

Changes to a cruise plan should be rare and minor in nature and must be undertaken to affect unforeseen issues that affect good forest management or other minor operational issues.

The submitting forest professional recognizes that changes to a plan, such as a change in area or the removal of a plot(s) is biased and will have assessed the impact of the alterations against the principles of sampling identified in these standards. The submitting forest professional will submit a record of all relevant information that was used to develop the original cruise plan and final appraisal map. This model is consistent with the direction of professional reliance.

The district will review each change on a case by case basis and determine if the change meets the intent of providing good forest management or addressing unforeseen minor operational issues.

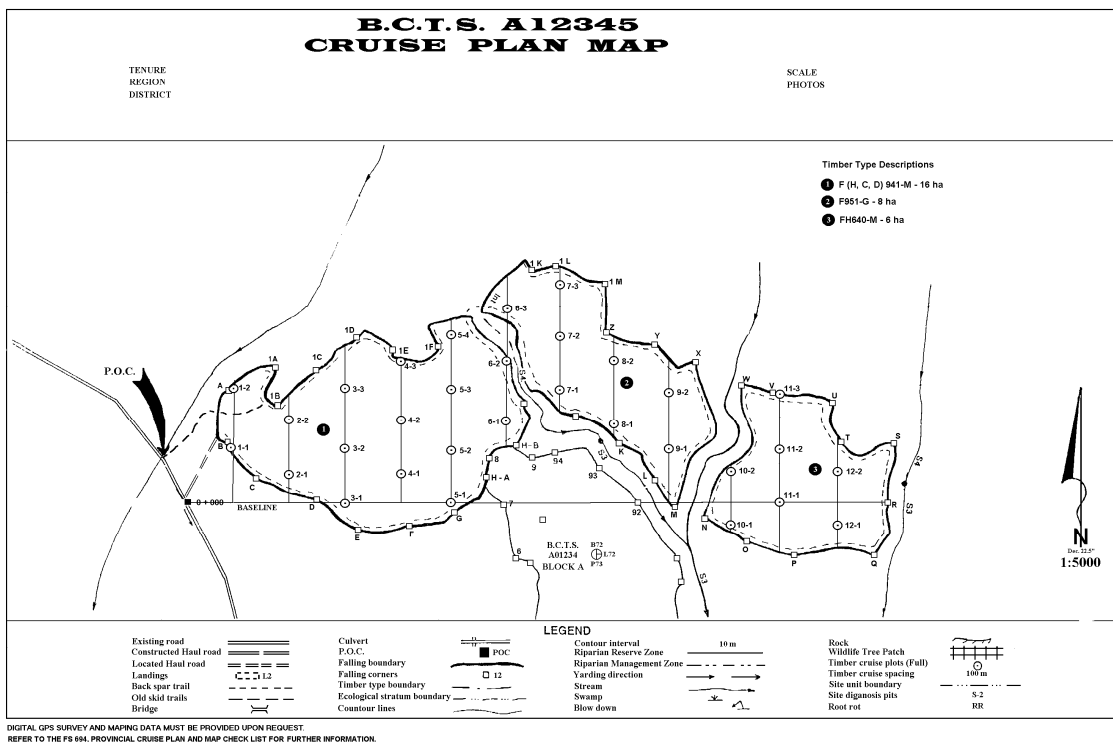


Figure 2.1 Cruise Plan Map.

2.1.2 Scale-Based Stumpage Assessment - Timber Sales or Cutting Permits

General Conditions:

- all species listed under Section 6.3.2 of this manual shall be cruised,
- the minimum tree sizes are specified in Chapter 6,
- all references to "plots", "cruise plots", and "measure plots" must be interpreted as Full Measure Plots unless specified otherwise,
- Sampling Error objective is based on full measure and count plots (unless specified otherwise),
- all plots must originate from the harvest area. Plots in areas 100 percent reserved from cutting must not be used in the compilation.
- all measure and count plot data originating from the harvest area must be used in the cruise compilation, and
- cruises are the responsibility of the district that contains fifty percent or more of the cruise area.
- cutting boundaries and timber types must not be located based on the inspection of cruise plot information as this constitutes bias.

Minimum Tree Counts (All Species, Tree Classes 1, 2, 3, 5, 7, 8, 9)

Variable Plots	Fixed Plots
4.0	10.0

- a. The minimum average tree counts are required for all cruises that do not meet the minimum sampling error requirements.
- b. If the timber types are very open and the minimum tree count can not be achieved with a BAF 2 prism, then the minimum tree count requirement may be waived.
- c. Include tree classes 1, 2, 3, 5, 7, 8, 9 of all species listed in Section 6.3.2. Also include trees that meet the minimum DBH specifications, but are converted to a tree class 6 in the compilation because they are too short for a merchantable log.

Sampling Error Objective:

1. The scale-based cutting authorities sampling error objective is 15.0 percent at 2 standard errors based on the total stand (before reduction).

2. If the cruise plan does not specify a sampling error objective, then the minimum standard requires the establishment of full measure plots on a 100 m * 100 m grid spacing.
3. The maximum grid spacing:
 - cutting authorities less than 250 ha - 200 m square grid, and
 - cutting authorities greater than or equal to 250 ha - 250 m square grid.
 - Sections 2.1.2.1 to 2.1.2.3 are subject to the requirements listed under Section 2.1.2 unless otherwise stated.

2.1.2.1 Sampling Requirements

1. Partial Cut

Count plots are permitted in partial cut cruises only if the minimum sampling intensity of a 100 m x 100 m grid of full measure plots has been achieved.

2. Clearcut

The number of count plots is not limited for clearcut cruises that meet the minimum sampling error requirement based on the measure plots only.

3. All plots must originate from the harvest area. Areas where no cutting is prescribed such as Riparian Management Zones with 100 percent retentions are to be excluded from the cruise.
4. If a range of leave tree or cut tree stems per hectare are reported in the Schedule B of the cutting authority then the average of the highest and lowest number will be used to determine the percent reduction input into the cruise compilation.
5. Helicopter Single Stem - The trees to be harvested must be marked prior to cruising.

The cruising options are as follows:

- a. establish variable plots and the 15.0 percent sampling error requirement will be based on the cut trees,
- b. two measure plots per hectare with an average of 2.0 cut trees per plot, or
- c. 100 percent cruise.

2.1.2.2 Comparative Cruises

While the *Interior Appraisal Manual* determines the situations **when** comparative cruise data **may be** used for appraisal purposes, the overriding principle of “*if there is time to perform a full cruise, then the timber will be cruised*” **shall be followed**.

1. Definitions:

New Cutting Authority (NCA): the area affected as a “catastrophic event” (i.e., Mountain Pine Beetle infestations, severe blowdown, etc.) that is to be appraised.

Parent Cutting Authority: a cutting authority that has been previously cruised which supplies the cruise data that will be “borrowed” and recompiled for the appraisal of the “New Cutting Authority”.

Insufficient Time to Harvest: when a delay in harvesting will severely impact quality and quantity of timber to be harvested.

2. Factors for Determining the Level of Data Required:

The following matrix is to be used as a guide to determine the amount of work and the level of data required to justify use of a specific comparative cruise.

Factors	Condition	Points	Condition	Points	Condition	Points
New Cutting Authority size m ³	>100 000	15	20 000 – 100 000	10	< 20 000	5
Catastrophic Event Type	None	10	Beetle	5	Unsafe to Cruise	2
Percent beetle in stand	< 25%	3	25% - 75%	2	> 75%	1
Cruise Types Similarity	Dissimilar	3	Similar	2	Very Similar	1
Species & size variability	Variable	3	Average	2	Uniform	1
Sufficient time to harvest	Some	15	Little	5	No time	1

0 to 13 points	A minimum of 2 plots per timber type in the New Cutting Authority.
14 to 23 points	A minimum of 6 plots per timber type in the New Cutting Authority.
> 23 points	Full Cruise of the New Cutting Authority.

3. Requirements to ensure that the New and Parent Areas are Comparable:

Levels of data/work required:

2.2 Types of Cruise

2.2.1 One Hundred Percent Cruise

The Regional Executive Director may direct that for certain forest stands and valuable species, a one hundred percent cruise is required.

2.2.2 Sampling Patterns - General

Samples within cutting blocks from previous operational cruises of the area may be used in the sampling plan if they meet the standards set in this manual.

Referring to the following types of sampling methods, systematic sampling in conjunction with a grid to locate the plots must be used for appraisal type cruises unless permission is granted by the Regional Executive Director to use one of the other sampling patterns.

All possible sample points that can be established in the harvest area must be cruised.

2.2.2.1 Systematic Sampling

In systematic sampling, plots are at fixed intervals with a minimum of two full measure plots per timber type. The sampling grid spacing must be the same for each timber type. If the grids are different within a timber type in different blocks, then the types can be either labelled as unique types within a block or the areas can be re-cruised to meet the minimum sampling intensity.

In addition:

1. The preferred method of establishing plot locations is to use a GIS based grid system that covers a specific operating area. If a GIS grid system is not available, then a local grid must be established using the following procedure:
 - a. Start at the most south-westerly point of the block and measure in one-half (1/2) of your grid distance at a bearing of N45E to set your base plot. Using the base plot, lay your local plot grid on the map oriented in cardinal directions (N-S & E-W) to determine the plot locations. You can start anywhere on the edge of the block and tie-in to the nearest plot.
2. The maximum plot spacing listed in Section 2.1.2 (4) will ensure adequate coverage of the area for timber typing and tree and terrain information.
3. The sampling grid horizontal distances must be equidistant between plots and strips. The options are square grid or staggered grid. The option selected must be used

consistently for the cutting permit. Refer to Figure 2.1 for an example of a staggered grid.

4. Where plots must be added to an existing cruise area, they must be positioned in a systematic random way so they cover the entire timber type(s) that has the highest coefficient of variation. The following method is recommended for adding plots to an existing cruise:
 - a. determine the number of additional plots required using the coefficient of variation from the statistical summary report. Adding 10 percent to the number of plots is recommended for a safety margin. If the number of plots meets or exceeds 1.0 plots/ha for the whole cruise area, then the maximum sampling intensity will be 1.0 plots/ha,
 - b. determine the new grid for the cutting authority area to obtain the additional number of plots required,
 - c. lay the new grid over the original grid by positioning the new plot over top of the original plot that is nearest the P. of C.. Use the same cruise grid orientation,
 - d. disregard the overlapping plot and locate the new plots on the cruise map, and
 - e. determine the bearings and distances to the new plots from the nearest original plots. This will reduce the amount of traversing required to establish the new plots.

The new grid must be submitted with a cruise plan to the Ministry of Forests and Range district office for approval at least 30 days prior to the commencement of field work.

2.2.2.2 Cruising Road Rights-of-Way

The following procedures are used where road rights-of-way require cruising and the minimum sampling error cannot be achieved:

1. The fixed area plot centres will be located at the midpoint between the R/W edge and centre line and on alternating sides of the R/W centreline.
2. The plots will be circular and 5.05 metre radius.
3. The minimum sampling intensity will be 2.5 percent of the R/W area.
4. Where timber on road rights of way within a cut-block is removed under a road permit (R.P.) after the block is cruised, the cruise plots that are within the area of the R.P. shall be included in the cruise compilation for the cutting permit and the area of R.P. will be removed from the cruise compilation. Record R/W areas that are not part of the cutting authority in card Type H of the Map Area Statement.
5. Refer to the requirements in section 2.1.2.2 of this manual where comparative cruising is permitted by the Appraisal Manual.

If typing changes after the cruising field work, due to reserves for example, cruisers may need to revisit the cruise plots in the field to ensure they are not influenced by these changes. Good traverse note taking, to identify potential reserves, will reduce the need for cruisers to re-visit cruise plots.

Use the following methodology for stratification:

1. Forest types must be distinguished before the cruise commences based on:
 - a. aerial photograph interpretation, or
 - b. the most recent forest cover maps,
2. Field inspection or sampling.

The type lines must be documented in the traverse notes.

3. If the transition from one timber type to another is very gradual and not detected in the field, then the type line must be drawn equidistant from dissimilar plots.
4. If non-forest types are stratified out of the harvest area, then they must not be sampled.

2.6.3.2 Minimum Plots Per Type

If the sampling error requirement has not been waived or there has not been a boundary amendment after the cruise has been completed the following requirements must be met:

The Average Line Method of Compilation requires a minimum of two measure plots per timber type in the cutting permit.



This is to enable the calculation of sampling statistics.

The second plot in small timber types will be located according to the following procedure to ensure that a minimum of two measure plots are located in the timber type:

1. Locate the second plot one half of the inter-plot spacing along the stripline in the current direction of travel from the single plot in the type. If the plot is still not in the timber type, then
2. Locate the second plot one quarter of the inter-plot spacing along the stripline in the current direction of travel from the single plot in the type. If the plot is still not in the timber type, then

3. Continue steps 1. or 2. at ninety degrees clockwise from the stripline until the second plot can be established.

2.6.3.3 Calculation of Number of Samples

When stratified sampling is used, an average weighted coefficient of variation must be determined. This value is used in the equation to calculate the total number of plots required. For example:

	Type Area		Area X	Proportional	Weighted CV	
Type	ha	Av. Volume/ha	Av. Vol.	(Area x Vol)	CV	(P x CV)
F P1	12	272	3 264`	0.43	30	12.9
P1	12	134	1 608	0.21	50	10.5
P1 F	16	171	2 732	0.36	40	14.4
	40		7 604	1.00		37.8

If this 40 ha timber sale is to be sampled with 0.1 ha plots, and a sampling accuracy of *plus or minus 15 percent* at 2 S.E., the required number of samples is:

$$\begin{aligned}
 n &= \frac{t^2 \times CV^2 \times N}{N \times E^2 + t^2 \times CV^2} = \frac{(2)^2 \times (38)^2 \times 400}{400 \times (15)^2 + (2)^2 \times (38)^2} \\
 &= \frac{4 \times 1444 \times 400}{400 \times 225 + 1444} = \frac{5776 \times 400}{90000 + 5776} = \frac{2310400}{95776} \\
 &= 24
 \end{aligned}$$

The probability factor for n-1 or 23 is then used to calculate a new "n", which equals 26. These 26 samples are then distributed among the three types as follows:

$$n_1 = \frac{PCV_1}{PCV} \times n \text{ etc.} = F-P1; n = \frac{12.9}{37.8} \times 26 = 9$$

$$P1; n = \frac{10.5}{37.8} \times 26 = 7 \quad P1-F; = \frac{14.4}{37.8} \times 26 = 10$$

Exact estimates of type size, volume and coefficient of variation are not necessary in advance of cruising to predict sampling requirements. Reasonable approximations are sufficient to establish correct relative intensities of sampling for each type.

The sampling error objective (e.g., *plus or minus 15 percent*, 19 times out of 20) for scale based cruises is for the total volume of the cutblocks, and the basis for estimating the number of samples required to meet this objective is the forest types within the area to be cut and their relative volumes.

Field Procedures

3

3.1 General Provisions

3.1.1 Signatures

Stumpage rates are estimated on the data collected by timber cruisers. Therefore cruise tally sheets (FS 205 and industry versions) must be signed, name printed and dated by the cruiser who accepts responsibility for the information contained on the card. This assists the check cruiser to sample a representative proportion of each cruiser's work.

3.1.2 Tie-Points

The cruise must originate from valid tie points such as unique photo and map locations like creek junctions, road locations, falling corners and GPS positions. All of the cruise strips must be linked together and to the boundary line.

The tie-point or reference point of each strip-line must be well established on the ground so that it may be found at a future date.



3.1.2.1 Options for selecting the Point of Commencement (POC)

1. Select the map feature (creek, junction, etc.) or GPS station, which is closest to the access in the block that the cruiser's plan to use.
2. In the case of patch-cuts, the POC for each patch will be from the nearest plot in the adjacent patch.

3.1.3 Strip-Lines

The strip-line will be run using compass, clinometer and metric surveyor tape or electronic measuring devices. Allowances for slope must be made since all distances must be horizontal. The line should be marked with plastic marking tape so it is easily visible.

3.1.4 Plot-Centres

When the required distance has been measured along the strip line, a stake, tree or equally effective marker must be established at the plot centre where the compass person marks the chainage. If the chainage is at a tree, mark the plot centre with an "X" at the point where the chainage touches the tree. If a stake is used then the plot centre is the ground level point and not the top of the stake.

A reference point (RP) must be recorded in the traverse notes or on the cruise tally card. It is acceptable to use a reference tree that is an “in” tree and record the bearing and distance to the nearest point on the tree at DBH. The reference tree will be used to determine the position of the plot centre for check cruising. It is recommended that the reference information is recorded below stump height to facilitate post-harvest evaluations. Refer to any regional guidelines for any additional requirements and use of reference trees.

3.1.5 Slopes

3.1.5.1 Slope Percent

Record the most severe slope measurement from the plot centre to a point 15 m slope distance within the harvest area and rights-of-way through block roads. **Plot slope data is required for all road rights-of-way areas contained within a cutting authority. Plot slope is not recorded on road cuts or fills.**

The plot slope reading must be confined to the harvesting method area if the harvesting method boundary is known when the field work is performed.

3.1.5.2 Distance Slope Correction

All distances (strip and base lines, plot radii and closed traverses) must be corrected for slope to obtain horizontal distance and measured to the standards listed in Section 3.6.3.1 or refer to Table 1.

The formula used to correct for slope is:

$$\text{COS} \left[\text{TAN}^{-1} \left(\frac{\text{slope}\%}{100} \right) \right] = \text{slope correction factor} \leq 1.000$$

The resulting number is multiplied by a measured slope distance to obtain the equivalent horizontal distance. For example:

- slope of 59 percent and measured slope distance of 8.62 m to tie-point,
- $\text{COS} \left[\text{TAN}^{-1} \left(\frac{59}{100} \right) \right] = 0.8613$, and
- $8.62 \text{ m} \times 0.8613 = 7.42 \text{ m}$ horizontal distance to the tie-point.

To obtain a slope distance, the specified horizontal distance is multiplied by the inverse of the slope correction factor. For example:

- slope of 74 percent and specified horizontal distance of 50 m,

- $\text{COS} \left[\text{TAN}^{-1} \left(\frac{74}{100} \right) \right] = 0.8038$ $0.8038^{-1} = 1.2441$, and
- $50 \text{ m} \times 1.2441 = 62.205 \text{ m}$ slope distance will give 50 m horizontal distance. Refer to Table 1 for Correction Table.

3.1.6 Traversing

All cutting permits require a closed or GPS traverse of each cut-block. Stations, tie-points, reference points and boundaries must be well established on the ground for permanent future reference and must not be destroyed during or after harvesting operations. Refer to any established district policy on boundary marking where the cruise area is located (e.g., *Forest Practices Code Boundary Marking Guidebook*). Traverse notes shall include tree species and diameters recorded for all stations, tie - points and other boundary references. Refer to Section 3.6.3.1 for the tolerances. The original strip line, type line, boundary traverse notes and GPS coordinates must be made available to the check cruisers upon request. The boundary traverse must be tied to the cruise strips in instances where the harvest boundaries are traversed after cruising.

All areas that are inside the block boundary and will be removed from the harvest area must meet the area error standards in section 3.6.3.1(8).

snag density in the stand for appraisal purposes. Only trees equal or greater than 3 m high and equal or greater than the minimum timber merchantability specifications must be tallied. Estimate their actual observed height and the original DBH, not an estimate of the stems original height.

3.5.6.5 Tree Class 5 (Mature)

A mature conifer tree is defined as any tree over 120 years old. A mature deciduous tree is defined as any tree over 40 years old. The exceptions are:

- a. Aspen and Cottonwood in FIZ K and L where tree classes 5 or 7 will be used for trees 141 years and older,
- b. Coastal cruises where there are trees between 121 and 140 years old, then tree classes 5 and 7 will be used for trees 141 years and older.

A reasonable number of mature ages should be sampled along with the age drilling of the main stand component.

3.5.6.6 Tree Class 6 (Live Useless)

Live Useless trees are trees that have only one or two live limbs. They are combined with TC 4 for the compilation of percent snags. This tree class must not be confused with a Tree Class 2 tree, which has a high proportion of rot due to conk.

Cedar and Cypress The tree must be almost completely rotten or hollow with just a thin shell of sound wood remaining. The low proportion of sound wood must be obvious (i.e., rotten or hollow knots, and large open scar).

Hemlock, Balsam, Fir, Pine & Spruce The tree must be broken off in the lower or middle thirds (i.e., at least the top third must be missing) with only a few live branches and almost completely rotten or hollow.

3.5.6.7 Tree Class 7 (Mature Dead Potential)

This class is a combination of Veteran and Dead Potential so that the correct loss factor tables are applied in the compilation. The guidelines for TC 3 and TC 5 apply. Dead potential Lodgepole Pine will use Risk Group 2 loss factors unless the tree has conk or blind conk then it will use the highest risk group.

3.5.6.8 Tree Class 8 (Younger Immature)

Younger immature coniferous trees (except Lodgepole Pine) are trees up to and including 80 years of age and Lodgepole Pine are trees up to and including 60 years of age. Younger immature deciduous trees are trees that are up to 20 years of age. When

cruising FIZ K and L Aspen and Cottonwood, tree class 8 will be trees that are up to and including 80 years of age.

On the Coast, when the age in 10s is 13 or 14, tree class 8 trees will be trees up to 120 years of age.

3.5.6.9 Tree Class 9 (Younger Immature Dead Potential)

This class is a combination of Immature and Dead Potential so that the correct loss factors are applied in the compilation. The guidelines for TC 3 and TC 8 apply.

3.5.7 Quality

Stem quality information forms the basis for a computerized grading system. Quality remarks are also used for the experimental interior Douglas Fir quality and the interior log grade algorithms (refer to Appendix 7). They are recorded when observed 30 cm or more above the high side of the tree. This data collection is currently optional in the interior.

The quality class information will be collected on all commercial living and dead potential trees (refer to Chapter 6, Positions 45-51, required on the coast for immature, partial harvest cutting authorities, woodlots, Small Business Forest Enterprise Program Timber Sales).

3.5.8 Damage Codes

Standard cruising methods as outlined in Chapter 6 and Appendix 6 of the *Cruising Manual* are to be followed.

Damage codes are to be used when damage is identifiable.

Code the trees as they appear at the time of the cruise with no attempt to guess what the future condition of the trees will be.

3.5.9 Ages

Ninety-five percent of all trees must be in the correct age class. Sufficient trees must be bored for age to ensure the correct maturity classes, **except Lodgepole pine where the inventory age will be used to determine the correct age classes**. The number of trees that need to be drilled will be dependent upon the maturity profile in each plot.

For over mature stands, the establishment of age is not critical except for interior cedar over 141 years as it requires a different top diameter for compilation.

The age in 10s on the Cruise Tally Sheet is required for all measure and count plots. This age is used in each plot to assign the correct loss factor table, determine maturity and for stratification.

It is important that height as well as age be taken on each age sample tree because the height is used to estimate the years to boring height to obtain total age.

The age correction to Dbh is found in Appendix 9.

Age of sample trees is determined by a ring count from an increment borer core, taken at diameter breast height (DBH).

The pith must be included in at least half the sample tree cores on each plot. In cases where the pith is not contained in the core, and is missed by an estimated three years or more, the tree must be rebored.

"Age bored at 1.3 m must be accompanied by a sample tree height. The Site Index is then determined by using the bored height age (1.3 m trees above high side) and the height of the sample tree. The Total Age of the Age Sample Tree is determined by adding the boring height age to the years to boring height (as determined by the Site Index)."

Tree class 3, 7 and 9 trees – record age as counted and corrected. Do not add the number of years that the tree has been dead.

Use the following procedure for determining the tree classes for interior Lodgepole pine (PL):

- Overlay the most recent Forest Cover Inventory or Vegetation Resource Inventory (VRI) polygon coverage on the cruise plan map.
- Identify the projected age or the age class code for each overlaying polygon. The projected age can be retrieved from the Vegetation Tab in Mapview or from the licensee forest cover mapping system. The age class codes can be retrieved from the most recent TFL or WL inventory maps. Refer to the age class code from the table below to determine the corresponding age range.

[Mapview Link](#)

- The age of each interior Lodgepole pine tree tallied in a plot is the projected age or the corresponding age of the inventory polygon in which the plot is located.

Code Age	Age Class Limits	Allowable Tree Classes
1	1 to 20 years	8, 9
2	21 to 40 years	
3	41 to 60 years	
4	61 to 80 years	1, 2, 3
5	81 to 100 years	
6	101 to 120 years	
7	121 to 140 years	5, 7
8	141 to 160 years	
9	250 + years	

Note: Tree Classes 4 and 6 are allowed for all age classes.

Examples of determining PL tree age and tree classes:

1 - Mapview

The polygon projected age is 125 years old. Therefore, the PL trees in the plots in the polygon are classified as mature tree classes 5 or 7.

#2 - Tree Farm Licence

The polygon age class is 4, which corresponds to 61 to 80 years. Therefore, the PL trees are older immature tree classes 1, 2 or 3.

3.6 Check Cruising

If requested by the Ministry of Forests and Range for checking purposes the licensee or consultant shall submit the originals of all the cruise tally sheets, cruise map and traverse notes. All required fields on the cruise tally card must be completed if a cruise compilation check is performed. If magnetic data is requested it must contain the Map Area Statement completed as per Chapter 7, the percent reduction data and followed with the tally sheet listed in numerical order, and shall be submitted electronically in ASCII format.

3.6.1 Data Replacement and Responsibility for Data

All cruise tally cards must be signed and dated by the original cruiser and as appropriate the check cruiser.

Any changes made to plot card data after the original cruise must be initialled and dated by the person making the change.

Any data that was changed must be reflected in the appraisal compilation.

If a re-cruise has been performed, then the cruiser will mark the date that they re-cruised the plot on the reference tree.

A field or compilation check does not preclude a check cruise at a later date by Ministry of Forests and Range staff.

3.6.2 Objectives of Check Cruising

The purpose of check cruising is to verify that field observations and measurements were taken and noted correctly. Checking includes traverse notes, compass notes and tally sheets.

Certain guiding principles will be the basis for all aspects of cruising:

1. All measurements shall be accurately and carefully taken. Personal bias must be eliminated and each classification determined fairly and honestly.
2. Magnitude of sampling errors should be calculable.
3. All measurements must be made with instruments of proven accuracy, and they must be calibrated regularly.

The field check should be performed while the production cruisers are on site provided that an acceptable cruise plan was submitted to the appropriate district office at least 30 days in advance of the commencement of field work. The licensee and cruising agency must be given the opportunity to attend the check and should be given at least ten working days notice unless the cruisers are on site.

3.6.2.1 Risk Management

The risk management principles for check cruising include emphasizing check cruising on parameters that have significant impact in the appraisal. The following parameters should be checked:

1. Check the greater of:
 - a. Ten percent of the cruise plots in the cruise.
 - b. Five measure or four measure and two count plots.
 - c. Twenty trees, including their heights and diameters.
2. Randomly select plots to check each cruiser's work.
3. Compare the cruise plan map with the cruise strip traverse notes and the final cruise map to verify that the timber type lines and cutting boundaries are correct. Verify that the cruise plots used in the compilation are not within wildlife tree patches (WTP) and non-forest areas, and that these areas are mapped according to the traverse notes. It is important to determine the reason for the addition or deletion of all cruised plots. If the placement of wildlife tree patches (WTPs) causes a cruise plot to be deleted, and it appears that the location of the WTP is not environmentally sound, an explanation by the licensee is required. It is recommended that a written explanation be obtained defending the location of the WTP.
4. At least one plot interval distance check per cruiser.
5. Emphasis in the plot measurements must include tree count, trees species, tree heights risk groups, diameters at breast height (DBH), and plot slope.
6. Boundary and type-line checks will contribute the equivalent of three cruise plots to the check cruise for each one-half day spent checking boundary and type lines.

The following should be used in establishing check cruising priorities:

1. Cruiser's past performance,
2. Cruiser's experience,
3. High value timber (as determined by species selling prices in the Coast Appraisal Manual or Interior Appraisal Manual),
4. Licensee's Allowable Annual Cut in the district.

Upon request, a copy of the Ministry of Forests and Range check cruise comparison shall be submitted to the licensee or consultant in a format acceptable to the Regional Executive Director or their designate.

Check cruising is required for all cruise based sales.

3.6.3 Allowable Non-Sampling Errors

Any one of the items listed in Section 3.6 can lead to either the remeasurement of the entire cruise or the specific parameters that were exceeded. Any changes to a cruise plan must meet the intent of Section 2.1.1 Cruise Plans.

These standards are defined as the maximum allowable measurement error or variation in any measured quantity before such a measurement is considered to be incorrect. Individual standard parameters are to determine whether bias has occurred or not. When an item has a *two part standard*, both parameters must be exceeded before the item is classed as incorrect.

The individual items to be checked and the acceptable limits of error are:

3.6.3.1 Tree Data

1. Number of Stems:

- a. Fixed Area and Prism Plots - not more than plus or minus 1 stem in 50 trees checked from the true number for all plots checked (measure and count-plots).

This tolerance (1 stem in 50 trees) is to be applied as follows.

Trees Checked	Allowable Error
1 to 50	plus or minus 1 tree
51 to 100	plus or minus 2 trees
101 to 150	plus or minus 3 trees

- b. The stem count will include all merchantable trees except live useless or dead useless trees in this check parameter,
- c. all borderline trees must be checked by actual measurement from the plot centre and measurement of the diameter to determine whether the tree is "in" or "out",
- d. all borderline trees are to be measured as per Section 3.3 and 3.4 of the *Cruising Manual*,
- e. if the borderline "out" tree has not been measured and found to be "in" on the check-cruise it will be counted as a "missed" tree,
- f. if the borderline "in" tree has not been measured and found to be "out" on the check-cruise it will be counted in the incorrect stem count,

- g. if the borderline 'in' or 'out' tree has been measured it will be accepted, provided that the original plot radius calculated for the tree does not exceed one (1) percent variation from the check plot radius and the original horizontal distance determined for the tree does not exceed one percent variation from the check horizontal distance, and
- h. tree diameters at breast height of 12 cm (coastal immature), 12.5 cm (interior Lodgepole Pine), and 17.5 cm are allowed 1 percent variation in diameter at breast height.

Dead useless and live useless tree counts are a check cruising item for interior appraisal cruises for snag percent. One in fifty trees are the maximum tolerance.

Trees incorrectly identified as dead potential versus dead useless or live useless versus live potential contribute to an incorrect stem count. If safe to do so, dead potential trees should be chopped into at three or more locations to verify percent sound wood content and the calculations shown on the tally sheet.

- 2. Species Identification:** the tolerance for species variations is 1 in 50 trees checked excluding tree class 4 and 6 (useless) trees.

Number of Trees Checked	Number of Species Errors Allowed
1 to 50	1
51 to 100	2
101 to 150	3

3. Heights:

- a. any intentional bias to tree height measurements will result in rejection,
- b. use a clinometer and measuring tape or an electronic measuring device to check all tree heights. The accuracy of electronic measuring devices must be demonstrated prior to the commencement of check cruising if they will be used for the true height, and
- c. a minimum of 20 tree heights must be checked. If the total cruise does not have 20, then check a minimum of 50 percent of the heights.

All Tree Heights - Average absolute variation must not exceed 5 percent.

Original – Height (m)		Check – Height (m)		Difference – (m)
40.0		42.0		-2.0
42.0		41.0		1.0
43.0		44.0		-1.0
46.0		44.0		2.0
Sum	=	171.0		6.0

$$\text{Absolute Variation} = \frac{6.0}{171.0} = 3.51 \text{ percent}$$

4. **Pathological Indicators and Risk Groups:** no more than 10 percent of all trees checked in a cutting authority area can have a risk group change.
5. **Damage Codes:** if they effect the risk group or an appraisal variable.
 - a. No more than 5 percent of all trees checked can have an incorrect code, and
 - b. Incorrect codes that result in a risk group change will contribute to Section 3.6.3.1, 4.
 - c. For assessment of Mountain Pine Beetle Codes on Lodgepole Pine the following standards will apply:
 - i) All reclassification of beetle damage codes must be based on field data collection.
 - ii) In order to provide the Ministry of Forests with adequate time to perform check cruises, resweep data must be provided to the Ministry at least 10 working days prior to the commencement of any harvest activity, or some other mutually agreed upon time frame. In turn, the MFR must respond to the licensee within that time frame if there are any concerns with the cruise, otherwise the cruise will be considered acceptable.
 - iii) In order to check and verify the resweep beetle code data and confirm who performed the cruise, the following information must be made available to the Ministry of Forests and Range: the date(s) the resweep was completed and by whom; and for each re-classified tree, the original damage code and the updated damage code.

- iv) Due to the rapid nature of change associated with needle colour attribute versus other timber attributes, beetle code classification will only be counted as an incorrect damage code if the cruisers' code is greater than the code determined by the Ministry of Forests and Range (e.g., the cruiser called a red attack (code 2) and the check cruise assessed the tree as green attack (code 1)).
 - v) The intent of allowing licensees to resweep for beetle codes is to provide the most recent description of the beetle code damage. As such, the Ministry of Forests and Range check cruise efforts will focus primarily on the correct determination of the beetle code attribute; however if in the general practice of completing the beetle code assessment, the Ministry of Forests and Range becomes aware of other significant inconsistencies with respect to the cruise standards, these issues will be addressed on a case by case basis.
- 6. Ages:** Refer to Section 3.5.9.
- a. The age in 10s and tree classes must result in the correct application of the loss factors consistent with the Tree Class Modification of Loss Factor Tables at the end of Table 17. The original and check cruiser must agree on the maturity class of the trees upon review of the drilled cores.
 - b. Ninety-five percent of all trees, **except Lodgepole pine** must be placed in the correct immature and mature class for loss factors,
 - c. **The inventory types will be used to adjudicate the correct age class assignment for interior PL trees.**
 - d. Coast - age in 10s of 13 and 14 - all tree classes must be verified since tree classes 1, 2, 3, 8 and 9 contribute to the percent second growth reporting (see **Section 9.1.5.7**).
- 7. Breast Height:** when this limit is exceeded, the true position is used for a. and b. below. The height of the diameter-line marked at breast-height must not exceed plus or minus 5 percent (plus or minus 6.5 cm) from the true breast-height of 1.3 m above high side.

Diameter at Breast Height (DBH)			
•	All live and dead potential trees as measured with a steel or equally accurate DBH tape.	a.	At least 90 percent of individual stems checked must be within 2 percent of true DBH.
		b.	Average absolute variation of all DBHs checked must be within plus or minus 2 percent.
•	DU trees can be estimated.	a.	Estimate to the nearest 5 cm class.

8. Strip Lines or Tie Lines to Prism or Fixed-area Plots:

Plus or minus 2 percent of horizontal distance.

Bearing-strip to strip or plot to plot and plot centre reference:

Plus or minus 2° - this translates to 3.49 m in 100 m using the formula:

$$(100 * (\tan 2 \text{ degrees})) = 3.49 \text{ percent}$$

Therefore, 3.49 percent * 100 m = 3.49 m.

Plot centre reference tree	Plus or minus 1 percent of horizontal distance
Radius - fixed area plots	Plus or minus 1 percent of horizontal distance
Radius - prism plots	Plus or minus 1 percent of horizontal distance
Length and width: fixed rectangular plots	Plus or minus 1 percent of horizontal distance

Boundary Traverse	Cruise-Based	Scale-Based
Closure error	Plus or minus 0.7 percent	Plus or minus 1 percent
Area error	Plus or minus 1 percent	Plus or minus 1.5 percent
Inter-station distance	Plus or minus 1 percent	Plus or minus 2 percent

3.6.3.2 Quality (Coast) - as they affect grade

1. **Pathological indicators:** 90 percent of the individual indicators that occur in the middle or lower third must be coded in the correct third.
2. **Quality indicators:**
 - a. by Check Plot – greater than or equal to 90 percent of all quality indicators checked must be within plus or minus one code change.
 - b. for All Check Plots – greater than or equal to 90 percent of all quality indicators checked must be within plus or minus one code change. The exceptions are:
 - knot codes 5 and 6 must be correct or they contribute to the number of incorrect codes, and
 - Spiral Grain – if the check code is greater than 4 and the original is less than 5, or vice versa, then it is an error. Codes 5 to 9 will generate Y-Grade in all cases.

3.6.3.3 Slopes

3.6.3.3.1 Slope:

1. **Plots:** ≥ 90 percent of the individual plots checked must be within plus or minus 5 slope percentage points of the slope measured by the check cruiser.

A flagging tape tied at 15 m slope distance from plot centre at the steepest ground with the plot slope written on the flagging tape is recommended to assist in the check cruise process.
2. **Block or Cutting Permit:** the average variation of all slopes checked must be within plus or minus 5 slope percent.

3.6.4 Allowable Non-Sampling Errors - Original Versus Check Plots

Compile original and check plots as separate cruises on the most recent cruise compilation software.

3.6.4.1 Net Volume Standard

The following standards may be used to adjudicate marginal pass/fail check cruises. This section is not used if the other check parameters are clearly exceeded.

	Allowable Error
1. Individual checked plot volumes	<ul style="list-style-type: none"> • ≥ 90 percent of the individual plot volumes must be within 7 percent of their true plot volume. This means that for 10 plots, only 1 may be 7 percent or more out. For 5 plots, none can be exceeded. Each plot must have a volume calculated for the original and the check data. Use a valid cruise compilation program and apply a one-hectare area. The plot pairs are then compared for net volume.
2. Total volume for all checked plots	<ul style="list-style-type: none"> • Average variation must be within 5 percent of true plot volume as determined by the check- cruiser. A minimum of 5 plots is required. The variation between the original plots and the check plot is calculated. The average variations are then calculated. The pluses cancel the minuses.
3. LRFs (Interior only)	<ul style="list-style-type: none"> • LRF must be plus or minus 1 percent of true LRF for all plots checked.

Any one of the foregoing items, if outside the permissible measurement standard, are grounds for redoing the work.

3.6.5 Standards for Some Basic Cruise Functions

- Sample location must be sufficiently accurate to enable relocation of the samples at a future date. Fixed-area plots are subject to the standards in Section 3.3,
- adequate records must be kept of all data so that they may be traced to their specific sources for evaluation in their primary or later applications,
- the sampling design must meet the standards of Chapter 2,

- inadequate identification of plot centres, sample trees and strip lines in the field may also lead to rejection of the cruise, and
- forest typing must meet the criteria listed in Section 2.6.3.1 to ensure consistency of forest typing within cut blocks and among multiple cut blocks.

3.6.6 Check Cruising Dispute Mechanism

It is strongly recommended that the licensee and cruiser be present at the check cruise.

Where the licensee and ministry check-cruiser do not agree on aspects of the cruise the following procedure is to be followed.

It is recommended that check cruisers carry digital cameras with them in the field so that they can send digital photos to region, branch and third party cruising staff as a method to resolve disputes.

Step 1	The Ministry of Forests and Range representative (MOF) sends the check cruise results to the licensee within one (1) week of the field check.
Step 2	If the cruise is rejected, the MOF attends the site with the original cruiser to attempt resolution of the dispute if necessary.
Step 3	The licensee submits a written complaint to the District Manager (DM) within 30 days.
Step 4	The DM or designate responds within 30 days.
Step 5	If the licensee appeals the District Managers decision, then the Regional Executive Director or designate must hear the appeal. The licensee must make the application to the Regional Manager within 30 days of the District Managers decision.

Ministry of Forests and Range Map

Area Statement (FS 121)

7

The Map Area Statement consists of cards A, B, C, D, E, F, G and H which are to be completed for every new Cutting Authority.

7.1 Card Type A

Positions 2 to 80

Cruise Identity Card - this card establishes the location of the cruise from the broadest area (Forest Region) to the most exact (UTM Grid Co-ordinates) and describes the nature of the sale.

Position 2 to 7 Licence Number

Enter:

1. For X type licences:

Position	2	X
	3	Region
	4 and 5	Year
	6 and 7	District No. (Region = 00)

2. CF0001 for Community Forest Agreement.
3. A56789 for licence A56789.
4. TFL001 for TFL 1
TFL038 for TFL 38.
5. L0001 for licence to cut.
6. TL0421 for Timber Licence TL 421.
7. If Unauthorized Timber Harvesting use the ERA case file number in Positions 2 to 10.

The tolerance for species identification is changed to:

Species Identification	
Trees Checked	Allowable Error
1 to 50	1 tree incorrectly identified
51 to 100	2 trees incorrectly identified
101 to 150	3 trees incorrectly identified

9.1.4.2 Use of Older Cruise Data

1. In mature stands where increment is very slow and decay would offset the growth after the cruise was carried out, the cruise data will be considered acceptable if the cruising was done within the last ten (10) years.
2. In immature stands, **cruise data will be considered acceptable if the fieldwork was completed within the past five (5) years.**
3. New cruise data must be collected if there is a major change in the stand condition as a result of fire, insect, disease or wind throw (refer to Section 9.1.11 - Cruising Damaged Stands and Exceptional Circumstances).

Notwithstanding the above, policy changes may necessitate cruise data to be updated.

Where there is doubt as to the applicability of the cruise data, it is the prerogative of the District Manager to request evidence that the cruise data still accurately depicts the stand parameters.

When a re-cruise is necessary, it will be mandatory that a cruise plan be submitted to the District Manager.

9.1.5 Technical Criteria

All distances in this circular are horizontal distances (corrected for slope).

9.1.5.1 Sampling Error Requirements

Where the sampling error requirement is achieved and cruise grades will not be used in the appraisal, there is no required minimum number of trees per plot.

Where cruise grades will be used in the appraisal the minimum tree count must be met even if the sampling error requirement has been achieved.



When the count plots are used in conjunction with full measure plots, all information must be used for determining if the sampling error requirement has been met, provided that a ratio of three (3) count plots to one (1) full measure plot is not exceeded.

The procedure for dealing with potential orphan (not recorded in a measure plot) species in a count plot during the fieldwork, is to record the measure information for all instances of that orphan species in the first count plot that you encounter that minor species. Move the tree(s) into the nearest measure plot in the same timber type. Record the tree number as 99, 98, etc.

If the orphan species is subsequently measured in a measure plot, then return the count plot orphan tree(s) to their respective count plot and remove the measure data for those trees from the plot card. Consideration will be given to waiving the sampling error if the minimum sampling error requirement is exceeded due to the shift in the tree count.

The options for dealing with an orphan (not recorded in a measure plot) species in a count plot after completion of the fieldwork are:





- Change the orphan species to a species with a similar tree form and value (if available) or,
- Delete all the count plots in that timber type from the compilation, or
- Return to the field and convert the count plot orphan tree to a measure tree and move it to a measure plot.









The standards for judging whether the sampling error requirement was met will be the standards in place at the time the cutting authority area was cruised.

Scale Based - Clear-cut and Partial-cut

Sampling Error Requirement = 15 percent sampling error at two (2) standard errors (95 percent confidence level).

The sampling error requirement will be waived where:

1. For cutting authorities of 20 ha or larger in size:
 - a. A 100 meter by 100 meter,  systematic grid  has been established, a ratio of one count plot to one full measure plot has not been exceeded and the minimum tree count requirement of an average of 4.0 trees per plot has been met.
 - b. A 70 meter by 70 meter,  systematic grid  has been established, a ratio of one count plot to one full measure plot has not been exceeded and the minimum tree count requirement of an average of 2.0 trees per plot has been met.

- c. A 50 meter by 50 meter,  systematic grid  has been established, a ratio of one count plot to one full measure plot has not been exceeded and the minimum tree count requirement of an average of 1.0 trees per plot has been met.
2. For cutting authorities less than 20 ha in size:
- a. A 100 meter by 100 meter,  systematic grid  of full measure plots has been established and the minimum tree count requirement of an average of 4.0 trees per plot has been met.
- b. A 70 meter by 70 meter,  systematic grid  of full measure plots has been established and the minimum tree count requirement of an average of 2.0 trees per plot has been met.
- c. A 50 meter by 50 meter,  systematic grid  of full measure plots has been established and the minimum tree count requirement of an average of 1.0 trees per plot has been met.
- Excludes live useless and dead useless trees.



The number of trees per plot is calculated to the nearest tenth and not rounded up to the nearest whole number (i.e., 3.6 does not round up to 4).

Cruise Based Sales

Cruise based sales will only be approved when the Regional Executive Director, or delegated district manager is satisfied that:

1. The loss factors, taper equations, and grade/quality standards proposed for use are appropriate, and that
2. Utilization will be improved compared to scale based sales, or
3. Administration will be simplified.

Sampling Error Requirement = 8 percent sampling error at two (2) standard errors (95 percent confidence level).

Count plots may be used in determining if the above requirement has been met. Proposed cruise based sales where the timber is very valuable or patchy, will be reviewed by the Regional Executive Director or designate, to determine if the above requirement should be accepted or changed.

For more information on cruise-based sales and their requirements, refer to Section 8.16 of the *Ministry of Forests and Range Policy Manual*, which is located on the Internet at:

<http://www.for.gov.bc.ca/tasb/manuals/policy/resmngmt/rm8-16.htm>

9.1.5.2 Sampling Patterns

The cruise grid must be square or rectangular and oriented in cardinal directions (N-S, & E-W) (unless otherwise approved by the district in a cruise plan). Do not use a staggered grid.

To determine your plot locations start at the most south-westerly point of the block and measure in one-half (1/2) of your grid distance at N45E to set your base plot. Using the base plot lay your plot grid on the map oriented in cardinal directions (N-S & E-W) to determine your plot locations. You can start anywhere on the edge of the block and tie-in to the nearest plot. Plot locations determined by plot grids that cover the entire map sheet and UTM grids are preferred. The district must approve use of a different method for randomly determining your base plot.

The direction of travel between plots is at the discretion of the cruiser, but must be clear to the ministry check cruiser.

Collection of slope information necessitates the implementation of fully systematic cruise designs in order to assure representative sampling over the entire cutting area.

A minimum of two (2) full measure plots per cutting authority area is required.

A minimum of one (1) full measure plot per timber type is required although two or more is strongly recommended. Plots should proportionally represent timber type areas.

9.1.5.3 Plot Data

All information on the Ministry of Forests and Range cruise tally sheet (FS 205) relevant to the appraisal and compilation of the data must be collected.

Glossary

Accuracy	The nearness of a measurement to the actual value of the variable being measured.
AAC (Allowable Annual Cut)	The rate of harvest determined by the Chief Forester for Timber Supply Areas (TSA's) and Tree Farm Licences (TFL's), and by the District Manager for Woodlot Licences (WL's), and the rate of harvest specified for a licence or in a management plan.
Absolute Variation	The difference between two measurements or a standard and a measurement, disregarding the plus or minus sign (e.g., standard of 7 and measurement of 5 gives absolute variation of 2).
BAF (Basal Area Factor)	Basal Area Factor or "BAF". Prisms come in a wide variety of sizes. They are classified by "diopter" size. The size denotes the basal area per hectare that each "in" tree represents (i.e., an 8 prism which tallies 7 trees in a plot would give a basal area (in timber) of 56 m ² /hectare).
Bias	Measurement bias occurs when the mean of the measured values differs from the mean of the actual values. Sampling bias occurs when certain sampling units are more likely to be included than others (lack of randomness). Statistical bias occurs when the expected value of the statistic differs from the population parameter.
Boring-Height	The boring-height is the distance from the ground (high-side) up the tree to where an age is taken with an increment-borer. It is always taken at dbh (1.3 m) above high-side.
Breakage	Breakage is defined as any piece broken at both ends and shorter than 3 m which results from normal falling or yarding/forwarding operations.

Breast-Height	The location on a tree where its diameter (dbh) is taken. It is located exactly 1.3 m above "high-side".
Catastrophic Losses	Damage to timber from fire, windfall, insects or disease that inflicts losses well above the norm reflected in the forest inventory for the locality or region.
Cardinal	North, South, East and West.
Closure Error	In a closed traverse, the closure error is the distance between the start and end of the traverse, divided by the length of the traverse, and is usually expressed in percent. It can also be calculated by taking the square root of the sum of the squared sum of latitudes plus the squared sum of departures. A closure error of 1 percent will result in an area error of approximately 2 percent.
Coast	Refer to the Coast Appraisal Manual for the definition of the Coast.
Coefficient of Variation (CV)	A relative measure of variation, equal to the sample standard deviation expressed as a percentage of the sample mean.
Confidence	An expression of accuracy of sample estimates, usually assessed by confidence intervals, a specified proportion of which, such as 95 percent confidence intervals, contain the true population parameters.
Count-Plot	A prism plot where only the number of "in" trees by species is noted. No individual tree measurements are taken. Enhanced count-plots have some measurements taken as required (i.e., diameters or heights).
Crown-Class	Trees are classified into four crown classes. They are dominant, co-dominant, intermediate and overtopped (see Figure 3.10).

Cutblock	A discrete area covered by a form of licence and logged according to an approved harvesting plan.
Cutting Authority Area	The authority to harvest Crown timber, as provided by the <i>Forest Act</i> . (Cutting authority area means a Timber Sale Licence, a Licence to Cut, a Road Permit, or a cutting permit issued under a Tree Farm Licence, Forest Licence, Timber Licence or a Woodlot Licence.)
Cutting Specifications	The timber merchantability specifications in the Cutting Permit document.
DBH (Diameter Breast Height)	The outside-bark diameter of a tree taken at breast-height (1.3 m above the high side of the ground).
Decay, Waste and Breakage (DWB)	Factors to reduce the gross merchantable volume to a net utilizable volume and to approximate the provincial volume depletion due to decay, firmwood waste and breakage due to harvesting. The statutory authority to allow for DWB is in the <i>Forest Act</i> , Part 2, Section 8(8)iv.
DIB (Diameter Inside Bark)	The inside-bark diameter of a tree. It can be anywhere along the stem of the tree from the base to the top.
Diopter	One way of denoting prism "size". A value of one diopter represents a right-angled deflection of one unit per one hundred units in distance. The formula for converting diopter size to baf size (metric) is: $\text{baf} = 10,000 / \left[1 + \left(\frac{200}{\text{diopters}} \right)^2 \right].$
Double-Sampling	This sampling method incorporates a second sampling procedure where only some of the characteristics of the main sampling method are noted. An example is measure and count-plots established on a cut-block. The major reason for using this method is the savings in time and therefore money because the count-plots take much less time to put in.
Endemic Losses	Damage to timber from normal populations of insects or disease that inflicts average losses over the long term for the locality or region. The forest inventory provides net merchantable volumes which reflect "endemic" (average or normal) losses.

Enhanced Count Plot	A count plot where some individual tree species measurements or specific tree attributes are measured to improve the estimate for the species or specific attributes.
Faller Selection	This timber falling technique applies to selection logging in cutting authorities where the cut and leave trees are not marked and the faller decides which trees to cut or leave. The decision is based on the partial cut prescription and safety considerations.
Fixed-Area Plot Sampling	A sampling method where a fixed amount of area is sampled in each plot within a stratum. All trees above the timber merchantability specifications are tallied regardless of their distance from plot centre. All plots within a stratum must be the same size and shape.
Forest Inventory Zone	British Columbia is segregated into 12 forest inventory zones. All commercial tree species were sampled for volume and decay by the Inventory Branch of the Ministry of Forests (now the Ministry of Sustainable Resources Management). All regions of the province were sampled and areas of similar timber types and climatic conditions were grouped into a common Forest Inventory Zone to produce DWB factors.
GPS (Global Positioning System)	A method of accurately determining or relocating a ground position using the signal from several satellites simultaneously. A small portable computer evaluates the time for each signal to reach it and then computes a three dimensional location.
High-Side	The position where the ground meets the tree on the (uphill side – side of the stump adjacent to highest ground), ignoring any root flare, obstacles, vegetation, and loose matter that has accumulated at the base of the tree.
Interior	Refer to the Interior Appraisal Manual for the definition of the Interior.
Licensee	The holder of the cutting authority area.