1 Introduction

This manual outlines the cruising procedures to be used for stumpage appraisal purposes for timber on the Crown lands of British Columbia. It supersedes previous manuals and instructions.

The sale of Crown timber is a business proposition and both the buyer and the Ministry of Forests, Lands and Natural Resource Operations (seller) must know an estimate of the quantity and the quality of timber being sold. The cruise provides the essential data for determining stumpage rates, for establishing conditions of sale and for planning of the logging operations by the licensee.

In order to ensure that all purchasers of Crown timber are being treated equally and equitably, the manual sets out the minimum cruising standards that must be met. These include specifications for the statistical design of the cruise, the accuracy of field measurements and standard compilation procedures.

Implementation of the procedures and standards is a regional responsibility and the manual provides for sufficient flexibility that special circumstances can be accommodated. The appropriate Regional office should be consulted periodically for any revisions to the manual, for copies of Regional Guidelines, or the issuance of specifications for cruising salvage sales, minor product sales, etc. Refer to Chapter 4 of the *Coast Appraisal Manual* and *Interior Appraisal Manual* for further guidance.

The reliability of any cruise is based on statistical concepts and the cruise provides an estimate of the volume on the area cruised. The reliability of this estimate is a function of the intensity of sampling, the uniformity of the timber on the area cruised and the degree of fit of the volume equation and loss factors to the particular stand. It is for these reasons that two cruises of the same stand, carried out to the same standard may yield different volumes. For administrative purposes it is assumed that the calculated volume is the true volume.

If it is determined that it is unsafe to measure any cruise attribute(s) and the safety concern cannot be reasonably mitigated, the attribute(s) may be estimated, provided the estimated attributes are signed off by a registered or associate member of the Association of BC Forest Professionals.

Timber cruisers can become accredited through the Association of BC Forest Professionals (ABCFP). Associate members and registered members are professionally accountable for their work.

Visit http://www.abcfp.ca for more information.

1.1 Definitions

In this manual:

"**100% Cruise**" means a cruise in which every tree is measured. There are no samples or estimates;

"**Absolute Variation**" means 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);

"**Accuracy**" means the nearness of a measurement to the actual value of the variable being measured;

"BAF (Basal Area Factor)" means the basal area (m^2) per hectare that each "in" tree represents when using a prism or relascope. Prisms are sometimes classified as "diopter" size or inscribed with the BAF number. The size denotes the basal area factor (i.e., an 8 BAF prism which tallies 7 trees in a plot would give a basal area (in timber) of 56 m^2/hectare);

"BC Albers" means a map projection that is one of the standard map projections used in British Columbia.

"**BCTS**" means BC Timber Sales;

"**Bias**" means a difference between the sampling result and the actual value due to errors in measurement, sampling procedure or calculations;

"Bole" means the trunk or main stem of the tree and excludes branches and candelabras. The bole of the tree includes merchantable and non-merchantable portions of the trunk of the tree.

"**Boring Height**" means the distance from the ground (high side) up the tree to where an age is taken with an increment borer. It is usually taken at breast height (1.3 m);

"**Breast Height**" means the location on a tree where its diameter (DBH) is measured. It is located exactly 1.3 m above "high side". If high side is lower than the point of germination (POG), breast height is 1.3 m above the POG;

"**Cardinal directions**" means North, South, East and West. All references to azimuths or bearings mean the "true" value. For a description of True North, please see True North, Magnetic North and Grid North in the Appendices;

"CEP" means Circular Error Probability, a measure of precision, defined as the radius of a circle, centered around the mean, which is expected to include 50% of the results.

"**Closure Error**" means the distance between the start and end of the traverse in a closed traverse, divided by the length of the traverse, and is usually expressed in percent;

"**Coast**" means the area subject to the *Coast Appraisal Manual*;

"**Coefficient of Variation (CV)**" is a relative measure of variation, equal to the sample standard deviation expressed as a percentage of the sample mean ($\frac{SD}{\bar{x}}$);

"**Confidence**" means an expression of precision of sample estimates, usually assessed by confidence intervals such as 95 percent, a specified proportion of which contain the true population parameters;

"**Count Plot**" means a prism plot where only the number of "in" trees by species and plot slope is noted. No individual tree measurements are recorded;

"**Crown Class**" means one of the four crown classes, which are dominant, co-dominant, intermediate and overtopped (see Figure 6.3 Crown Classes.);

"**Cruise Based**" means a cutting authority where under section 106 of the *Forest Act*, the stumpage payable is calculated using information provided by a cruise of the timber conducted before the timber is cut;

"**Cutblock**" means an area that meets the cutblock requirements as specified in the *Coast* and *Interior Appraisal Manuals*;

"**Cutting Authority Area**" means the area authorized to harvest Crown timber, as provided by the *Forest Act*;

"**Cutting Specifications**" mean the timber merchantability specifications as defined in the *Coast* and *Interior Appraisal Manuals*;

"**DBH (Diameter Breast Height)**" means the outside bark diameter of a tree measured at breast height;

"**Decay, Waste and Breakage (DWB)**" means factors to reduce the gross merchantable volume to a net merchantable volume and to approximate the volume depletion due to decay, firmwood waste and breakage due to harvesting;

"**DIB (Diameter Inside Bark)**" means the diameter of a tree, excluding bark;

"**Diopter**" means a method 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**" means a method which incorporates a second sampling procedure where only some of the characteristics of the main sampling method are recorded. An example is measure and count plots established on a cut block;

"**Faller Selection**" means a timber falling technique that 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**" means a sampling method where a fixed amount of area is sampled in each plot within a stratum. All trees larger than the timber merchantability specifications are tallied if they are within the plot. All plots within a stratum must be the same size and shape;

"**Forest Inventory Zone**" means one of the 12 zones delineated by Forest Analysis and Inventory Branch of the Ministry of Forests, Lands and Natural Resource Operations.

"**GIS (Geographic Information System)**" means a system designed to capture, manage, analyze, store and present digital geographic data;

"GMT" means Greenwich Mean Time, a global time standard. For the most part it is synonymous with UTC, but does not have a precise definition at the sub-second level.

"**GPS (Global Positioning System)**" means a method of 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;

"**Grid system**" means a method used to locate cruise plots systematically along a grid, usually a predetermined management unit specific GIS grid or a local cutblock level grid.

"HDOP" means horizontal dilution of precision, which is a measure of the precision of GPS results related to the satellite positions. As HDOP decreases, the level of precision increases.

"**High Side**"" means the position where the ground meets the tree adjacent to highest ground, ignoring any root flare, obstacles, vegetation, and loose matter that has accumulated at the base of the tree;

"**Interior**" means the area subject to the *Interior Appraisal Manual*;

"**Licensee**" means the holder of the cutting authority;

"**Log Grade**" means those log grades that are identified in the *Scaling Regulations*, Cruise Compilation Grade Algorithms or *CGNF Standards and Procedures for the Coast Forest Region*, as appropriate;

"**Loss Factor**" means the method used to determine the net volume of a tree. The loss factors were determined as part of the provincial inventory system. Loss factors use a combination of tree maturity, pathological indicators and tree location (FIZ and PSYU or local factors) to determine the percentage of decay, waste and breakage that will be deducted from the gross merchantable volume equally from each log in a tree;

"**Major Species**" means a species that comprises 20 percent or more of total net merchantable volume in a timber type, cut block or cutting permit;

"**Mean**" means the sum of all measurement values divided by the number of measurements;

"Mean Difference of Hits" means the average of the absolute variations of each GPS hit or coordinate from the plot reference point (PRP), measured in metres.

"**Merchantable**" means a segment of a tree between 30cm stump height and a top diameter inside bark that is at least 3 metres in length and within the timber merchantability specifications as defined in the *Coast* and *Interior Appraisal Manuals*;

"**MFLNRO**" means the Ministry of Forests, Lands and Natural Resource Operations;

"**Minor species**" means a species that comprises less than 20 percent of the total net merchantable volume in a timber type, cut block or cutting permit;

"Orphan Tree" means a tree of a certain species that occurs in a count plot but has not been tallied in a measure plot within the same timber type.

"**Partial Cutting**" means silviculture systems in which only some of the trees are felled during the harvesting phase. The selection method may specify "removal" or "leave" trees. Some examples of selection criteria are diameter, species, volume, age, height, disease or other damage. For the "partial cutting" criteria, please refer to chapter 4 of the *Interior Appraisal Manual*;

"**Pathological Indicators**" means conk, blind conk, scar, fork or crook, frost crack, mistletoe, rotten branch, and dead or broken top;

"PDOP" means positional (3D) dilution of precision, which is a measure of the precision of GPS results related to the satellite positions. As PDOP decreases, the level of precision increases.

"**Percent Reduction**" means a specified percentage reduction of the cruise volume which is targeted to be reserved from harvesting;

"**PRF (Plot Radius Factor)**" means a factor which multiplied by the DBH (cm) of a tree represents the appropriate plot radius (m) for the tree. In variable plot cruising, each tree has its own plot radius. This is a function of tree diameter (DBH) and prism BAF (m^2/ha) size.

The PRF formula is: $PRF = 0.5/\sqrt{BAF}$

"**Plot Sampling**" means the estimation of volumes and grades by species within a cut block from sample plot measurements, and the determination of the sampling error associated with the plot estimates;

"**Precision**" means the closeness, to each other, of repeated measures of the same quantity, expressed as Sampling Error or Standard Error of the sample estimate;

"PRP" means plot reference point; a GPS waypoint located a short distance (e.g. 15 to 20 m) from the cruise plot. The bearing and distance to the cruise plot are calculated and measured from this point.

"PSYU (Public Sustained Yield Unit)" means a management area of Crown land, with similar forest attributes based on local samples. PSYU always overrides the tables determined by FIZ;

"Residual tree" means a tree which does not bear any of the following external indications of decay on or immediately adjacent to the bole of the tree: conk, blind conk, scar, fork or pronounced crook, frost crack, mistletoe trunk infection, rotten branches, dead or broken top.

"**Risk Group**" means a grouping by expected "risk" or probability of average decay, waste and breakage. A combination of tree class, pathological indicators, Forest Inventory Zone and PSYU determines the Risk Group of an individual tree for volume deduction.

"RMS" means root mean square and is calculated by taking the square root of the average of the squared errors. It is a measure of precision, meaning that there is a 63 to 68% probability that the results will be within the RMS distance.

"**Sampling Error %"** means an expression of the accuracy of the sampling of the cruise, calculated as a percent of an estimated mean to a desired probability;

"**Scale Based**" means the stumpage payable is based on a scale of the timber harvested from the cutting authority in accordance with Part 6 of the *Forest Act*;

"Single Stem" means the removal of individual trees based on specific tree level criteria, regardless of harvest method. It includes helicopter single standing stem selection as defined in the *Coast Appraisal Manual*. Single stem removal, for the purposes of this manual, does not include the removal of trees based on spatial distribution or for silvicultural purposes, such as commercial thinning.

"**Site Class**" means a set of 4 site quality classes (good, medium, poor, low) which characterize the potential growth capacity of the minerals and moisture in the soil, as measured in tree height (metres) attained at the breast height age of 50 years;

"**Standard Deviation (SD)"** means the square root of variance. It characterizes dispersion of individuals about the mean and gives some idea whether most of the individuals in a population are close to the mean or spread out;

"**Standard Error (SE)**" means an expression of how close the sample mean is to the true mean. Two standard errors (2 SE) means there is a 95% chance that the true mean is within the sampling error of the cruise.

"**Stratification**" means the process of delineating strata boundaries within a subpopulation, where each stratum has unique characteristics such as species composition, height, stand volume or age;

"**Stratum**" means a specified portion of a sub-population area for which separate volumes and sampling statistics are calculated. A sub-population may be made up of one or many strata. Strata are commonly known as timber types;

"**Strip Line**" means a ribboned line located through the forest and tied to the boundary at one or both ends. Cruise plots are located at regular intervals along each strip;

"**Stubbed**" means the practice of harvesting or removing a portion of the tree so that part of the bole (stem) above stump height remains.

"**Stumpage Rate**" means a charge levied by the Crown determined in accordance with the policies and procedures approved for the forest region by the minister;

"Suspect tree" means a tree which bears one or more of the following external indications of decay on or immediately adjacent to the bole of the tree: conk, blind conk, scar, fork or pronounced crook, frost crack, mistletoe trunk infection, rotten branches, dead or broken top.

"**Tie Point**" means a specific point on the ground whose location is readily identifiable on a digital image, aerial photograph or map. (eg. road intersection, corner of a field or swamp, field located traversed or GPS station);

"**Timber Supply Area**" means large contiguous areas of Crown land on which an annual allowable cut is calculated;

"**Tree Class**" means a series of classes (nine) signifying age/maturity, presence of pathological indicators, and live/dead classification. This classification, in combination with pathological indicators and age in 10's, determines the appropriate risk group for volume deduction;

"UTC" means Coordinated Universal Time, the primary global time standard. It is defined more precisely than GMT as it is defined to the sub-second level.

"UTM" means Universal Transverse Mercator coordinate system, a two dimensional coordinate system that divides the earth into 60 zones.

"**Variable Plot Sampling**" means a method of plot sampling where the trees to be tallied are based on their size and not the frequency or density of trees in the stand. Each tree has its own plot radius and can be assessed with an angle gauge (eg. Prism or relascope);

"**Variance**" is the mean of squared deviations of observations about a sample mean. (These deviations or differences from the mean are called residuals);

"**Variation**" is the difference, plus or minus, between two measurements or a standard and a measurement (e.g., standard of 7 and measurement of 5 gives variation of -2);

"**Waste**" is waste as defined in the *Provincial Logging Residue and Waste Measurement Procedures Manual*.

1.2 Terms of Reference

The *Forest Act*, Section 103 to 108 and regulations provide the statutory authority for the determination of stumpage rates for crown timber.

The *Forest Act*, Section 105, requires adherence to the policies and procedures approved for the forest regions by the Minister of Forests, Lands and Natural Resource Operations. The policies and procedures are used in the *Coast Appraisal Manual* and *Interior Appraisal Manual*, for determining stumpage rates charged for Crown timber.

The *Coast Appraisal Manual* and *Interior Appraisal Manual* specify that cruise data must be gathered and compiled according to procedures established in the *Cruising Manual* and the *Cruise Compilation Manual*. The *Cruising Manual* and *Cruise Compilation Manual* are approved by the Director, Timber Pricing Branch.

1.2.1 Calculation Conventions

Each calculation will be calculated to the nearest tenth. This is consistent with the data precision level of the compilation reports.

The rounding rules to be used in this manual are the same as those in the *Cruise Compilation Manual* (see Appendix 16 of the *Cruise Compilation Manual*). (ie. digits 0-4 are rounded down and 5-9 are rounded up).

For example, meeting a check cruise standard:

- 10.03 = 10.0 and does not exceed 10.0%
- 10.05 = 10.1 and exceeds 10.0%

For example, meeting a minimum threshold:

- 34.99 = 35.0 and meets the 35.0% threshold
- 34.94 = 34.9 and does not meet the 35.0% threshold