inspecting each plot and recording the results. Figure 1, page 8 shows a completed sample plot card for 10 plots in a fictional treatment unit A.

1. Enter at the top of the plot card the M Value for the treatment unit as specified in the agreement covering the work.
2. Observing the total plot, select and flag those trees that best meet the crop tree criteria as specified in the agreement, up to the M Value, regardless of whether they were brushed or not.

A tree having part of its stem (not just a branch) that falls on the plot boundary is a 'borderline' tree. Tally such trees as crop trees when the point of germination lies within the plot.

3. Determine the total number of crop trees in the plot and record this in column 2 of the plot card.

For the majority of plots, the total number of crop trees will be the M Value. However, the total is decreased when there is a physical lack of crop trees to be brushed and increased where there are tall naturals that are required under an agreement to be brushed. If an agreement's M Value is 8, for example, the total number of crop trees in a plot could range from 0 to 16.

4. Assess each crop tree for treatment errors. Note any error codes in the reworkable or non-reworkable columns as appropriate.

Assign only one fault to an individual crop tree. If there are several faults associated with the same crop tree, assign the most serious one, noting the others in the comments section of the inspection card. If an agreement holder re-works an area, all reworkable errors must be corrected in order to improve performance quality.

5. If there is a crop tree with an error, look for an error-free excess tree that may be substituted for it. An excess tree, however, must be equal to the crop tree having the error in meeting the crop tree criteria.
6. After assessing crop tree errors, subtract the # of trees in the plot having errors from the plot crop tree total and enter the result in the 'Satisfactory' column.
7. Finally, record the number of broadleaf leave trees within the plot. Put the count of those that the agreement requires to be left under the 'Mandatory' column of the plot card and those that the agreement states may be left under the 'Optional' column.

Because the number of broadleaf leave trees is usually small, the plot count of leave trees/ha is not likely to be statistically valid. If having a specified number or range of leave tree

stocking is a mandatory requirement, more plots or a larger plot radius will likely be needed to meet statistical requirements.

Two infractions can occur with respect to broadleaf leave trees. A mandatory leave tree that is cut or damaged is recorded as a non-plot fault (see the next section). An untreated optional broadleaf tree that is in excess of the allowed number is recorded against the nearest crop tree as reworkable error R2 – Target Vegetation Not Treated.

Figure 1. Sample Plot Card, Manual Brushing

Treatment Unit: A Agreement M Value: 8 Plot Radius: 3.99 m

Inspection Date: _____ Inspector: _____

Plot #	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total ^a	Satisfactory	Rework Errors	Non-rework Errors	Mandatory	Optional	
1	8	6	1 – R3 1 – R5	0	0	0	R-5 tree also has R-6 error.
2	8	7	0	1 - NR1	0	0	Large scrape on crop tree.
3	8	8	0	0	0	1	Optional alder leave tree. Excess tree used to absorb R2 fault.
4	6	5	1 – R2	0	1	0	Dogwood tree left uncut as req'd.
5	9	9	0	0		0	1 large natural brushed as required.
6-10 ^b (condensed)	40	37	2	1 - NR1		3	
Total	79	72	5	2	1	4	

Non-Plot Fault Code	# Faults	Comments/ Observations
F1	2	11 Pacific Yew trees cut in 2 locations - between plots 3 & 4 and immediately north of plot 8.
F4	3	Cut vegetation left in approx. 200 m of road ditch. This is approx. 17% of total SRZ. Contractor advised and will clean out. Check before TPQ calculation finalized.

General Comments
1. About 80 optional broadleaf leave trees/ha left. This is below max of 100/ha allowed in the agreement.
2.
3.

- a The total number of crop trees in a plot ordinarily should equal the agreement M Value, but may be decreased when insufficient crop trees are present or increased to no more than twice the M Value when additional natural crop trees that an agreement requires to be brushed are present.
- b Plots 6-10 are condensed into a single row in this example for brevity. This would not be appropriate in actual practice.

Non-Plot Quality Faults

A non-plot quality fault can be found inside or outside a plot. In other words, it is not limited to the plot inspections. Following are the common faults that may occur in manual brushing.

F1 – Cutting or Damaging a Tree Required Not to be Cut

Fault F1 – Cutting or Damaging a Tree Required Not to be Cut is assigned at the rate of one fault for every five trees that are cut or damaged that an agreement specifies not to be cut or damaged. A minimum of five such trees must be cut before the first fault is recorded. In other words, one F1 fault is assigned when the observed number of cut trees reaches five, two when it reaches 10, three at 15, etc.

F2 – Felling a Wildlife Tree

Fault F2 – Felling a Wildlife Tree is assigned when a designated wildlife tree has been cut or damaged in a manner that will impair its function or duration as a wildlife tree.

F3 – Damage to a No-treatment Zone

Fault F3 – Damage to a No-treatment Zone is assigned at the rate of one fault for every 5% of the total area of all no-treatment zones (NTZ) that has been cut or damaged. A minimum of 5% of the total NTZ area must be damaged before the first fault is recorded. In other words, one F3 fault is assigned when the observed area of damage in a no-treatment zone reaches 5% of total area, two when it reaches 10%, three at 15%, etc. The total area of no-treatment zones includes all areas, both within and bordering a treatment unit, that an agreement specifies are not to be treated.

F4 – Failure to Remove Slash

Fault F4 – Failure to Remove Slash is assigned at the rate of one fault for every 5% of the total area of all slash removal zones (SRZ's) that has not had slash satisfactorily removed. A minimum of 5% of the area in SRZ's must have slash remaining before the first fault is recorded. In other words, one F3 fault is assigned when slash remains in 5% of total area of all SRZ's, two when it reaches 10%, three at 15%, etc. The total area of slash removal zones includes all areas, both within and bordering a treatment unit, from which an agreement specifies slash is to be removed.

F5 – Concealed Damage

Fault F5 – Concealed Damage is assigned whenever the cut portion of a crop tree is found in a location where it could not normally be as a result of cutting or cannot be found at all. Concealing damage is a serious matter. Reflecting this, three faults are recorded for each occurrence.

Examples of concealed damage are:

- a stump of a crop tree is found and the top cannot be found;

- the top of a crop tree is found, and the stump from which it was cut cannot be located or is not within a reasonable distance of it; or
- the top of a crop tree is found in a location where it could not lie as a result of the work, such as stuffed under the stump of a harvested tree or under a rock.

F6 – Wastage of Brush Mats

Fault F6 – Wastage of Brush Mats is assigned where brush mats are provided by the Province and the agreement holder has lost, destroyed or wasted brush mats, or fails to account for all the brush mats. Fault F6 is assigned at the rate of 1 fault for every 1% of total brush mats issued that are wasted or unaccounted for. The number of brush mats unaccounted for is calculated by subtracting the number of brush mats satisfactorily installed, as measured using the Ministry's performance quality inspection system (total # of satisfactory trees in all plots X the plot factor), plus 10 percent (or the standard error of the estimate as calculated by the Province, whichever is greater), from the net number of brush mats issued or the reported number installed.

F7 – Stashed Brush Mats

Fault F7 – Stashed Brush Mats is assigned when an agreement holder (or the holder's employees or agents) have purposely abandoned or disposed of brush mats supplied by the Province. Each occurrence of stashed brush mats is assigned a 2% reduction in Total Performance Quality. When Total Performance Quality before such a reduction is between 92% and 100% the Total PQ is adjusted to 90%. In addition, the Province will treat occurrences of stashed brush mats as a potential criminal matter and will request a police investigation.

Recording Non-Plot Faults

Violations of agreement conditions or specifications that could occur either inside or outside of an inspection plot are termed “non-plot” quality faults. Typical non-plot faults and their quality measures are described in the preceding sections.

When a non-plot quality fault is observed, the appropriate number of associated faults must be determined. For some types of faults (e.g., slash left in slash removal zones, cutting trees required not to be cut, etc.) the number of fault points cannot be finalized until the entire assessment area is covered.

Any observed non-plot faults are recorded in the section provided on the inspection plot card. They should not be recorded as a plot fault.

Performance Quality Calculation

Calculating Performance Quality - Overview

Performance quality formulas should be set out in the agreement governing the work. If no formulas are specified in an agreement the formulas below are to be considered the standard.

Calculating performance quality is a three step process. The plot performance quality (PPQ) is calculated first, starting out at 100% with the reworkable and non-reworkable plot error percentages then subtracted as follows:

Start	100%
Less:	Reworkable Error %
Less:	<u>Non-reworkable Error %</u>
Equals	Plot Performance Quality %

Next, the plot performance quality is then tested for statistical significance (see “Determining the Statistical Validity of the Plot PQ Estimate,” page 12). If the estimate of PPQ % is not statistically valid, then more plots must be installed (see “Installing Additional Plots,” page 12).

Once the estimate of plot PQ is confirmed statistically valid, the last step is to determine the non-plot fault percentage and then subtract this from the Plot PQ to obtain Total PQ.

	Plot Performance Quality %
Less:	<u>Non-plot Fault %</u>
Equals	Total Performance Quality %

These three steps are described in more detail in the sections below.

Calculating Inspection Plot Performance Quality

The standard formula for the plot reworkable error percentage is:

$$\text{Reworkable Error \%} = \frac{\text{Total Number of Reworkable Errors}}{\text{Total Crop Trees}} \dots X \dots 100$$

Using the sample plot data in Figure 1, the reworkable error % is calculated as:

$$\text{Reworkable Error \%} = \frac{5}{79} \dots X \dots 100 = 6.33\%$$

The standard formula for the plot non-reworkable error percentage is:

$$\text{Non - reworkable Error \%} = \frac{\text{Total Number of Non - reworkable Errors}}{\text{Total Crop Trees}} \dots X \dots 200$$

Using the plot data in Figure 1, the non-reworkable error % is calculated as:

$$\text{Non - reworkable Error \%} = \frac{2}{79} \cdots X \cdots 200 = 5.06\%$$

Substituting the above two values into the Performance Quality calculation gives a Plot PQ of 88.61% as follows:

Start	100%	100.00
Less:	Reworkable Error %	6.33
Less:	<u>Non-reworkable Error %</u>	<u>5.06</u>
Equals	Plot Performance Quality %	88.61

Determining the Statistical Validity of the Plot PQ Estimate

(To be completed.)

Installing Additional Plots

If additional plots are required to meet statistical requirements, determine the plot interval for the new plots by dividing the original number of plots by the number of additional plots required plus one, rounding the result to the nearest integer. For example, if the original number of plots is 10 and two additional plots are required, divide 10 by (2+1) to get a result of 3. Thus the new plots should be placed after every third original plot, in this case halfway between plots 3 & 4 and 6 & 7. These plots can be marked in the field and on the survey map as plots 3A and 6A.

Calculating Non-Plot Performance Quality

Performance quality faults outside the plot are described in “Non-Plot Quality Faults,” page 9. Of the non-plot faults, only failure to remove slash is reworkable. For simplicity in the performance quality calculation, all are treated on a common basis with the more serious faults being assigned a higher number of faults per occurrence.

The non-plot fault % is determined by adding all the non-plot faults in a treatment unit (or combination of areas being assessed) and multiplying the total by the adjustment factor in the table to the right that corresponds with the total area being assessed. Assuming treatment unit ‘A’ is 10 ha, then the area adjustment factor is 0.005. The sample plot in Figure 1 has 5 non-plot faults, so the non-plot error % is $0.005 \times 5 = 0.025\%$.

<u>Area (ha)</u>	<u>Area Adjustment Factor</u>
1	0.050
2	0.025
3	0.017
4	0.013
5	0.010
6	0.008
7	0.007
8-9	0.006
10-11	0.005
12-14	0.004
15-20	0.003
21-33	0.002
34+	0.001

Substituting this into the performance quality equation yields a Total PQ of 88.585% as follows.

	Plot Performance Quality %	88.610
Less:	<u>Non-plot Error %</u>	<u>- 0.025</u>
Equals	Total Performance Quality %	88.585

Unsatisfactory Performance

Total Performance Quality Below 85%

The ministry considers 85% to be the lowest acceptable level of total performance quality. Under most agreements between the ministry and other parties, when TPQ falls below 85% the ministry may choose to terminate the agreement or require the agreement holder to rework the area. As most brushing faults are reworkable, depending upon the payment provisions of the particular agreement, agreement holders will usually want to rework an area when total performance quality falls much below 90%.

Crop Tree Damage Exceeds 3%

The definition of crop tree damage may vary between agreements or forms of agreement. The ministry *Schedule A* for manual brushing (FS 717A) defines crop tree damage as:

- (a) a cut to more than one-third of the circumference of the main stem;
- (b) a cut or scrape to the main stem that exposes more than five cm of cambium or
- (c) breakage or cutting of greater than thirty percent of the branches of a Crop Tree.

Unless otherwise specified in an agreement, the ministry considers work to be unsatisfactory when crop tree damage exceeds 3%.

Excessive crop tree damage is a serious situation, particularly where stocking is already borderline. In such cases, careless brushing can reduce a stand's final timber yield by a substantial amount. This is why the tolerance for crop tree damage is relatively low.

The % crop tree damage is calculated by dividing the total number of crop trees across all plots having error NR1 (crop tree damage) by the total number of crop trees and multiplying by 100 to express the result as a percentage. Using the sample plot data in Figure 1, crop tree damage is:

$$(2 \div 79) \times 100 = 2.5\%$$

In this example, the damage level is borderline as only one more damaged crop tree would exceed the 3% acceptability limit. An agreement is usually terminated when 3% crop tree damage is exceeded.

Stratifying an Assessment Area

An assessment area should be stratified into sub-areas, or strata, whenever an inspection reveals it to have two distinct populations – areas that are properly treated and areas that are not. A tip-off that this might be the case would be when the standard level of sampling (see “Survey Design,” page 2) does not yield a 95% confidence on the estimate of plot performance quality.

There are typically two situations where stratification is appropriate, the first of these being where overall performance quality on an assessment area has fallen below 70% but there are distinct areas of satisfactory performance. However, stratification should not be done when 3% crop tree damage has been exceeded or performance quality is below 85% on the better treated area; in other words, when performance quality on the better treated area is unsatisfactory.

The second situation where stratification may be appropriate is where a reasonable total performance quality has been attained, but there are parts of an assessment area that are clearly below 70% TPQ. Stratification would particularly be warranted when crop tree damage has exceeded 5% on part of an area.

If a decision is made to stratify an assessment area, the plot data is used in conjunction with the plot layout map to determine where the concentrations of acceptable vs unacceptable treatments lie. A walkthrough may be needed to confirm and/or refine the strata boundaries. There must be a clear boundary to justify a stratification. If necessary, additional plots should be installed on a random basis within each stratum to confirm visual observations but care must be taken to ensure the selection of plot location is not biased.

Sample Plots

Tree Species Codes

The following tree species codes are used in the sample plots.

Fd	Douglas-fir
Hw	western hemlock
B	balsam fir
Sw	white spruce

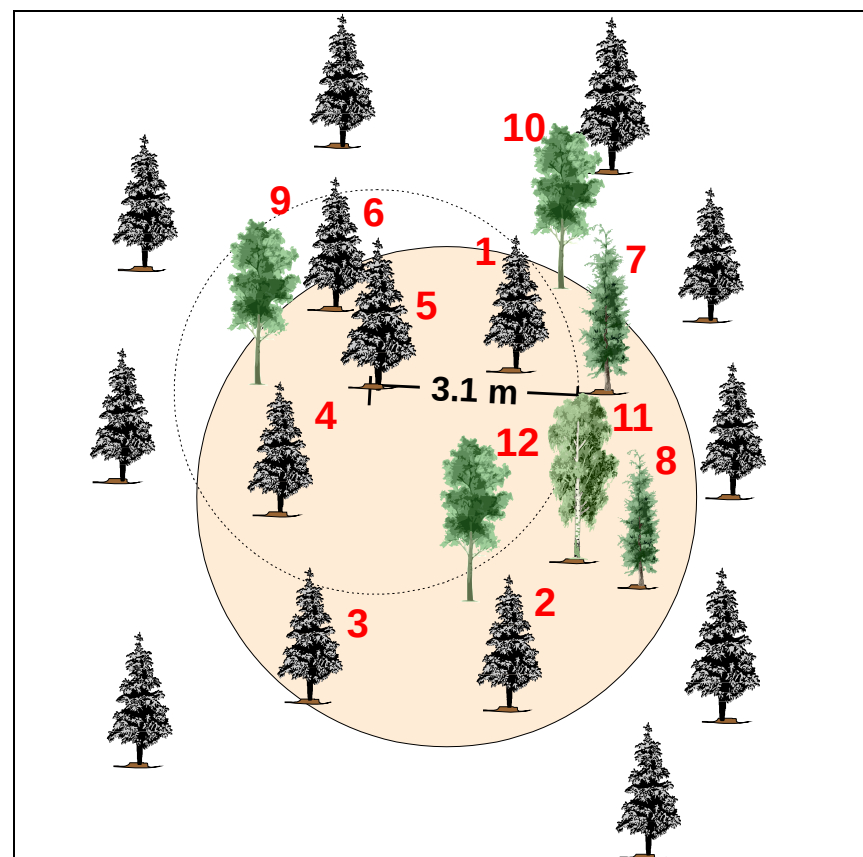
PLOT 1: Untreated Plot Description

Work Unit Description

Plot Radius	3.99 m (1/200 th ha)
Method of establishment	Planted 1 200 sph Fd, large stock (6/plot, 3.1 m inter-tree distance)
Treatment regime requirement	One brushing, 4 years after planting
Stocking Status before Brushing	
Total Trees	2 400 sph (12/plot)
Planted Crop Trees	1 200 sph, (6/plot) 2.0 m avg ht, some 2.3 m ht
Naturally established Crop Tree species	400 sph Hw (2/plot), 2.5 m avg ht. Occasional Hw is 3.5 m tall.
Broad-leaved Trees	600 sph red alder, birch (3/plot) (plot contains 1 extra tree)

Plot Trees

Tree Number	Description
1 to 6	Planted Fd
7, 8	Naturally established Hw
9 to 11	Naturally established red alder
12	Naturally established birch



PLOT 1A: Crop and Leave Tree Selection

Work Unit Description

See info under Plot 1

Agreement Specifications

Crop Tree species	Fd, Hw
Agreement M Value	6 (1 200 sph)
Minimum inter-tree distance between Crop Trees	2 m (no min. between planted trees)
Target Vegetation & Treatment Circle radius	Salal, vaccinium spp, --- 1.5 m elderberry, broadleaf trees --- 2.0 m
Minimum height for an additional natural crop tree	1.5 X height of adjacent planted Fd
Optional broadleaf leave tree species (in order of preference)	Western white birch, red alder
Max. # optional broadleaf leave trees	200 sph (1/plot)
Minimum distance between a Crop Tree and a Broadleaf Leave Tree	1.5 m
Treatment type	Cutting

Plot Card

Plot No.	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total	Satisfactory	Rework Errors	Non-Rework Errors	Mandatory	Optional	
1	7	7	0	0		2	2 nd decid tree OK. No other decid trees w/in 5.64 m plot.

Discussion of the Plot

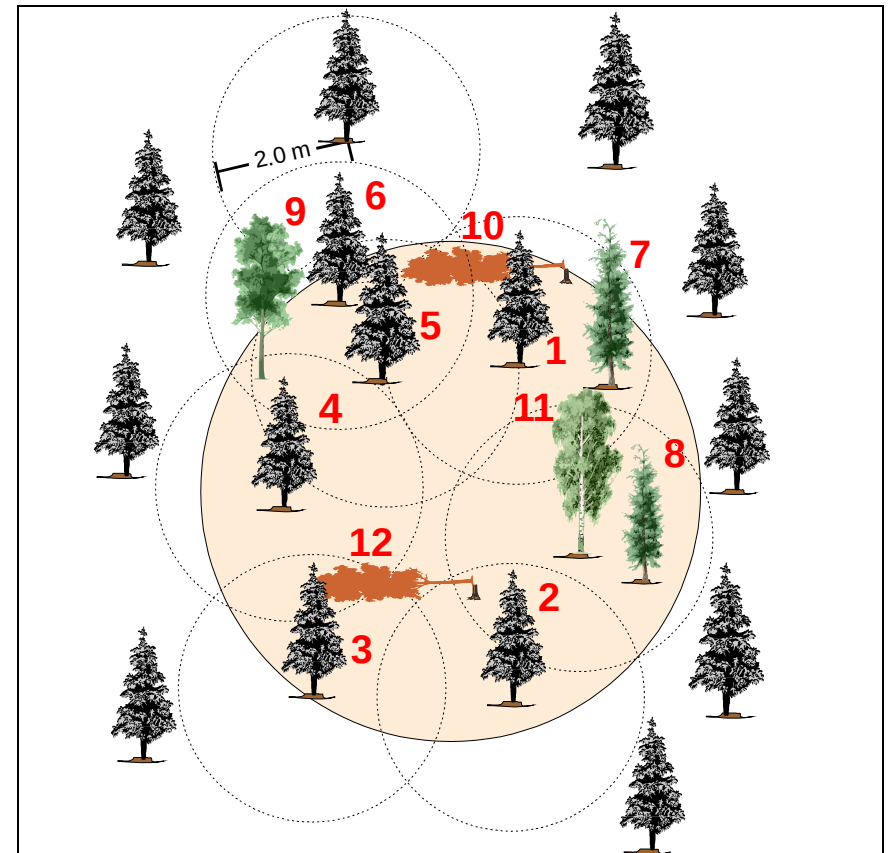
Although the agreement M Value is 6, it is increased by 1 in this plot due to the requirement to include tree 7, a natural tree that is 1.5 times the height of tree 1.

During the brushing treatment, the total tree count was reduced from 11 down to 9. Alder trees 9 & 10 were correctly cut as broadleaf trees within 2 m of a crop tree.

Trees 1 to 6 were correctly chosen as planted crop trees. Although trees 5 & 6 are close to each other, both are crop trees because they are planted trees.

Tree 11, a birch tree, is allowed to be left as it is > 2 m from any crop tree. It is correctly chosen in preference to tree 10 based on agreement species preference.

Tree 8, an alder tree, is greater than the 1.5 m minimum inter-tree distance from a crop tree requirement and therefore is acceptable as an optional broadleaf



leave tree from that perspective. However, there being 2 broadleaf trees in the plot (8 & 11) may indicate that the density of optional broadleaf leave trees is too high.

The easiest way to check broadleaf tree density is to lay a wider plot radius of 5.64 m over the existing 3.99 m plot (or 7.98 m if the existing plot is 5.64 m). This doubles the size of the plot. In Plot 1A there are no other broadleaf trees within the wider plot and therefore tree 8 is acceptable as a leave tree. If there were another broadleaf tree in the wider plot, then tree 8 would be considered above the allowable limit, in which case error R2 – Target Vegetation Not Treated would be assigned against tree 4 or 5.

PLOT 1B: Brushing Quality

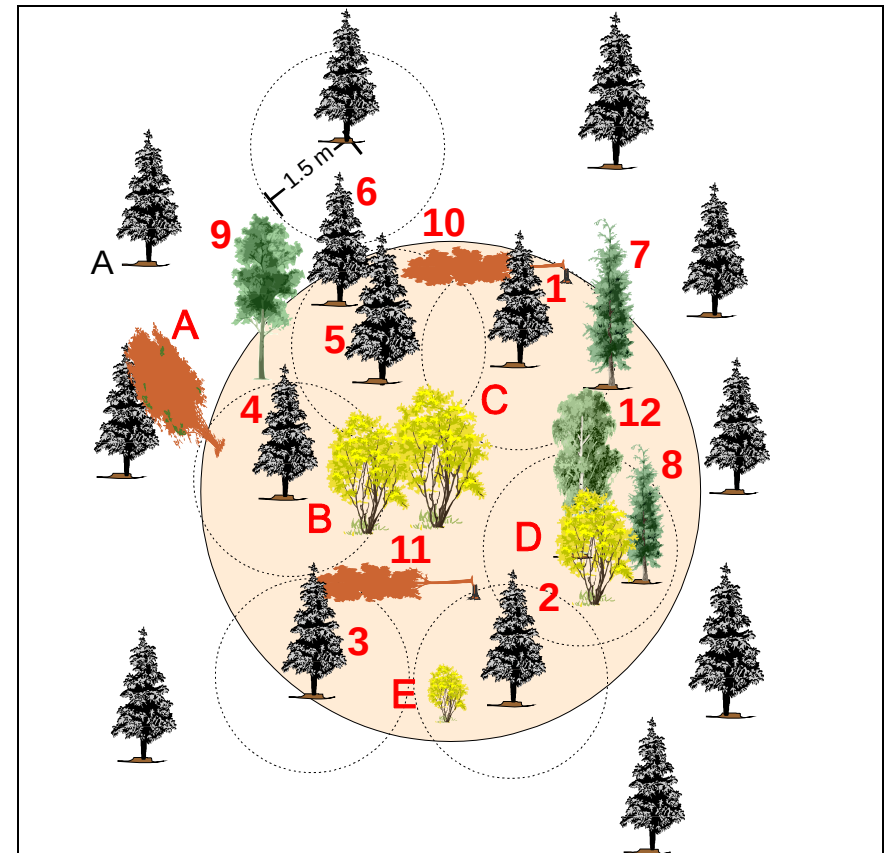
Work Unit Description

See info under Plot 1

Agreement Specifications

Crop Tree species	Fd, Hw
Target Vegetation & Treatment Circle radius	Salal, vaccinium spp, --- 1.5 m elderberry, broadleaf trees --- 2.0 m
Height below which target vegetation is not required to be cut	1 m
Treatment type	Cutting
Max cutting height	30 cm
Max slash height	1.5 m

Plot No.	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total	Satisfactory	Rework Errors	Non-Rework Errors	Mandatory	Optional	
1	7	7	T4 – R2	0		2	2 nd decid tree OK. No other decid trees w/in 5.64 m plot.



Discussion of the Plot

The plot has no non-reworkable errors and two reworkable errors.

Brush A is leaning against a crop tree. Because the crop tree is outside the plot this is not a plot fault and nothing is recorded on the plot card.

Brush B is within 1.5 m of tree 4 and should have been cut. It is assigned fault R2 – Target Vegetation Not Treated. Brush C, however, is allowed to remain untreated as it is not within 1.5 m of any crop tree.

Brush D, although within 1.5 m of tree 11, is not required to be treated because tree 11 is an optional broadleaf leave tree. No fault is recorded.

Brush E is within 1.5 m of tree 2 but is not required to be cut as it is less than 1 m tall.

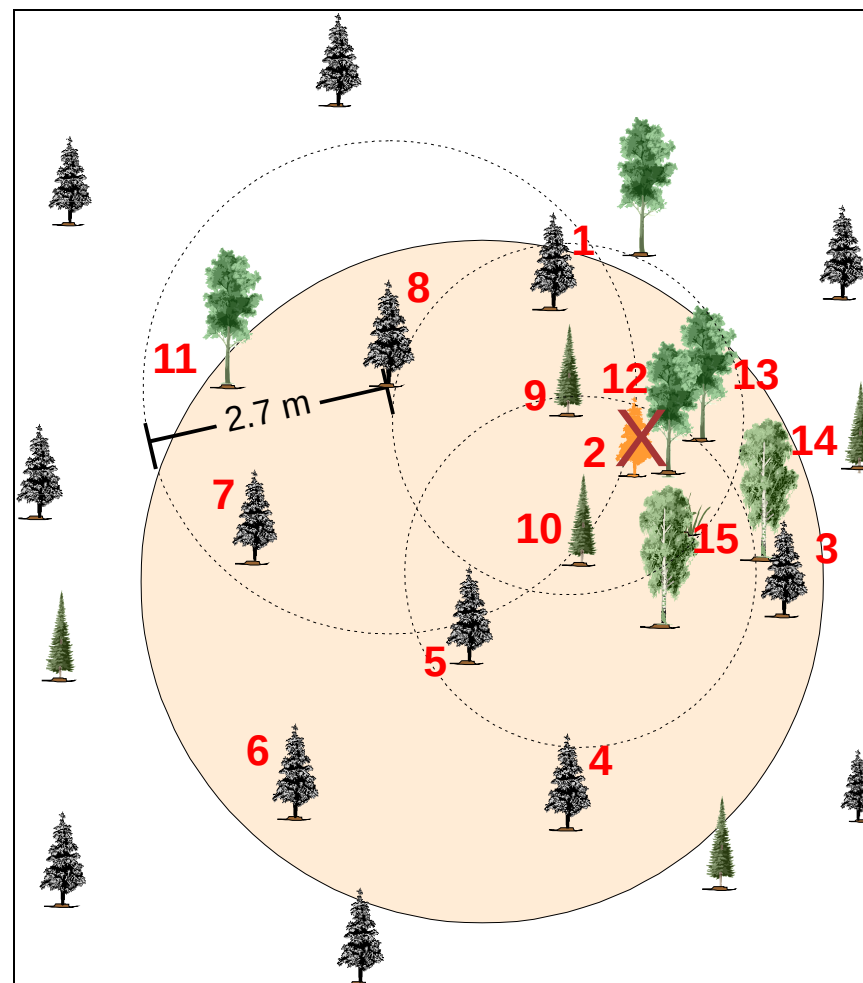
PLOT 2: Untreated Plot Description

Work Unit Description

Plot Radius	3.99 m (1/200 th ha)
Method of establishment	Planted 1 600 sph Sw, large stock (8/plot, 2.7 m inter-tree distance)
Treatment regime requirement	2-3 brushings, this is the first brushing 2 growing seasons after planting.
Plot Radius	3.99 m (1/200 th ha)
Stocking Status before Brushing	
Total Trees	2 800 live sph (14/plot)
Planted Crop Trees	1 400 live sph (7/plot), 1.0 m avg ht 200 dead sph (1/plot)
Naturally established Crop Tree species	400 sph balsam, 0.8 m avg ht. (2/plot)
Broad-leaved Trees	1000 sph cottonwood, birch, (5/plot), 1.6 m avg ht
Brush species present	willow, devil's club, cow parsnip

Plot Trees

Tree Number	Description
1 to 8	Planted Sw (tree 2 is dead)
9, 10	Naturally established B
11 to 13	Naturally established cottonwood
14, 15	Naturally established birch



PLOT 2A: Crop and Leave Tree Selection

Work Unit Description

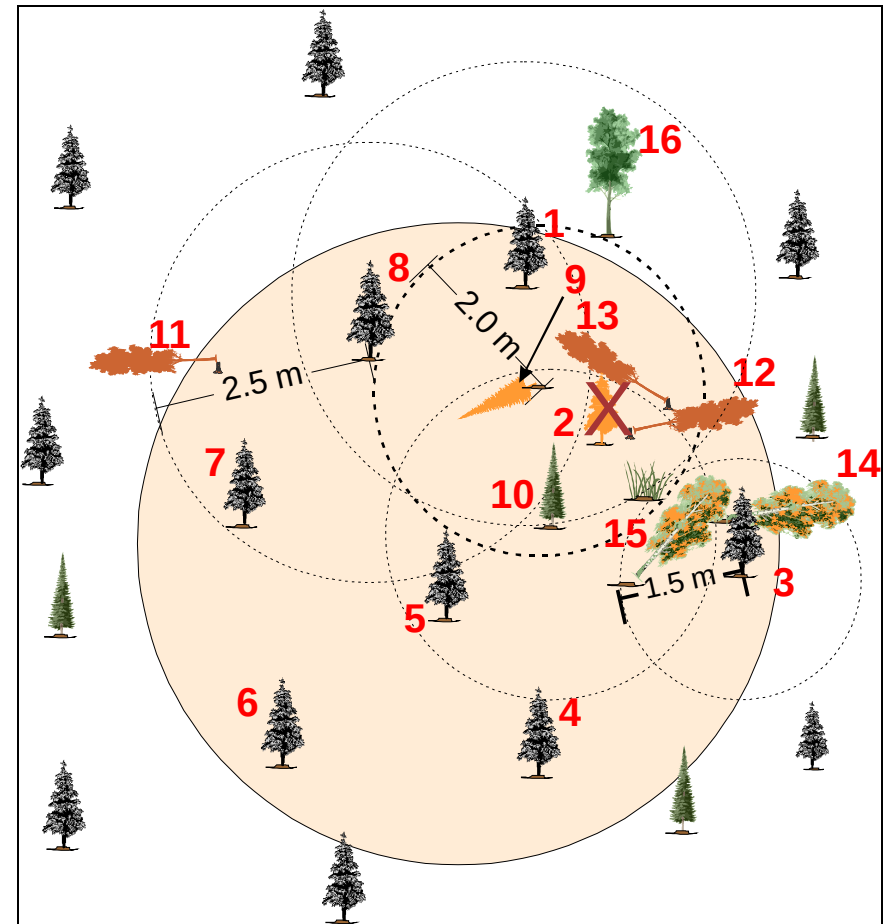
See info under Plot 2	
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Agreement Specifications

Crop Tree species	Sw, B
Agreement M Value	8 (1 600 sph)
Minimum inter-tree distance between Crop Trees	2 m
Target Vegetation & Treatment Circle radius	All brush species --- 1.0 m All broadleaf trees --- 2.5 m
Minimum height for an additional natural crop tree	1.5 X height of adjacent planted Sw
Optional broadleaf leave tree species (in order of preference)	Western white birch
Max. # optional broadleaf leave trees	200 sph (avg 1/plot)
Minimum distance between a Crop Tree and a Broadleaf Leave Tree	1.5 m
Treatment type	Cutting

Plot Card

Plot No.	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total	Satisfactory	Rework Errors	Non-Rework Errors	Mandatory	Optional	
1	7	6	T1 – R2		N/A	0	B tree cut - \$50 assessment



Discussion of the Plot

Although the agreement M Value is 8, it is not possible to fill the hole left by tree 2 (a dead planted Sw) with a natural balsam tree because the 2 adjacent balsam trees (9 & 10) are not further than the required minimum distance of 2 m from a planted crop tree. Thus the M value for this plot is lowered to 7 and trees 9 & 10 are not required to be brushed.

During the brushing treatment, the total tree count was reduced from 14 live trees to 8. Trees 9 (balsam), 11-13 (cottonwood) and 14-15 (birch) were cut. Even though tree 9 was correctly not selected as a crop tree for brushing, it is a crop tree species and should not have been cut. A \$50 assessment is therefore noted in the plot comments column.

The 3 cottonwood trees (11-13) were correctly cut as broadleaf trees within 2.5 m of a crop tree. Although the agreement provides the option of leaving 1 birch tree/plot, neither birch tree in the plot (14 & 15) could be left as both were less than the required minimum 1.5 m distance from a crop tree.

Tree 16, a cottonwood tree, lies outside the plot but should have been cut because it is within 2.5 m of tree 1, a crop tree. Reworkable error R2 – Target Vegetation Not Treated is therefore assigned to tree 1.

PLOT 2B: Brushing Quality

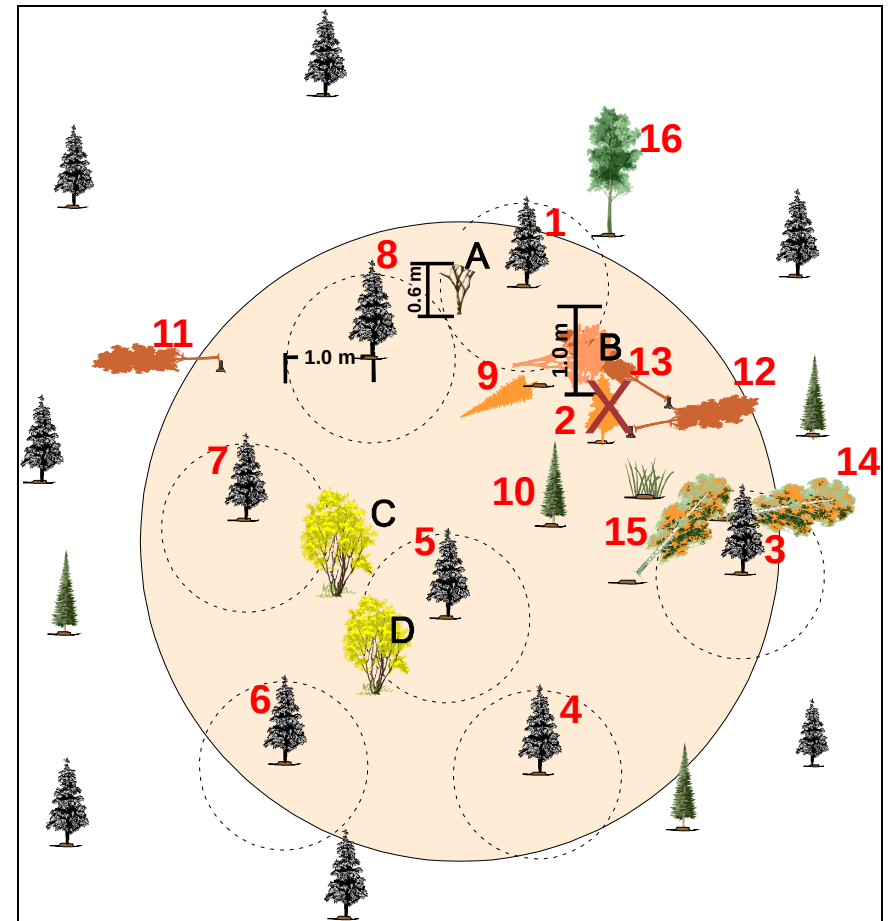
Work Unit Description

See info under Plot 2

Agreement Specifications

Crop Tree species	Fdi, Hw
Target Vegetation & Treatment Circle radius	All brush species --- 1.0 m All broadleaf trees --- 2.5 m
Tree height over which trees not required to be brushed	N/A
Height below which target vegetation is not required to be cut	N/A
Treatment type	Cutting
Max cutting height	30 cm
Max slash height	1.0 m

Plot No.	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total (max M)	Satis- factory	Rework Errors	Non- Rework Errors	Manda- tory	Optional	
1	7	6	T1 – R2		N/A	0	T1 also has fault R6.



Discussion of the Plot

The brushing in the plot has one reworkable error. Brush A was clipped across the top, but at 0.6 m is well above the maximum cutting height of 0.3 m. Ordinarily this would result in fault R6 – High Point of Treatment being assigned against tree 1. However, tree 1 already has fault R2 assigned against it (see Plot 2A), so this fault is recorded in the observations column. Note that if this were a more serious fault than the already-recorded fault then the two faults should be switched in their locations on the plot card.

The slash height of brush B is acceptable, being less than the 1.0 m limit.

Portions of bushes C & D are within the 1 m treatment circles of crop trees 5 & 7 respectively. This is acceptable as the bases of these bushes are outside of the treatment circle.

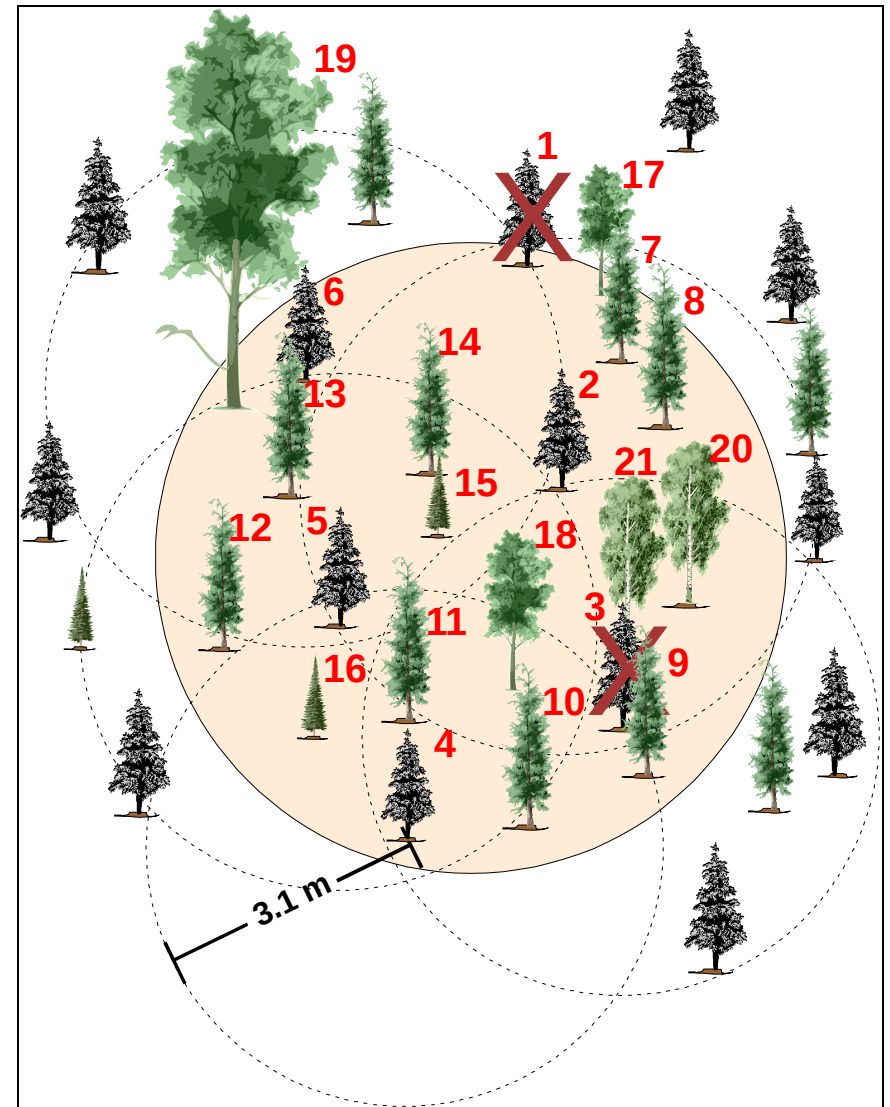
PLOT 3: Untreated Plot Description

Work Unit Description

Plot Radius	3.99 m (1/200th ha)
Method of establishment	Planted 1200 sph Fdc, large stock (6/plot, 3.1 m inter-tree distance)
Treatment regime requirement	2 brushings, this is the first brushing 2 growing season after planting.
Stocking Status before Brushing	
Total Trees	3 800 live sph (average 19/plot)
Planted Crop Trees	800 live sph (4/plot), 1.5 m avg ht 400 dead sph (2/plot)
Naturally established Crop Tree species	1600 hemlock, (8/plot) 2.0 m avg ht 400 sph balsam, (2/plot) 0.8 m avg ht
Broad-leaved Trees	1000 sph cottonwood, birch, (5/plot) 2 m avg/ht
Brush species present	willow, devil's club, cow parsnip

Plot Trees

Tree Number	Description
1 to 6	Planted Fd (trees 1 & 3 are dead)
7 to 14	Naturally established Hw
15, 16	Naturally established B
17 to 19	Naturally established cottonwood
20, 21	Naturally established birch



PLOT 3A: Crop and Leave Tree SelectionWork Unit Description

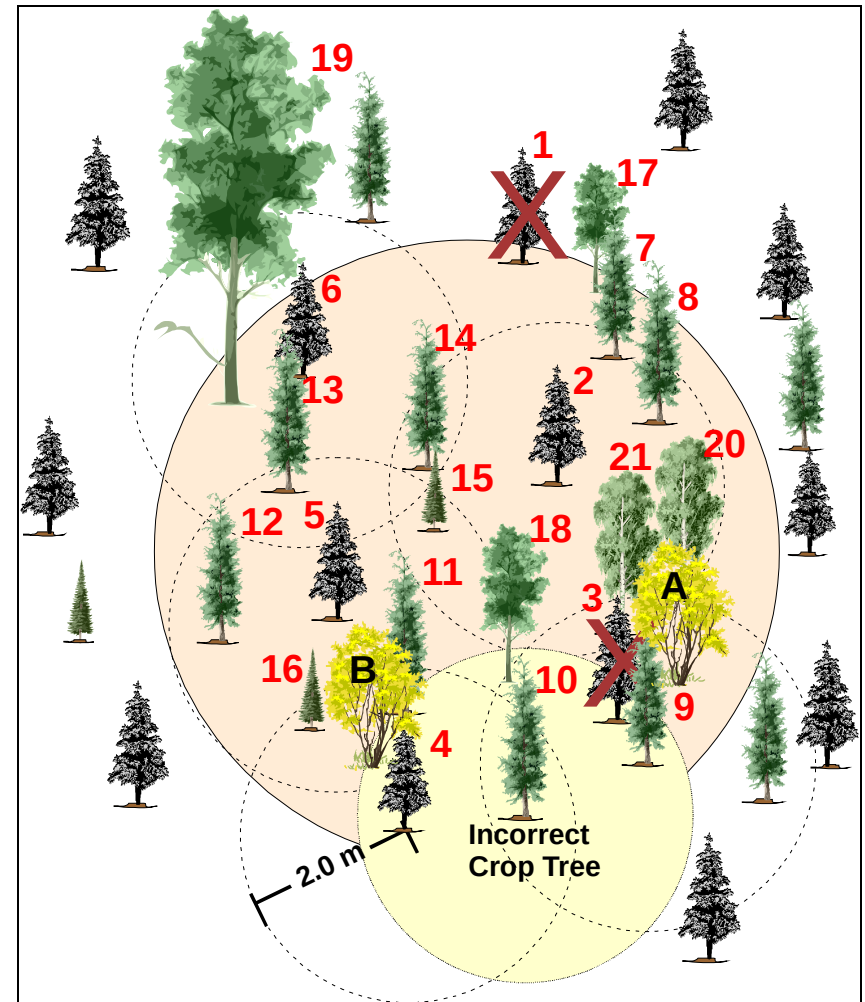
See info under Plot 3

Agreement Specifications

Crop Tree species (in order of preference)	Fd, Hw
Agreement M Value	8 (1 600 sph)
Minimum inter-tree distance between Crop Trees	2 m
Target Vegetation & Treatment Circle radius	All brush species --- 1.5 m All broadleaf trees --- 2.5 m
Minimum height for an additional natural crop tree	1.5 X height of adjacent planted Fd
Optional broadleaf leave tree species (in order of preference)	None
Max. # optional broadleaf leave trees	None
Minimum distance between a Crop Tree and a Broadleaf Leave Tree	N/A
Treatment type	Cutting, except decid over 4 m tall to be girdled

Plot Card

Plot No.	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total	Satisfactory	Rework Errors	Non-Rework Errors	Mandatory	Optional	
1	6	4	T4 – R1 T9 – R1		N/A	N/A	

Discussion of the Plot

Because crop trees 1 & 3 have died (leaving only 4 live planted crop trees), 4 natural trees must be recruited to meet the agreement M Value of 8. The only candidate that is more than 2 m from a planted crop tree is tree 9, a hemlock. However, tree 10 was incorrectly brushed as a “best” crop tree instead of tree 4, a planted Fd (as indicated by untreated bushes A & B being within a 1.5 m radius of trees 9 & 4 respectively). This resulted in tree 9 not being selected as a crop tree as it was within the 2 m min. inter- tree distance of tree 10.

In fact, trees 4, 10 and 9 should all have been selected as crop trees. The correct selection should have started with tree 4 as a preferred species (planted Fd),

followed by tree 10 which is a natural more than 1.5 X the height of tree 4 (note: the 1.5X ht. criterion applies to the adjacent crop tree ht, not the avg. crop tree ht.). Because tree 10 is an additional natural associated with tree 4, tree 9 is a crop tree that is more than the 2 m inter-tree distance from tree 4.

As there are no other natural Hw that are further than 2 m from a crop tree the total number of crop trees in the plot is 6 (trees 2, 4, 5, 6, 9, 10). There are 4 satisfactory trees (2, 5, 6, 10) and 2 reworkable errors, both R1 – Improper Crop Tree Selection (trees 4 & 9). Alternatively, trees 4 & 9 could each be assigned error R2 – Target Vegetation Not Treated.

PLOT 3B: Brushing Quality

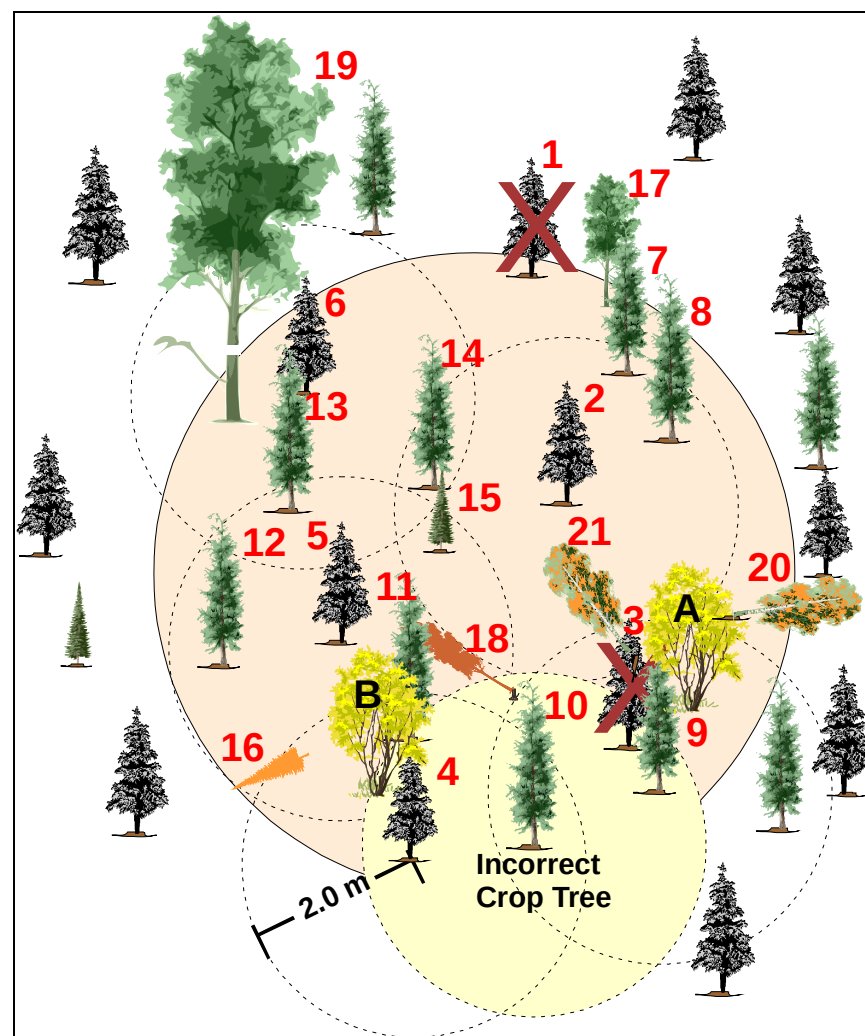
Work Unit Description

See info under Plot 2	
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Agreement Specifications

Crop Tree species (in order of preference)	Fd, Hw
Agreement M Value	8 (1 600 sph)
Minimum inter-tree distance between Crop Trees	2 m
Target Vegetation & Treatment Circle radius	All brush species --- 1.5 m All broadleaf trees --- 2.5 m
Minimum height for an additional natural crop tree	1.5 X height of adjacent planted Fd
Optional broadleaf leave tree species (in order of preference)	None
Max. # optional broadleaf leave trees	None
Minimum distance between a Crop Tree and a Broadleaf Leave Tree	N/A
Treatment type	Cutting, except decid over 4 m tall to be girdled
Max cutting height	30 cm
Tree height over which trees not required to be brushed	N/A
Height below which target vegetation is not required to be cut	N/A

Plot No.	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total	Satisfactory	Rework Errors	Non-Rework Errors	Mandatory	Optional	
1	6	3	T4 – R1 T9 – R1 T19 – R4		N/A	N/A	



Discussion of the Plot

The brushing in the plot has one reworkable error. Tree 19, a 4.8 m cottonwood, was girdled as required, being over 4 m tall. However, a branch below the girdle was not removed, so reworkable error R4 – Live Branches is assigned.

Tree 16, a balsam, was cut. This is acceptable as the species was not specified as a crop tree species. Likewise, it is acceptable that tree 15, also a balsam, was not cut as it was not named as a target vegetation species.

Because tree 1, a planted Fd, has died, tree 17 (a cottonwood) is not within 2.5 m of a crop tree inside the plot and therefore is not recorded as a plot fault, despite it being within 2.5 m of a crop tree outside the plot.

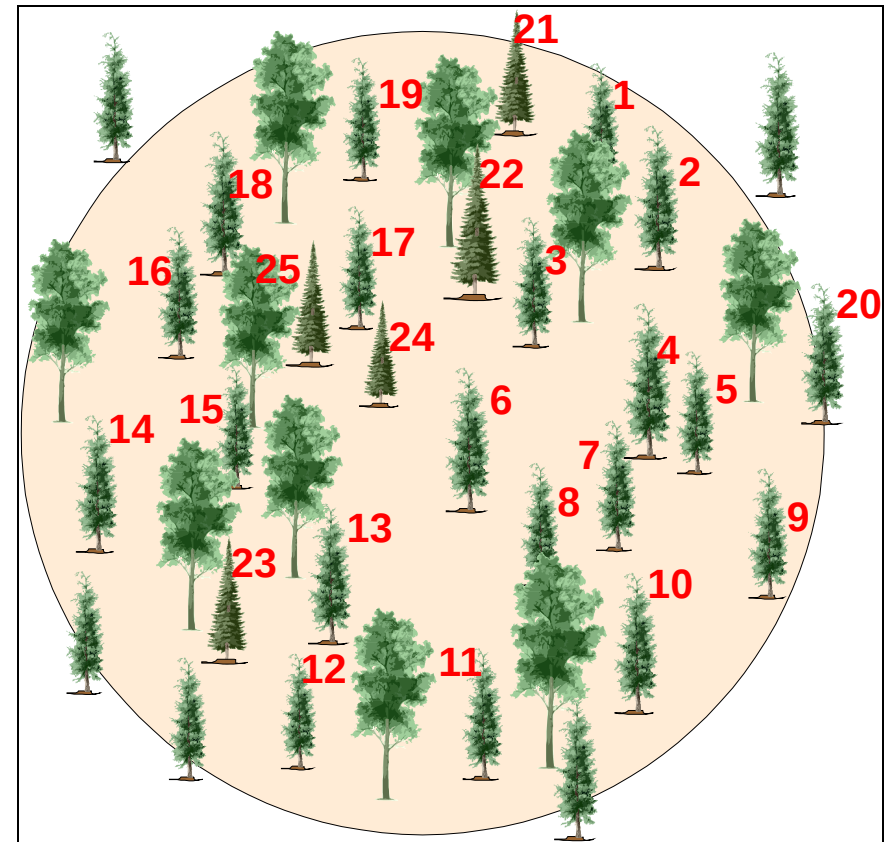
PLOT 4: Untreated Plot Description

Work Unit Description

Plot Radius	3.99 m (1/200th ha)
Method of establishment	Natural
Treatment regime requirement	1 brushing to ensure free growing attained.
Stocking Status before Brushing	
Total Trees	6 800 live sph (average 34/plot)
Planted Crop Trees	N/A
Naturally established Crop Tree species	3800 hemlock, (19/plot) 1.3 m avg ht 1000 sph balsam, (5/plot) 1.1 m avg ht
Broad-leaved Trees	2000 sph alder (10/plot) 1.8 m avg/ht
Brush species present	

Plot Trees

Tree Number	Description
1 to 19	Naturally established Hw
20	Naturally established Hw, borderline tree
21-25	Naturally established B
26 to 36 (not shown)	Naturally established red alder



PLOT 4A: Crop and Leave Tree SelectionWork Unit Description

See info under Plot 4

Agreement Specifications

Crop Tree species (in order of preference)	Hw, B
Agreement M Value	8 (1 600 sph) 2.7 m inter-tree distance
Minimum inter-tree distance between Crop Trees	1.5 m
Target Vegetation & Treatment Circle radius	All brush species --- 1.5 m All broadleaf trees --- 2.5 m
Minimum height for an additional natural crop tree	N/A
Optional broadleaf leave tree species (in order of preference)	None
Max. # optional broadleaf leave trees	None
Minimum distance between a Crop Tree and a Broadleaf Leave Tree	N/A
Treatment type	Cutting, except decid over 4 m tall to be girdled

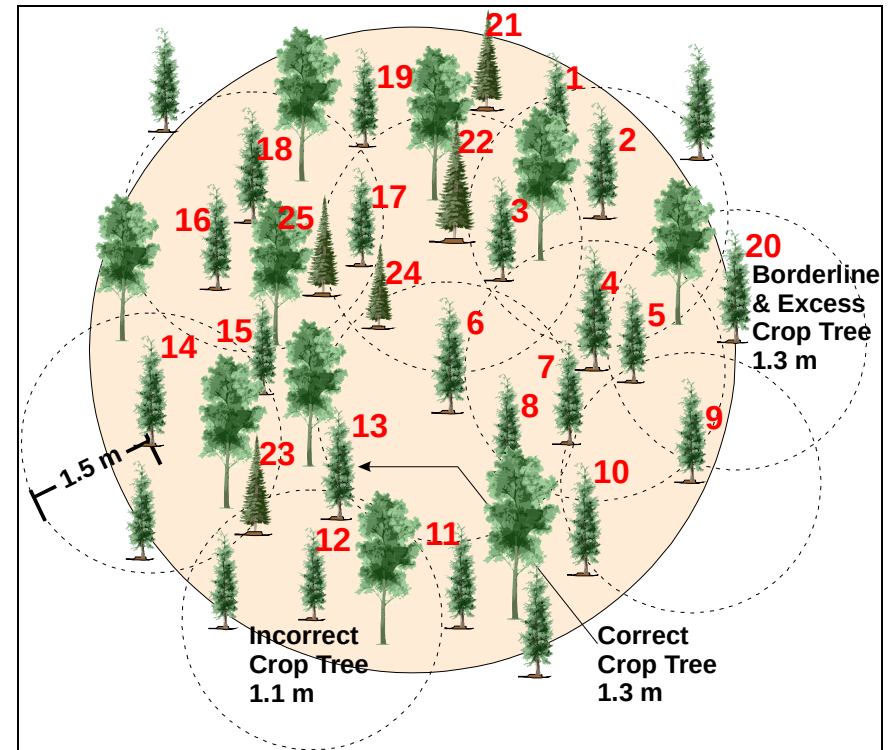
Plot Card

Plot No.	Crop Trees				Leave Trees		Plot Comments/ Observations
	Total	Satisfactory	Rework Errors	Non-Rework Errors	Mandatory	Optional	
1	8	8			N/A	N/A	Excess tree 20 used to absorb incorrect crop tree selection on tree 12.

Discussion of the Plot

There are 24 potential crop trees from which to choose the agreement M requirement of 8 crop trees. The challenge is to select the best “set” of 8 trees that are not within the 1.5 m minimum inter-tree distance of each other or of any crop tree outside the plot. The 8 trees selected are trees 2, 4, 6, 9, 12, 14, 18 & 22, plus tree 20 which is an excess tree.

Tree 12, a 1.1 m hemlock, was incorrectly selected as a crop tree over tree 13, a 1.3 m hemlock. No fault is recorded, however, because tree 20, a 1.3 m hemlock, is an excess tree that can be used in substitution for the incorrect selection. This maintains the total crop tree count at the agreement M Value of 8.



Note that the excess tree (20) has to be equal or better than tree 13 (the missed crop tree) in order to be acceptable as a substitute. If it were not, then fault R1 – Improper Crop Tree Selection would be noted against tree 12, along with a note in the plot comments column that tree 13 should have been selected.

Tree 20 is also a borderline tree, having its stem on the plot border. It is included as a plot crop tree as its point of germination is within the plot boundary.

Tree 22, a superior balsam, is acceptable as a crop tree. Despite balsam being a secondary preference, this tree is superior to all its hemlock neighbours and is the best tree that is not closer than 1.5 m to neighbouring crop trees.

Illustration of Other Brushing Faults

The following brushing faults are essentially the same as for juvenile spacing:

- R4 – Live Branches
- R5 – Stump Cut Angle
- R6 – High Point of Treatment (in spacing – High Stump)
- R8 – High Slash (in spacing – Unsatisfactory Slash Disposal)

For illustrations of these, refer to the booklet, *Juvenile Spacing Quality Inspection*.