MINISTRY OF FORESTS

Resources Inventory Branch

Inventory Audit Sampling Standards and Procedures

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Changes in the 1998 Standards and Procedures Manual

1. Quality Assurance (QA) specification. GPS data are used to validate plot positions to determine the extent of gross errors plot location
2. Regions when creating the field sampling packages, are to ensure that extra 1:20,000 scale maps are produced, along with plot position maps. This is to be supplied to the GPS data correction contractor.
3. Field contractors must supply digital data and final plot position maps directly to the GPS correction contractor in an expedient manner.
4. Non-Forest sampling. If the selected polygon has extensively large alpine areas the procedure of sampling the number of maps and airphotos will be assessed on a case by case situation by Resources Inventory Branch.
5. Immature sampling. If volume age data is required for age class 3 stands, the age criteria is based on the inventory age and **not** the ground age.

1.0 Introduction

The goal of checking the statistical integrity of British Columbia's forest inventories has been identified as an urgent priority. The integrity of forest inventories shall be verified by a series of inventory audits conducted on all crown managed tenures, Tree Farm Licenses (TFLs) and Timber Supply Areas (TSAs), throughout British Columbia.

To achieve this goal, statistical analysis techniques combined with ground estimation procedures have been developed to examine and assess the accuracy of the forest polygon attributes and reported volume of the forest inventory system. These estimation procedures must be conducted under stringent quality and procedural standards. The accuracy of the polygon specific variables is a key component in the forest management planning process.

This document presents procedures and standards for performing this analysis for both TSAs and TFLs for the Inventory Audit Program.

The technique used to assess the accuracy of timber volumes has been termed "ratio sampling" or statistical audit. Ratio sampling involves sample selection and ratio estimation. The sample can be selected based on a variety of sampling designs such as simple random sampling. Ratio estimation requires measurement of two variables, y and x, on each element of a sample. In this case, the y represents the volume estimated on the ground from cruise plots and x represents the estimated volume from a computer yield model (VDYP). The process involves determining the "true" inventory volume (y) from ground samples and obtaining the "estimated or projected" volume (x) using various forest growth projection models for the stand. The ratio of y/x and the scatter plots of y on x shall be used to make accuracy statements about a given inventory and assist in prioritizing future re-inventories (in conjunction with pre-inventory assessments).

1.1 Inventory Audit Objectives And Goals

A statistical audit is a tool used to confirm the accuracy of the volume and/or label of a timber inventory in an area. The results of the audit may be used to recommend that a new inventory be conducted, prioritize re-inventory activities, or provide baseline data that may be used with additional information as an adjustment factor. Information from the audits may also be used by the Chief Forester to help determine the degree of risk and uncertainty associated with mature inventory volumes. Data collected as part of this program shall also provide detailed tree list information for further volume and decay sampling.

Statistical audits will assist with setting priorities and focus for pre-inventory assessments and re-inventories. An inventory audit shall be performed prior to a pre-inventory assessment; a pre-inventory assessment is performed prior to a re-inventory of a management unit in order to provide an in-depth review of the state of an inventory and to assist in developing a sampling plan to address the principal inventory issues for a new re-inventory.

Statistical audits will also be used to check new inventory work. An audit will provide baseline measurements to compare with new inventory data and estimates.

2.0 Sampling Process And Design(s) Overview

The inventory audit program has several key steps. These procedures are applicable to both TFLs and TSAs, although modifications are required for each management unit. The following description is a brief overview of the general processes and responsibilities. A more detailed description of the procedures is included in section 3.

2.1 Inventory Audit Sampling Process

1. **Selection of Area to Audit:** Complete management units are selected to audit.

   Responsibility: Regions to select areas to audit (Note: complete TFLs or TSAs)

2. **Inventory File Assembly:** The inventory files for the selected audit area shall be assembled. The TSA forest inventory planning (FIP) files are downloaded from BCSC while TFL files shall be requested from the licensee. Due to potential corruption of TFLs files within Resources Inventory Branch the licensee shall be requested to supply the most current attribute files available.

   Responsibility: TSA file assembly: Branch. Acquisition of TFL files (if not available in FIP format): Region

3. **Polygon Selection Procedures:** Stands shall be systematically selected from a sorted, area weighted list using FIR or from other suitable database system.

   Responsibility: Branch

4. **Polygon Selection Verification:** Following the selection process, the polygon information for the selected stands within the TSA/TFL shall be compared to the reported inventory. The two populations shall be compared on the basis of site class, age class, GTG. Population summaries are prepared and forwarded to the Statistical Decision and Support staff for approval.

   Responsibility: Population summaries: Region. Review and approval of sample distribution: Branch

5. **Information Request:** In the case of TFLs, the licensee shall supply the assigned volume/label for each selected polygon (if appropriate) and any maps, photos or additional information that is required.

   Responsibility: Region

6. **Office Sample Preparation:** After verifying the target population, maps and aerial photos shall be collected for each selected polygon in the management unit. Ground samples are assessed for accessibility and identified on the operational inventory map.

   Responsibility: Region

7. **Contract Package Preparation:** A contract package is prepared amalgamating all relevant information for each management unit.

   Responsibility: Region

8. **Contract Viewing:** Contracts shall be viewed at a central location with the option for a local viewing.

   Responsibility: Branch/Region

9. **Contract Award:** All contracts shall be awarded using an RFP evaluation point rating system.

   Responsibility: Branch/Region/District

10. **Quality Assurance:** At the start up of all contracts, MOF staff will conduct a pre-work meeting with the contractor and their staff to ensure that all the contract conditions, standards and procedures are clearly understood and agreed upon, by the contractor and MOF quality assurance staff. A proportion of sample polygons (minimum 10%) will be checked to verify the quality of the field work.

    Responsibility: Branch/Region/District

11. **Data Analysis:** Field sheets shall be submitted to the Resources Inventory Branch, Statistical Audit Forester together with staff from Statistical Decision Support and regional/district staff will compile and interpret the results. A public overview and a detailed technical report will be produced.

    Responsibility: Branch/Region/District/Licensee

2.2 Field Procedures And Plot Layout

The following general sampling designs will be used to assess inventory accuracy. A more detailed description may be found in sections 3 and 4.

1. **Ground Sample:**
   a) **Volume Age Sampling :** For all TSAs 50 polygons shall be selected in stands, >= 61 years of age and measured for volume. A sampling grid consisting of four full measure and five variable radius count plots shall be positioned randomly within the selected polygons with the measurement procedures consistent with current MoF Valuation Branch cruising standards.

   b) **Immature Stands:**
   Twenty polygons shall be selected in stands less than 61 years of total age but greater than free growing or the equivalent status. A sampling grid consistent with the volume age sampling design and placement, consisting of 9 fixed area or variable radius plots will be used to assess site index and species composition in immature stands and will be used to assess volume in age class 3 stands. Note that not all contracts will be assessing volume in age class 3 stands.

2. **Air Photo Sample:**

   a) A sample of 30 non-forest, non-productive classification polygons shall be assessed for classification accuracy, by a BC MoF certified air photo interpreter.

3.0 Inventory Audit Sampling Procedures

The following procedures describe in detail the sampling procedures for inventory audit assessments.

3.1 Defining The Population

For inventory audit sampling purposes the population will be stratified into several components and assigned an appropriate sampling design and analysis technique. The components have been identified as:

1. Volume Sampling Age Stands

Volume Sampling Age Stands shall be identified as stands greater than or equal to 61 years of total age (Ministry of Forests age class >=4). These stands are seen as the greatest contributors in the next 20 to 50 years of timber supply for British Columbia

A total of 50 polygons will be sampled. Volume accuracy will be assessed consistent with current MoF Valuation Branch cruising standards, unless otherwise stated. Map label attribute accuracy will also be reported. Note that in the case of smaller TFLs, less than 100,000 ha of total forested area, that the volume age sample size may be reduced to 40 polygons. The decision to reduce the sample size on the smaller TFLs shall be reviewed by the RIB Statistical Decision Support staff.

A sampling grid consisting nine variable radius plots shall be positioned randomly within the selected polygons to measure volume.

2. Immature Stands

Twenty polygons shall be selected in stands less than 61 years of total age but greater than free growing or the equivalent status. A sampling grid consistent with the volume age sampling grid, consisting nine fixed area or variable radius immature plots shall be positioned randomly within the selected polygons. A maximum of nine fixed area or variable radius immature plots shall be established to assess polygon site index and species composition. Note that for the majority of contracts in 1997 that volume will measured on age class 3 (41 to 60 years of age) stands to standards consistent with the volume age component. Site index data will also be collected in the age class 3 stands consistent with the standards for all immature stands.

3. Other Forest Land Descriptions

A total of 30 non-forest and non-productive classification types shall be sampled, which may include:

- Alpine
- Rock
- Claybank
- Slide
- Gravel bar
- Cultivated Meadow
- Icefield
- Gravel pit
- Sand
- Mudflat
- Open Range
- Urban
- Water
- Swamp
- Muskeg
- Non-productive brush
- Non-productive forest
- Non-productive burn
- Non Commercial

For information on non-forest land see Inventory Manual Forest Classification Appendix II, page 32-33.

Note: If the selected polygon has extensively large alpine areas, the collection of maps and air photos, the procedure of sampling the number of maps and airphotos will be assessed on a case by case situation. Contact Resources Inventory Branch.

4. **Non-sufficiently restocked (NSR)**

All stands classified as NSR, that are selected by the random selection process, shall be assessed in the field as either a volume age sample or an immature sample. All immature NSR stands must be greater than free growing or the equivalent status. Due to the variable nature of NSR classification within B.C., it was felt that it would be inappropriate to assign one sampling design for all situations throughout B.C. Therefore, the method of field sampling shall be a regional decision. Based on the information obtained from the detailed polygon listings, maps, photos and personal experience, the polygon may be sampled as either a volume sampling age stand, or as an immature stand. The intent is to select a sampling design that will provide the best level of information to verify the NSR classification.

3.2 Polygon Selection Procedures

The following procedures apply to selecting polygons from TSAs and TFLs.

1. **TSA Polygon Selection** (The following procedures apply to selecting polygons from TSAs)
   a) **Area Summaries:** Obtain the most recent TSA Inventory Summary Report and note the leading species, site and age class distribution for the entire area. This information shall be compared to the selected stands. The comparison shall ensure that the sampled population is similar to the reported population in terms of species, age and site class. Note that the reported population summary statistics should follow the same age, species and site class distribution as the selected samples (e.g. age class 4+) A summary report comparing the selected population to the reported population shall be supplied to the Statistical Audit Forester at Resources Inventory Branch for review. The following format is suggested:

Age Class Distribution

Age Class	*TSA area (ha) %*	*Number of Samples (f) %*
4		
5		
6		
7		
8		
9		

Site Class Distribution

Site Class	*TSA area %*	Num*ber of Samples (f) %*
G		
M		
P		
L		

Species Distribution

Species	*TSA area %*	*Number of Samples (f) %*
Fd		
Hw		
Cw etc.		

After confirming the distribution of the sample population, the polygon positions shall be located on the overall (1:250,000) base map and checked to confirm that the physical distribution of the sampled polygons is evenly distributed. Visual estimation shall be adequate in confirming the distribution.

b) Polygon Selection: Stands are selected using the pre-inventory analysis module within FIR. There are three basic steps to this process (see Appendix 1 for FIR image examples):

Step 1: Involves loading the .FIP files, for the area of interest, into FIR.

Step 2: Involves producing a report that documents the total area of files loaded into FIR. This report must be compared to the reported area for the area of interest in order to ensure that the total area is loaded and that no map sheets are missing.

Step 3: Involves the selection of polygons from the pre-inventory analysis module of FIR.

c) Detailed Description of Polygon Selection Process

Step 1: The first step is to load FIP files into FIR. From the Timber Inventory Screen in FIR activate the following screens (see the enclosed screen prints):

- ***System***
- ***Communications***
- ***Import Map Files***
- Map type: ***New***
- TSA or TFL File: ***TSA***
- Import/Delete Individual Maps or Map Blocks: ***Import/Delete Individual Maps***
- Maps Available to Import: ***highlight the maps you wish to import or activate the Add All key***
- Activate the import key to load maps: ***The loaded maps should appear in the Maps Loaded screen***

All selected maps should now be within FIR. The next step is to produce a report that documents the total area of maps loaded.

Step 2: Activate the following screens:

- ***Reports***
- ***Summary Reports***

In the Summary Reports Screen, activate the following:

- ***Timber Supply Area***
- Biogeoclimatic Zone/Subzone/Variant: activate the **All** key
- Timber Supply Area: ensure the correct ***TSA*** has been activated
- Administrative Area: ***activate Individual Unit***

Hit the **OK** key

In the Summary Report Options Screen activate the following screens:

- Report ***activate b. Forest and non-forest land***

Ensure the selected area of interest is correct

- Site Classification: ***activate MOF Classes***
- Extraction By: ***activate Area and Volume - Gross***
- Utilization Level: ***activate 17.5***

Hit the **OK** key

On the Area and Volume By Forest Land And Non-Forest Land activate the following:

- Ownership: ***activate Crown 62***

(Regional staff must confirm if other ownership classifications should also be selected)

Hit the ***Print*** key and the report will be produced. Ensure that the area reported in the FIR summary report matches the area reported for the area of interest (use Provincial Summary Report (PSR) software to reconfirm area of interest).

Step 3: Polygon Selection From FIR

The following steps shall be followed while selecting polygons from FIR. Activate the following fields with the indicated response:

Timber Inventory

- ***Reports***
- ***Pre-Inventory Reports***
  - ***Timber Supply Area***
  - Biogeoclimatic Zone/Subzone/Variant: activate the **All** key
  - Timber Supply Area: ensure the correct ***TSA*** has been activated

Polygon Systematic Sample Selection Report Options Screen 1/2

- ***Polygon Systematic Sample Selection***
- Ownership:

  - ***Crown Ownership 62***

  (Note: Some Regions have included other ownership that is considered by of the AAC determination process).

- Site Classification

  - ***MOF Classes***

  - ***All polygons***
- Land Classification:

  - ***Forest and Non-forest Land***
- Select By ***"No"***
- Selected Area of Interest (AOI)

  - ensure the correct ***TSA*** is indicated
- Environmentally Sensitive Areas - ***"No"***
- Select Display Order for Samples: ***activate on samples***

  - activate the sample number key and indicate a sample number of ***1000.***

Activate the More.... key

Polygon Systematic Sample Selection Report Options Screen 2/2

- Select by Age Class: ***enter No***
- Select by Height Class: ***enter No***
- Select by Stocking Class: ***enter No***
- Select by Crown Closure Class: ***enter No***
- Utilization Level: ***enter 17.5***
- Selected area of interest: ensure the correct ***TSA*** is indicated
- Select Sort Sequence:

  1 = Site Index

  2 = Age Class

  3 = Inventory Type Group
- Select Weight: ***activate area***

Activate the ***previous*** key

Activate the ***OK*** key

A default .spl (ASCII) file is created in the c:\firpam\fir5\source\firtemp.spl directory, with an Excel file created in the c:\firpam\fir5\com\firexcel.xls directory.

2. **TFL Polygon Selection** (The following procedures apply to selecting polygons from TFLs)
   a) **Area Summaries:** Obtain the most recent Management Plan Summary Report for the TFL and the leading species, site and age class distribution for the area. As in the TSA, the summary information shall be compared to the selected stands to ensure that the selected samples proportionally represent the ground population. As in the TSA, a summary report comparing the

selected polygons to the reported type and operable land base distribution shall be supplied to the Statistical Audit Forester within the Resources Inventory Branch. [**Note:** Sample polygons shall not be biased to the operable land base]

b) Polygon Selection: The licensee shall be requested to provide a single digital file of the TFLs inventory. If available and tested, the licensee shall provide the file in .FIP format, however an ASCII or dbf file is acceptable. Note that polygons classified as non-forested, non-productive or NSR land shall be included in the sample population. The total area represented in the file should represent the total area within the TFL.

The flat file should contain the following minimum information:

- label (species/age/ht/site class)
- polygon location (identification and latitude and longitude)
- site index/site class
- Biogeoclimatic (variant) if available
- area (ha)
- operability
- species composition
- age_in, age_projected
- crown closure, stocking class projected
- npd (non-productive descriptor)
- nfd (non-forest descriptor)
- fiz (forest inventory zone)
- psyu
- analysis unit (au) volume
- esa1, esa2, vqo

The selection of polygons within TFLs shall be completed by following the same process used for TSAs.

i Sort the database, in the following order and attributes:

- site index;
- age class; and
- inventory type group.

ii From the supplied inventory file create a cumulative total of areas for all polygons.

iii Divide the total area of the polygons by the suggested sample size for each sampling unit to give the selection interval. The sampling units and recommended sample size are:

1. volume age stands select 40 or 50 polygons depending on the size of the TFL.
2. immature stands select 20 polygons
3. non-productive/non-forest types select 30

The final sample size should be large enough to allow for additional samples in the event that the selected polygons can not be located in the field due to unsafe conditions.

iv Using a random number table select a random start point between 1 and the selection interval.

v The systematic selection points are derived by adding the random start point value to the selection interval. For example: If the random start point is 194 and the sample interval is 244, the sequence of selection points would be 194, (244 + 194) 438, 682, 926 etc. Selected polygons are then tagged. The tagging process involves starting from the top of the list and systematically progressing down the list identifying the selected polygons. Ensure that additional polygons are chosen in case the selected polygons have been logged or are physically impossible to access (unsafe).

Selection of polygons is proportional to polygon area, therefore each hectare of land has equal probability of being selected. Ensure that the final list of polygons is randomly sorted and not systematically ordered by mapsheet, (see Table 3.2.1 for an example).

Selected Polys	Polygon Area	Cumulative Poly Areas		
	12			
	56	68		
	89	157	Random points are:	
***	63	220	194	
	98	318	438	
***	321	639	682	
***	62	701	926	
	2	703	1170	
	95	798		
	32	830	Random start point =	194
	95	925	Sample Interval =	244
***	32	957	Sample size =	5
	12	969	Selected polygons = ***	
	45	1014		
	75	1089		
	32	1121		
***	96	1217		
	5	1222		

Table 3.2.1 Sorted Area Weighted List of Polygon Selection (example)

3.3 Information Requests

1. **Mapping Requests**. After MOF staff have selected and verified the polygons to be sampled the licensee may be asked to supply the following:

   Inventory Map: Inventory maps for each polygon are required at an appropriate operational scale. (preferably 1:5,000/1:10,000). This map should be of sufficient scale to allow plot positions to be clearly established and to be used for field access purposes. Tie points and physical features should be visible on the maps. In the case of TFLs with EGAF format inventories, the licensee shall be requested to supply the area of the selected polygon. If appropriate any mapping or scale irregularities should be identified.

   Overview Map: An overview map (1:250,000) shall be provided for the TFL showing the entire TFL in relation to all major roads and physical features. The location of each selected polygon

shall be identified on this map, so as to show the general distribution of the samples and to provide an overview for overall access.

Operational Air Photos: The most recent operationally scaled, stereo pair photos (1:15,000/1:10,000) shall be provided for each sampled polygon. These photos shall be used to verify the polygon position and assist in locating the sample in the field. Laser copies of critical photos shall be made by Ministry of Forests staff.

Overview Air Photos: If available, overview photos are required for each polygon (1:40,000). These photos shall be used for access. If not available from the licensee, regional offices should have TRIM base photography.

Air Photo Flight Line Maps: Air photo flight line maps are required for each scale of photos supplied.

Latitude and Longitude Coordinates: Ensure latitude/longitude data is recorded in degrees, minutes and seconds.

Access Information: Detailed access information shall be required for each polygon. (See contract package preparation for details.)

3.4 Office Sample Preparation

1. **Ground Sample Establishment Procedures for Volume Sampling Age Stands** After selecting and verifying the polygon distribution, staff shall identify the sampling points within the polygon. The following procedures shall be applied:

Note: If the polygon is split between two mapsheets only sample that portion of the polygon related to the selected mapsheet. Do not combine the halves of the polygons and sample the entire polygon.

a) Grid Size and Distance

Due to potential photocopy distortion that may occur to grid overlays, use the grid distances that are based on the following spacing. These distances should be clearly defined on field maps. Use the digital version that is provide by Resources Inventory Branch.

polygon size >= 18 ha	150 meters
polygon size between 14-17.9 ha	130 meters
polygon size between 8-13.9 ha	100 meters
polygon size between 3-7.9 ha	75 meters
polygon size =< 2.9 ha	70 meters

b) Identifying Area of Polygon to be Sampled

i Place the sample **location** (see Appendix 2) grid #21 transparency on a table.

Due to potential photocopy distortion that may occur to grid overlays, use the grid distances that are based on the following spacing. These distances should be clearly defined on field maps. Use the digital version that is provide by Resources Inventory Branch.

ii Using a light table, overlay the operational inventory map containing the selected polygon over the grid. Ensure that the selected polygon is within the coordinate points of the grid. Do not intentionally position the grid in any systematic fashion.

iii Note the x and y axis coordinate points that are within the polygon boundary.

iv Using a random number table select corresponding x and y coordinate points that fall either within or on the boundary of the polygon.

v Identify this point with a small x on the polygon. This point represents the general area of the polygon that shall be sampled and will determine the plot positions.

vi Based on the scale of the map select the appropriate sampling grid overlay (see Appendix 2).

c) Identifying Sample Plot Location

i Place the appropriate sampling grid on a light table.

ii Overlay the operational inventory map over the sampling grid, ensuring that it is not positioned or aligned in any systematic fashion.

iii Note the closest grid intersection point to the previously identified sample location point. The sample grid has now been defined. The sampling grid comprises four grid squares. Each outside corner of the grid shall contain a full measure plot, with count plots distributed at the midpoint of each side of the grid and at the central grid intersection point.

iv Using the central grid intersection point as a pivot point, rotate the lines on the grid until they are aligned in a cardinal (NSEW) direction. This will make office and field layout easier.

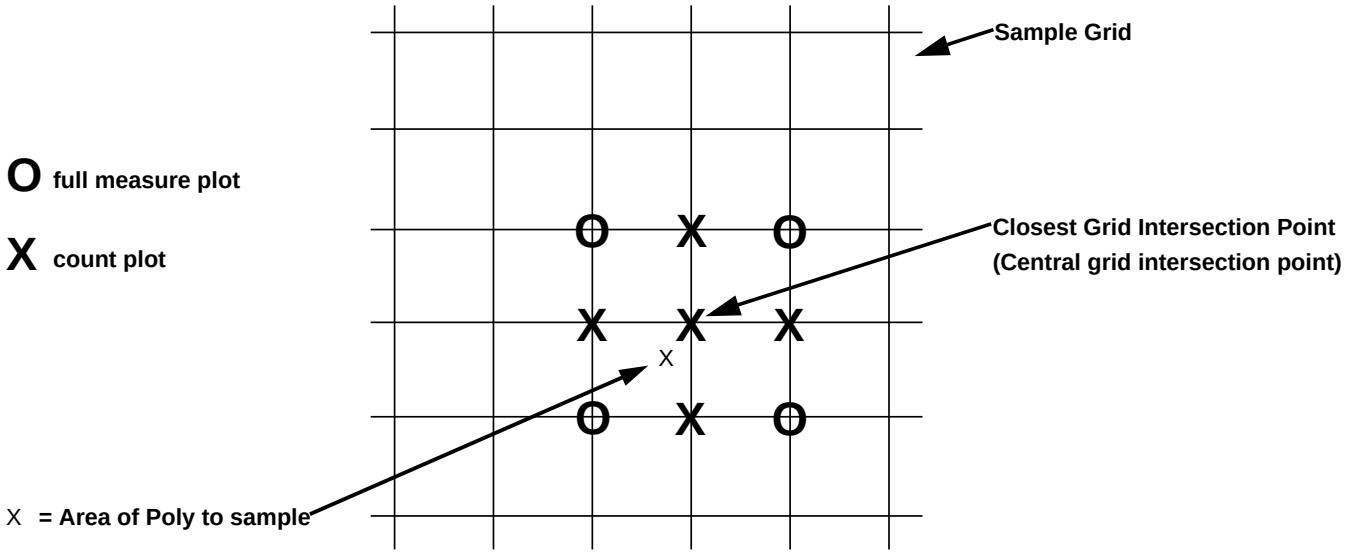

Figure 3.4.1 Sample grid positioning

d) Entire Sample Grid Fits Within Polygon

i Identify the plots on the map that fall within the grid or on the boundary of the polygon. If the selected grid fits within, or falls on the boundary and contains four full measure plots and five

count plots then selection process is complete for the polygon. The determination of count or full measure plots shall follow the configuration shown in Figure 3.4.1.

ii Full measure plots shall be identified by a small circle with count plots identified by Xs.

iii Identify the bearings and distances on the map. Ensure that the distances are defined from the original grid distances and not measured off the map, as the grid scale may be difficult to accurately interpret.

e) Entire Sample Grid Does Not Fit Within Polygon If the selected grid contains plots that are outside the polygon or do not fall on the boundary or fall on double lined roads and the sample does not contain the required number of plots, then extra plots shall be chosen from an adjacent grid(s). The process shall involve:

i Select other candidate plot positions that fall either within or on the polygon boundary. The preference for plot positions shall be based on adjacency. Select those positions that are adjacent to the previously selected plot positions. Plot positions should not be biased to the interior of the stand, or be located so as to minimize access time.

ii To determine whether to establish a full measure or count plot, simply alternate count and full measure plots. If the shape and size of the polygon will not allow the full number of plots to be established, this will be acceptable. If the situation occurs where the plots fall on a double lined road or any other mapped, non-forest type, that plot position would be unacceptable and an alternative plot position shall be chosen.

iii In the case of very small polygons, position the plots as per d(i). If the polygon does not contain the full complement of plots this will be acceptable. If less than three plots can be established contact the Statistical Audit Forester at Resources Inventory branch. The first priority will be to establish 4 full measure plots.

2. Ground Sample Establishment Procedures for Immature Stands The following procedures is identical to the *Ground Sample Establishment Procedures for Volume Sampling Age Stands* in the above section.

a) Grid Size and Distance

Due to potential photocopy distortion that may occur to grid overlays, use the grid distances that are based on the following spacing. These distances should be clearly defined on field maps. Use the digital version that is provide by Resources Inventory Branch.

polygon size >= 18 ha	150 meters
polygon size between 14-17.9 ha	130 meters
polygon size between 8-13.9 ha	100 meters
polygon size between 3-7.9 ha	75 meters
polygon size =< 2.9 ha	70 meters

b) Identifying Area of Polygon to be Sampled

i) Place the sample **location** (see Appendix 2) grid #21 transparency on a table.

Due to potential photocopy distortion that may occur to grid overlays, use the grid distances that are based on the following spacing. These distances should be clearly defined on field maps. Use the digital version that is provide by Resources Inventory Branch.

ii) Using a light table, overlay the operational inventory map containing the selected polygon over the grid. Ensure that the selected polygon is within the coordinate points of the grid. Do not intentionally position the grid in any systematic fashion.

iii) Note the x and y axis coordinate points that are within the polygon boundary.

iv) Using a random number table select corresponding x and y coordinate points that fall either within or on the boundary of the polygon.

v) Identify this point with a small x on the polygon. This point represents the general area of the polygon that shall be sampled and will determine the plot positions.

vi) Based on the scale of the map select the appropriate sampling grid overlay (see Appendix 2).

c) Identifying Sample Plot Location

i) Place the appropriate sampling grid on a light table.

ii) Overlay the operational inventory map over the sampling grid, ensuring that it is not positioned or aligned in any systematic fashion.

iii) Note the closest grid intersection point to the previously identified sample location point. The sample grid has now been defined. The sampling grid comprises four grid squares. Each outside corner and midpoint at each side of the grid and at the central grid intersection point of the grid shall contain a immature plot.

iv) Using the central grid intersection point as a pivot point, rotate the lines on the grid until they are aligned in a cardinal (NSEW) direction. This will make office and field layout easier.

d) Entire Sample Grid Fits Within Polygon

i) Identify the plots on the map that fall within the grid or on the boundary of the polygon. If the selected grid fits within, or falls on the boundary and contains nine plots then the selection process is complete for the polygon. The determination of count or full measure plots shall follow the configuration shown in Figure 3.4.2.

ii) Immature sample plots shall be identified by Xs.

iii) Identify the bearings and distances on the map. Ensure that the distances are defined from the original grid distances and not measured off the map, as the grid scale may be difficult to accurately interpret.

e) Entire Sample Grid Does Not Fit Within Polygon If the selected grid contains plots that are outside the polygon or do not fall on the boundary or fall on double lined roads and the sample does not contain the required number of plots, then extra plots shall be chosen from an adjacent grid(s). The process shall involve:

i) Select other candidate plot positions that fall either within or on the polygon boundary. The preference for plot positions shall be based on adjacency. Select those positions that are

adjacent to the previously selected plot positions. Plot positions should not be biased to the interior of the stand, or be located so as to minimize access time.

If the shape and size of the polygon will not allow the full number of plots to be established, this will be acceptable. If the situation occurs where the plots fall on a double lined road or any other mapped, non-forest type, that plot position would be unacceptable and an alternative plot position shall be chosen.

In the case of very small polygons, position the plots as per d(i). If the polygon does not contain the full complement of plots this will be acceptable. If less than three plots can be established contact the Statistical Audit Forester at Resources Inventory Branch.

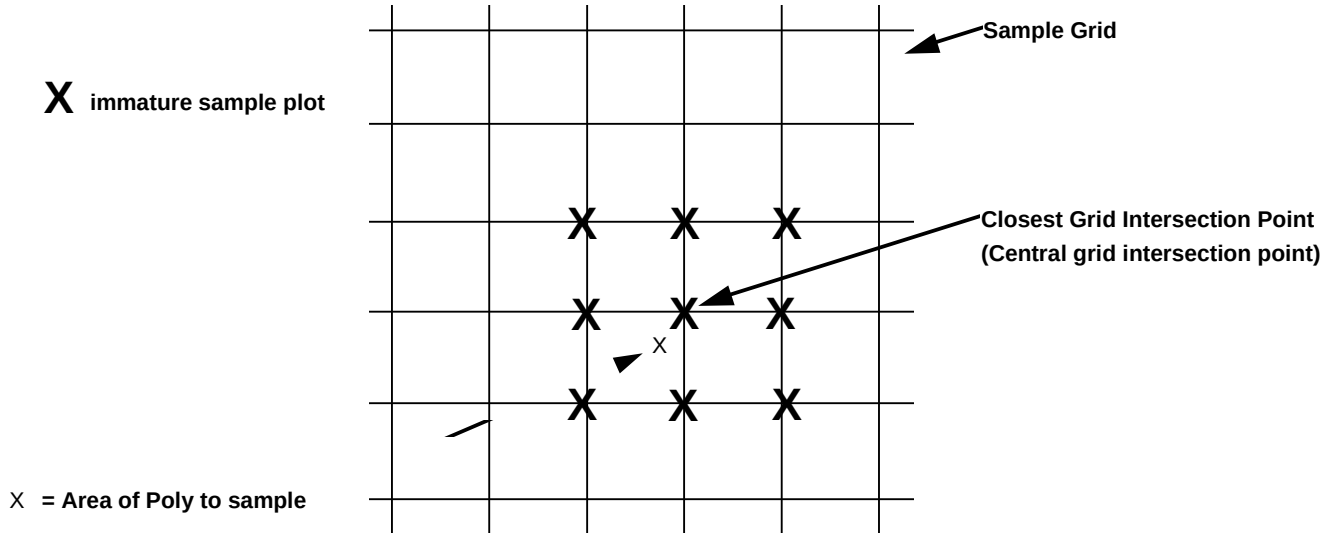

Figure 3.4.2 Immature sample grid positioning

3. **Air Photo Assessment Procedures** The following procedures shall be followed while assessing non-forested or non-productive forest types within a management unit.
   - From the 30 selected non-forested or non-productive land description types obtain the most recent large scale photos for the entire area covered by each polygon.
   - All the non-forest assessment will be completed by a certified photo-interpreter in Victoria, where he/she shall assess the classification and typing accuracy.
   - The photo interpreter shall identify those polygons that they suspect were incorrectly classified.
   - If appropriate, those polygons identified as incorrectly classified shall be assessed in the field using standard air/ground call techniques.
   - In the case of very large polygons, all photos representing the polygon must be assessed.

3.5 Contract Package Preparation

1. **Tender Viewing Requirements** In preparing a contract package for tender the following items are required:

a) Overview Map: An overview map of the management unit (1:250,000) shall be required, showing the area and all physical features. The map shall identify the location of the selected polygons. Additional backup polygons shall also be identified. Blue dots shall used to identify volume aged stands, red dots for immature stands and green dots for non-productive/non-forest types;

b) Polygon Specific Maps: A single envelope shall be created for each polygon. The envelope shall clearly identify the polygon and ideally contain the following:

i an inventory map identifying the sample location (bearings and distances);

ii 1:15,000 scale (+/-) photos with the polygon circled with blue erasable felt pen or omnichrome;

iii 1:40,000 scale (+/-) photos with the approx. location identified with blue erasable felt pen;

iv Potential primary and secondary access points (helicopter access) shall be identified on the photos in erasable felt pen;

c) Access summary: the access summary, in Table 3.5.1, is recommended for all polygons. Each package shall contain an individual access summary. A combined access summary shall be required for all polygons (Appendix 3).

- Polygons will not be accessed that are unsafe. **Under no other circumstances will a polygon be dropped from sample selection unless the polygon is clearly a safety issue.**
- If the field crew arrives on site, and determines that the polygon cannot be accessed due to unsafe conditions, it may be dropped. A short report should be prepared by the contractor stating the reason the polygon was unsafe. A systematically identified back-up polygon shall then be selected. The final audit shall contain the full compliment of polygons.

d) Safety issues: Unsafe is defined as not free from harm or risk, or the conditions of being unsafe from undergoing or causing hurt, injury, or loss. Examples are plots located on rock face, steep slopes where personal safety is in question.

Long distances to and from plots are not consider *a* safety issue unless there is unsafe physical barriers preventing field crews from reaching their objectives or navigating appropriate offsets.

In the access summary polygons that are identified as requiring very long hikes shall be clearly identified. Contractors are clearly obliged to sample these stands. Crews may be required to overnight in the case of very inaccessible samples.

MARSHALL POINT							
GPS POSITION	**MAPSHEET NO**	**POLY NO**	**ROAD ACCESS**	**DIST. KM**	**DIST. TO PLOT (R)**	**HELI ACCESS**	**DIST. TO PLOT (H)**
			2WD **4WD** **BIKE**				
Comments:							

Table 3.5.1 Access Summary Table

All distances in km

GPS POSITION	Global Positioning Coordinates (latitude and longitude).
MARSHALL POINT	Identify major marshaling point.
MAPSHEET NO	Mapsheet number.
POLY NO	Polygon or stand number.
ROAD ACCESS	Identify type of vehicle required to access road.
DISTANCE KM	Distance from Marshall point to start of proposed tie point based on type of vehicle required.
DIST. TO PLOT (R)	Distance on ground from proposed tie point to closest plot.
HELI ACCESS	Distance from Marshall point to drop off point.
DIST. TO PLOT (H)	Distance from primary heli drop off point to first plot.

e) Contract Specifications. See enclosed.

f) Minimum Mapping Requirement. The Ministry of Forests shall provide operationally scaled maps showing the exact plot positions and a suggested tie point and tie line to the plots. Contractors may change the tie point/tie line, but under no circumstances may they change the plot locations. The final map produced after the field work has been completed must show the tie point or tie line as laid out in the field. The following minimum mapping requirements shall be required for each completed polygon:

- an operational 1 : 5,000 suitably scaled map showing the cluster layout shall be required. Ideally plots should be numbered in the following manner:

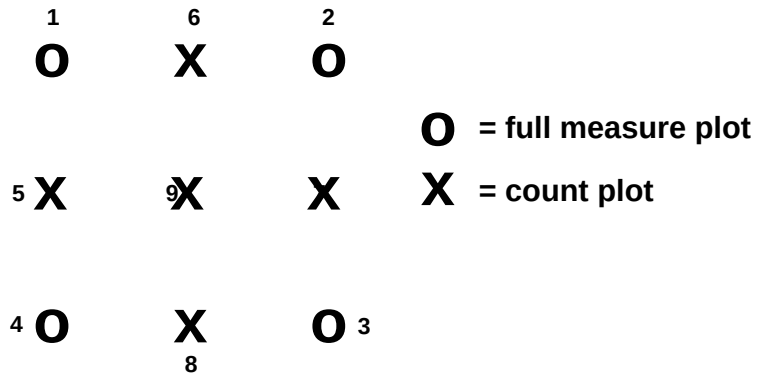

Figure 3.5.1 Plot Numbering

- the operational (1:5,000) map shall clearly show (see Appendix 4 for map sample):

a) final tie line to the cluster samples, indicating bearing and horizontal distance.

b) final road or heliport access

c) adjacent topographic features from the MOF Forest Inventory map

d) north arrow and scale

e) a header listing project title, polygon number, mapsheet number, date, field crew and legend of symbols

f) any significant physical obstructions that would make future access difficult (i.e. fallers accessing the plots for destructive sampling)

g) GPS coordinates

3.6 Helicopter Safety Policy :Deplaning from a Helicopter -Standards and Procedures

All ministry of Forests and contract staff involved in helicopter field sampling require helicopter hover exit training.

Specifically toe in or one skid landings will be allowed and will be assessed as potential access points. However, steep tallus slope type of landing spots will NOT be allowed or any other landing spot where due to steep ground there is a risk of the helicopter blades hitting the ground.

For more information on Helicopter Hover exit procedures contact the MoF Protection Branch.

3.7 Contract Viewing

Provincial and local regional contract viewing shall be conducted. For more detail see the inventory audit request for proposal documentation.

4.0 General Field Procedures

4.1 Quality Assurance Standards

Overview

Sampling Procedures and Quality Assurance (QA) Standards for Volume Age and Immature stands (age class 3 only) will comply with the current Ministry of Forests Provincial Cruising Manual (PCM), unless otherwise stated. The following summary describes or clarifies, in general terms, those standards that are in *addition or differ* from the PCM. Detailed contract QA specifications on which contracts shall be assessed for payment and post contract evaluation (see Inventory Audit Contract) are described in Appendix 5, *Inventory Audit Quality Assurance Report.*

At the start of all inventory audit contracts, the MOF contract officer will conduct a pre-work meeting with the contractor to ensure that all the contract conditions, standards and procedures are clearly understood. A proportion of sample polygons (minimum 10%) will be checked by the MoF. QA will be

assessed on a batch plot basis, with the number of plots per batch determined by the contract officer. A minimum of 2 polygons per batch will be checked.

In the *Inventory Audit Quality Assurance Report* the MoF will summarize the measurement precision. The report shall contain a summary of the measured attributes, signed check plot and original tally sheets.

a) QA Field Measurement Standards for Volume Age and Immature Stands: Overview (see appendix 5 for detailed specification)

*For immature stands (not including age class 3 volume age stands) the plot measurement standards shall conform to the Ministry of Forests, Forest Inventory Manual, Forest Classification/Sampling and Environmentally Sensitive Areas (Vol. 2), appendices (page 151)., unless otherwise noted in this document***.**

i) Distance

a) Overall strip / tie line: Bearings $\pm$ 4 degrees, Horizontal Distance $\pm$ 4 %
b) Final plot position distance (50m): Bearings $\pm$ 2 degrees, Horizontal Distance +- 2 %

ii) Species

a) Species correct 0.5% (1 tree in 200)

ii) Stem Count

a) Allow 1 missed stem in 50. (i.e. 1/50=2.0%)

Note: The stem count is only applicable to mature volume/age component and volume/age for age class 3 (41-60 years) for immature component.

v) Height Samples

a) Measured allowance $\pm$ 5% *(90%)*
b) Estimated allowance $\pm$10 % *(75%)*
c) Height Variation (difference) 3 %
d) Top Height: correct assessment

v) Diameters

a) plus or minus ($\pm$) 2%

vi) Pathological Indicators

a) Percentage with RG change (maximum allowance 5%)

vii) Ages

a) volume age $\pm$ 10%
b) immature $\pm$ 2%

b) QA Office Measurement Standards for Volume Age and Immature Stands: Overview (see appendix 5 for detailed specification)

i) Plot Sheets

a) all fields completed
b) correct coding
c) legible
d) signed
e) compass notes clear and legible

ii) Sample Location Maps

a) all plots/tie lines/physical features identified
b) GPS tie point and plot location identified.

iii) Photographs

a) all original photos returned
b) tie points pinpricked and described
c) suitable tie point selected

iv) Top Height Summary Form

v) Internal Quality Assurance Report

vi) Dropped Plot Summary

***vii)* GPS (if required)**

a) non-corrected digital data provided
b) GPS data summary (separate summary card and comments on tally sheet)
c) GPS used to validate sample plot

Note: Correct GPS data may be used as a quality assurance mechanism to ensure that the gross errors in plot locations (plot in wrong polygons) do not occur.

c) QA Standards for Non-productive / Non-forest classification Assessment

Plot measurement attributes shall conform to the Ministry of Forests, Forest Inventory Manual. Forest Classification / Sampling and Environmentally Sensitive Areas (Vol. 2), section: appendices pg. 151.

4.2 Data Collection/Summarization

1) Internal Quality Assurance Requirements

With the submission of each batch of samples for MoF approval, the contractor shall also provide verification that a minimum of 10% of all batch samples were checked for internal quality control. The following minimum documentation is required:

i) a minimum of 5 plots per sample must have all attributes checked and recorded on tally cards
ii) check tally cards must be completed and signed by check cruiser (identified in the RFP)
iii) original check plot cards and photocopies of original plot cards must be submitted
iv) a check cruise summary report (appendix 5) must be completed and signed

2) Volume Age Stands

a) MOF FS 205 Plot Cards

The Ministry of Forest FS 205 Cruise Tally Card or similarly formatted plot sheet should be used to collect cruise data. Contractors wishing to use their own tally sheets must confirm the format with the contract officer.

See Appendix 6 for examples of completed FS 205 tally sheets. *A plot card shall be completed for every plot regardless if the plot was not established (ex. in the case of unsafe plots).*

b) Polygon Top Height/Age Summary

A top height/age summary shall be required for each polygon (see section 5.2 (7) for details). *Top height / age trees shall be clearly identified by an* ******* *beside the tree number on the plot cards.*

The following Polygon Top Height/Age Summary is required for volume age samples. The data should be presented in this format as a separate form (Appendix 7).

Contract ID_____Mapsheet Number_____ Polygon Number_____

Biogeoclimatic Zone_____Subzone_____

FIZ _____ Region_____ Compartment_____

Species_____

Plot No____Tree #_____	Top Height	_____	BHage	____	Total Age	___
Plot No____Tree #_____	Top Height	_____	BHage	____	Total Age	___
Plot No____Tree #_____	Top Height	_____	BHage	____	Total Age	___
Plot No____Tree #_____	Top Height	_____	BHage	____	Total Age	___
	Average	_____		____		___

Age correction must be determined using the site curves represented in the Inventory Field book, Classification and Sampling, 1992.

3) Immature Stands

The intent of the immature sampling component of the audit program is to assess:

i) the species composition accuracy assignment for the sample polygon. The species composition for age class 1 and 2 stands will be determined by stem count and average mean height as per the FS 806 Forest Classification Ground Call Short Form. Species composition for age class 3 stands will be determined on basal area (prism stem count) The field data is collected on a per plot basis on an FS 205 and summarized on a FS 806 Forest Classification Ground Call Short Form. Sampling specifications shall conform to the Ministry of Forests, Forest Inventory Manual, Forest Classification/Sampling and Environmentally Sensitive Areas (Vol. 2), section : Forest Sampling page 31, Table 7, "Sample Specifications by Stand Structure". Examples of completed tally sheets and table 7 are included in the Appendix 8. Species composition analysis will focus on comparing the map label to ground growth type group accuracy.

It should be noted that the existing inventory manual specifications regarding immature sampling implies minimum dbh sampling levels of 7.5 cm dbh and 0.3 m in height. In order to accommodate stand conditions where these minimum tagging levels would result in either unacceptably high or low stem counts, or provide information that would identify an unacceptable top height species, alternate minimum tagging limits are to be used. The acceptable minimum tagging limits are, in order of preferred selection, 7.5, 4.0, 2.0 and 0.0 cm dbh and 0.3 m in height. It should be stressed that the tagging limit and plot size shall be maintained consistently for all plots within the cluster.

It should also be noted that for the purposes of determining species percent composition on the FS 806 that **average mean height** is defined as the arithmetic average height of all dominant and co-dominant trees of a particular species.

Due to the variable nature of immature stand assessment the final format for the data collection should be reviewed by the contract officer [See Appendix 8 for examples of a completed FS 806 summary card.].

ii) the site index accuracy of the map label versus the ground sample. Site index for the polygon is derived by measuring the top height and age of the leading species for the nine sample plots. **If the ground leading species composition is different than the leading species on the map label**, site index information is to be collected for the map leading species as well. The polygon average site index is the arithmetic mean of the individual plot site index estimates. There are two methods to assess site index in immature stands used in the audit program:

Polygon Top Height/Age/Site index Summary

a) *Site index curve method* where site index is predicted from height and age of sample trees that are over 30 years of age. If this method was used to determine site index the field crew will only record the relevant age and height information for each plot, in the following format

Contract ID___________Mapsheet Number________ Polygon Number__________

Biogeoclimatic Zone_________________________Subzone____________________

FIZ ________ REGION____________ Compartment________________

Species__________

Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
Plot No____Tree #_______	Top Height	_______	BHage	____	Total Age	___
	Average	_______		____		___

b) *Growth intercept method* where site index is predicted from height and age sample trees that are 3-30 years old. If this method was used to determine site index the field crew will complete the following form.

Contract ID___________Mapsheet Number________ Polygon Number__________

Biogeoclimatic Zone_________________________Subzone____________________

FIZ ________ REGION____________ Compartment________________

Species__________
Plot No____Tree #_______Top Height_______BHage____Total Age ___Site Index______
Plot No____Tree #_______Top Height_______BHage____Total Age ___Site Index______
Plot No____Tree #_______Top Height_______BHage____Total Age ___Site Index______
Plot No____Tree #_______Top Height_______BHage____Total Age ___Site Index______
Plot No____Tree #_______Top Height_______BHage____Total Age ___Site Index______
Plot No____Tree #_______Top Height_______BHage____Total Age ___Site Index______
Plot No____Tree #_______Top Height_______BHage____Total Age ___Site Index______

Plot No____Tree #_____Top Height_____BHage____Total Age ___Site Index_____
Plot No____Tree #_____Top Height_____BHage____Total Age ___Site Index_____

Average _____ ____ ___ _____

Note that for inventory audit purposes stand stratification is not required when using growth intercept or site curve site index sampling procedures.

For more detail on the specific site index measurement procedures refer to " How to Determine Site Index in the Inventory Audit Program, appendix 13.

4. Non Productive/Non-forested Stands

Classification accuracy is summarized in accordance with the *Forest Inventory Manual, Forest Classification /Sampling and environmentally Sensitive Areas* (Volume 2), Appendix, pg. 157.

5. Data Collection Standards for non-conventional plot situations

The inventory audit program recognizes various plot establishment situations that vary from the conventional cruising standard. The following section describes these situations and the procedures required to complete the sampling in these situations. If the field crew is uncertain about the correct plot status, a clear description will assist in making a final decision.

Note, that for all non-conventional situations *a plot card will be established for each plot*, which will include:

- in the notes section of the plot card a clear written description of the situation (e.g. plot center established 2m NE of spur road 9G center line. No trees tallied)
- on the face of the plot sheet a clear diagram detailing the situation (see Appendix 9 for examples)
- compass notes will also detail the situation

The following section describes the types of recognized non-conventional plots and the appropriate coding. (for examples, see Appendix 10):

a) Void plots that land on roads: "VOID PLOT ROAD"

In the establishment of a plot landing on or near a road or right of way, that would not allow the establishment of a full *border* plot the field crew will clearly write across the face of the plot sheet **"VOID PLOT ROAD"**. The field crew should attempt to describe in detail the type of road encountered. (e.g. secondary access road, road right of way etc.) and clearly indicate the bearing and distance from the plot center to the center line of the road. They should also note the bearing of the road, the road width and the road right of way width. A small sketch map should also be included. (See appendix 11) If required this coding will allow recompilation of the plots.

b) Plots that could not be established due to safety concerns: "VOID PLOT SAFETY"

In the situation where a plot could not be established due to a safety hazard (e.g. steep cliffs or slide tracks etc.) the field crew should clearly write across the face of the plot sheet **"VOID PLOT SAFETY"**. The field crew should describe in the notes section of the plot sheet why the establishment of the plot would be considered unsafe. Field crews must always attempt to establish the plots.

c) Plots that land in recently logged areas: "VOID PLOT LOGGED"

In the situation where a plot landed in a recently logged area and no live trees were tallied the field crew should clearly write across the face of the plot sheet **"VOID PLOT LOGGED"**. Note that for areas that were selectively logged and no trees were tallied a comment in the notes section should describe the type of logging.

d) Plots that fall outside the polygon: "VOID PLOT OUT OF POLYGON"

In the situation where a plot lands clearly outside the polygon, the field crew should write across the face of the plot sheet **"VOID PLOT OUT OF POLYGON"**. A complete plot must be established with all the pertinent tree measurements taken, even though this is a void plot.

Collecting plot data will allow multiple plot compilations to be performed on the sample. The full measure/count plot status should NOT be changed if the plot appears out of the polygon.

A plot may land outside the polygon by an error in the type line position on the map or an error by the field crew in locating the plot. An error in the type line location does not invalidate the plot, it means that the field crew should indicate that the plot does not represent the sample type. Recording out of polygon data will allow an assessment of the audit volume differences due to type line/stratification errors. All plots that the field crew suspect land outside the polygon should have tie points and chainages verified by the crew. The field crew should indicate in the compass notes the position of the plot to the expected type line and any reasons they feel could explain why the plot fell out of the polygon. Additional photo ties to mapped physical features will assist field verification of the plot location. GPS data may confirm the true plot position during the office mapping process.

e) Plots that land in openings: "ZERO TREE PLOT - OPENING"

In the situation where a plot landed in a non-mapped opening (brush area, natural opening, rock opening, seismic line, etc.) and no live trees are tallied in the prism sweep, the field crew should clearly write across the face of the plot sheet **"ZERO TREE PLOT - OPENING"** and clearly describe the type of opening. If one or more acceptable trees are encountered in the prism sweep, a complete plot is to be established with all of the appropriate measurements taken.

6. Data Collection Standards for Border Plots

If the plot falls directly on a polygon boundary, borders an inaccessible rock face, or borders a double-lined road, etc., then the plot will be split into a border plot. The following procedures shall be applied (Appendix 11):

- In all cases where plots fall in, or near, or overlap non-timbered, *non-mapped* types (e.g., *non-mapped* swamps, slides, scrub etc.) full sweep plots will be established. This will incorporate proper representation in the overall compilation for non-mapped, non-timbered openings.
- Where plots fall in, or near, or overlap *mapped* polygons,(and where a distinct type line is apparent) that are not the selected type establish a full plot, but mark on the tally card the appropriate one-*border* plot split so each one-*border* can be compiled separately if needed. Also measure and record the distance from the plot center to the type edge. Split the plot in halves parallel to the type line break. Record the split direction.
- Border plots will not be allowed for any other circumstance, other than physical obstacles/safety or mapped type boundaries. *Half* plots are not allowed for excessive tree count.
- Plots influenced by major roads (a major road is defined as a double lined mapped road whose area would deleted from the operable polygon area) or mapped swamps or cutblock boundaries shall have a border plot established. The distance of influence would be determined by the critical distance of the largest diameter tree.
- Record the split direction in the notes and sample the entire polygon, clearly indicating the trees represented in each half. Half plots are allowed for both full measure and count plots. Note: do not create 2 plot sheets for each half plot, please record both split plots on one plot sheet and **clearly indicate which half represents the sample type** (Appendix 11 for examples).

- Plots that fall adjacent to a severe or inaccessible (unsafe) physical obstruction shall have a border (half) plot or an estimated full plot established. If the field crew determine they can accurately estimate the measurement attributes for inaccessible unsafe trees within the normal full measure plot they may record these estimated attributes and clearly indicate on the plot sheet that the data was estimated. If however, the field crew does not feel that they can accurately estimate these attributes, they should establish a normal border (half) plot. As in all border (half) plot situations a clear diagram should be completed detailing the situation.

7. Plot Movement / Plot Status Changes

Plot positions will not be moved for any reason. Plot status (Count or Full Measure) will not be changed for any reason. Previous inventory audit sampling procedures indicated that plot status could be changed. Due to "potential" biases in this procedure, plot status (full measure/count) changes shall not be allowed. The type of plot (full measure/count) will be established exactly as indicated on the plot position map.

Full measure plots that fall on a double lined road or that have clearly fallen outside the polygon boundary or were not established due to safety concerns, will have a plot sheet recorded indicating the reason for the void plot, however all plot data will still be collected *(except in the case of safety).* Plots that fall on unmarked abandoned roads or trails or non-double lined mapped roads shall not be moved and a full plot shall be recorded.

8. Enhanced Count Plots Standards

If a count plot contains a new species not already tallied in a measure plot, then ensure that the first tree of the new species has the following information collected: height (estimated), diameter (measured), path and tree class. The plot also requires the appropriate age in tens. The enhanced tree is chosen by selecting the first enhanced species encountered in a clockwise prism sweep direction starting from north. Only select one enhanced tree *per* species per polygon. If a full measure plot is established which later contains the enhanced species, field crews should carefully cross out the additional enhanced count plot data. (height and path)

Tree class 3 dead potential are also considered enhanced species and should be tallied as any other tree class 1 and 2 (Appendix 6).

4.3 Plot Location

The following procedures shall be followed while locating ground samples:

- Plot center stakes shall be located exactly where they fall and shall not be moved to a nearby sapling. Aluminum stakes, supplied by the MoF will be used in all full measure plots. Wooden stakes 1.3 m in height will used for all count plots and for *all (age class 3 volume)* immature plots. All plot centre stakes will be well flagged.
- If a stake cannot be located, a painted rock cairn will be adequate.
- **The plots will be established at the point of location and will not be moved for any reason to accommodate type boundaries, or any other circumstance.**

- A description of the encountered type will be recorded in the notes/tally sheets in such a manner as to indicate which type the plot represents.

4.4 Field Tie Point Establishment

The selection of a well defined tie point is a critical component of the field data collection process. The ideal tie point will be readily identifiable on the ground/photo and map. If crews establish questionable tie points the location of all subsequent plots (and especially border plots) will be in doubt. Field crews must attempt to locate tie points at well defined swamps/lakes/rivers etc. even if that location requires a longer tie line. Type boundaries and roads are generally poor tie points due to the uncertainties in mapping accuracy and the ability of field crews to accurately identify their position on the map/photo. (If required, GPS data would be collected at this point)

After selection of a re-locatable, suitable tie point, the following procedure shall be followed for tie point marking:

- Select a tree of suitable size and stature that the stem will be present for a number of years (i.e., not on edge of roadside where it will be subject to removal during road maintenance etc.).
- Blaze the tree (optional) near breast height using bark blazes where possible.
- Delimb the circumference of the tree to a height of approximately five to six feet.
- On small trees discretion will be required so as to not damage the stem for future growth.
- Limb the branches flush with the main tree stem without damaging the bark.
- Tie Arctic grade ribbons around the tie tree near dbh height. Paint the tree with tree marking paint.
- Scribe an aluminum tag and securely nail to the base of the blazed tree (this tag should be secured with aluminum nails at a point below potential power saw felling height). In very young stands use 3" aluminum nails, with the tag offset from the trunk to allow for growth.
- Ribboning to be coordinated with land owner or licensee.

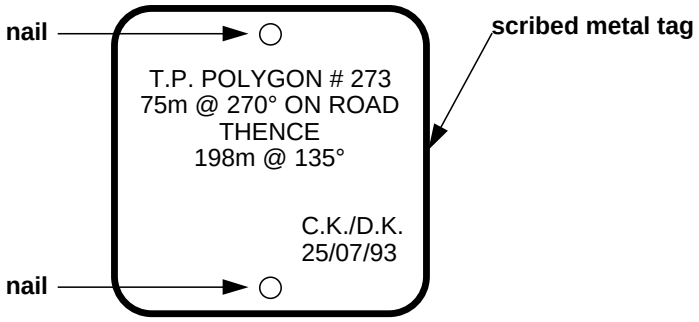

Figure 4.4.1 Tie Point Tree Tag

4.5 Photo Tie Point Establishment

Photos shall be marked in the following method:

- locate appropriate tie point visible on the field photo and an appropriate base map
- pin prick field photo
- record tie point location on the back of the photo with the following information:
- *samples that do not contain this information will NOT be accepted for payment.*

T.P. Inventory Audit 94
to poly# 273
75 m @ 270 deg on road
thence 198 m @ 135 deg

Figure 4.5.1 Photo Marking For Tie Point's

4.6 GPS

GPS is a satellite based system that provides continuous, accurate and instantaneous position to the user. The audit program has adopted the Vegetation Resources Inventory GPS standards for GPS data collection. Vegetation Inventory guidelines specify data collection procedures for NAD 83 referenced x,y,z coordinates collected at tie points and sample plots. Data is collected by a GPS field receiver and corrected against reference data validated by the Geographic Data BC, Ministry of Environment, Lands and Parks (MELP). The contractor shall collect the data with the MOF (Resources Inventory Branch) performing the differential correction and mapping processes.

The following is a brief overview of the general contract requirements, sampling methodology, standards and procedures that will be used to collect GPS data. For a more detailed description see appendix 15.

- Contractors are required to rent or purchase a suitable GPS receiver(s) that provides data consistent with this document (see appendix 15 for GPS hardware/software requirements).
- Regions when creating the field sampling packages, are to ensure that extra 1:20,000 scale maps are produced, along with plot position maps. This is to be supplied to the GPS data correction contractor.
- Field contractors must supply digital data and final plot position maps directly to the GPS correction contractor in an expedient manner**.**
- GPS receivers should be capable of tracking at least 6 satellites (with parallel tracking channels). Accuracy of corrected positions on static points should be less than 10 meters 95% of the time.

- GPS data will be collected on the sample tie point and at least one other plot for all volume age and immature samples. If possible a double reading is required on at least one of these points.
- Receiver data collection parameters must be used as outlined in appendix 15.
- GPS data will also be referenced on tally cards and compass notes.
- GPS data will provided to the Regional contract officer on a 3.5 inch disk with the submission of each batch of plots for approval. In order to ensure data integrity, contractors should daily download the GPS data on to a laptop PC.
- It is recognized that GPS data may not be collected for all polygons. This should be a rare occurrence. Difficulties in collecting this information should be forwarded to the contract officer. If data is not collected for reasons such as signal unavailability the contractor is not obliged to return to the site and collect the data.
- GPS data will not be used to determine plot positional accuracy for quality assurance purposes. If GPS data indicates that minor plot positional errors occurred due to tie point establishment or mapping inaccuracy, contractors will not be required to reposition the plots.
- *Field crews should record the helicopter landing spot GPS coordinates, if different from the tie point.*
- MOF Regional staff will provide field training in the collection of the data at the start of the contract, while Resources Inventory staff will provide continuous on-line technical assistance.

4.7 Field Tie Line

All strip lines shall be clearly marked in the field using suitable Arctic grade ribbon. As these samples may be used for volume and decay sampling studies these tie lines should allow a falling crew to locate the plot at a later date. Check with the contract administrator to ensure the ribbon colour will not conflict with other operational initiatives.

- The tie line must be measured with the use of a nylon chain (tight-chained). **String machines *must* not be used.**
- Distance to be measured to the nearest meter.
- The tie line must be ribboned with Arctic grade ribbon so the ribbon is visible from one point to the next,
- Offsets should be used to avoid unsafe or difficult situations.

4.8 Compass Cards or Field Notes

A detailed **neatly** written compass card shall be kept to record the following (Appendix 9):

- distances and bearings;
- tie point tree measurements: species, diameter and any distinguishing features;
- tie point locations and plot locations;
- make notes as to creeks, rock bluffs, windfall and other planimetric detail;

- date, crew, weather etc.;
- comments: if the plot data appears to indicate that the old forest inventory label was severely inaccurate, if appropriate, ensure that comments are recorded that may indicate "why" the area was misclassified.
- GPS offset information.
- See appendix 9 for the minimum standards for compass notes.

4.9 Plot Establishment

These samples are to be located in such a fashion that will allow re-location in the future at periods up to and exceeding 5 years. These samples shall be used for volume and decay sampling and other inventory/research purposes.

1. **Plot Center Stake** A ribboned aluminum 3 ft. stake, supplied by the Ministry of Forests, shall be established at all full measure plots. A ribboned wooden plot center stake shall be established for all count plots and for all *(age class 3)* immature plots. The count plot stake shall be at least 1.3 m tall and of sufficient quality to remain standing for several years and be used as an accurate assessment of borderline trees. Immature sampling will require a wooden stake of 1.3 m tall, clearly ribboned, indicating plot number, chainage, strip number. The plot center stake shall not be moved to a nearby sapling but shall be established exactly where it fell for both volume age and immature samples.

2. **Reference Tree** A reference tree shall be established so as to relocate the plot center for volume age sampling. The following procedures shall be followed:
   - Reference trees **are** required for count and full measure plots, however are **NOT** required for immature plots (except for immature age class 3).
   - Choose a reference tree within a short distance of the plot center.
   - Establish this reference tree in the following manner:
     - blaze the tree on four sides (optional) near breast height using bark blazes where possible, or narrow blazes to minimize damage to the cambial layer; (confirm blazing with landowner or licensee)
     - place several ribbons above and below the blazes;
     - paint the blazes with log marking paint;
     - place a metal tag near the base of the tree with the distance and bearing to the center stake measured from the tree to the stake. Record the bearing and distance from the reference tree to the center stake on the appropriate plot card.

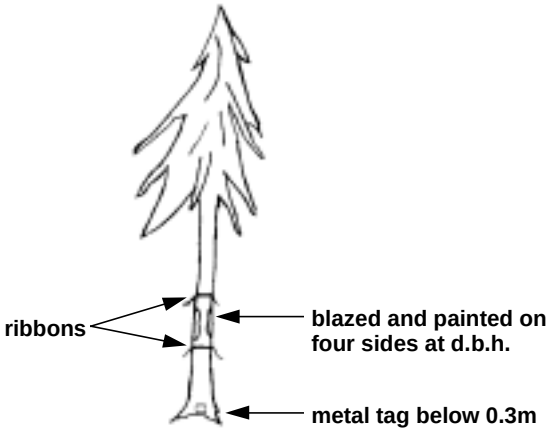

Figure 4.8.1 Reference Tree Marking

5.0 Plot Measurements

Unless otherwise stated, measurements shall conform to the **Current** MOF *Cruising Manual.*

5.1 Plot Types

The following plot types shall be used:

- Full measure variable radius plot
- *Border* plots (variable radius)
- Count plot (variable radius)
- Enhanced Count plot (variable radius)
- Fixed Area (top height and immature)

5.2 Attributes Measured For Volume Age and Immature Plots

Plot Tally Cards:

- Use MOF FS 205 field sheets or similar sheet
- **All data shall be neatly recorded.**
- All calculations (heights) **shall** be completed in the field. Immature data will be compiled in the office. If electronic height measurement devices were used, record the type of device used, e.g. “vertex”

1. Tree Count

i) Variable Radius:

The selection of BAF and the tree count has been designed to increase accuracy by reducing the radius of the variable radius plot thereby reducing the incidence of "missed" trees.

- With a suitable BAF prism or relascope determine the trees "**in"** and "**out"** similar to appraisal cruising procedures.
- Selection of BAF:

- The desired tree count is 4 to 8 **live or dead potential** trees per full measure variable radius plot on average. Dead useless, *live useless* and dead potential shall also be sampled as per cruising standards.
- Once a BAF is selected it will be maintained throughout the grid cluster. Multiple prism sizes are not allowed in the final plot tally.
- If several BAF sweeps were performed in order to determine the optimum BAF ensure that the plot card correctly identifies the correct BAF.
- Dead useless (tree class 4) and live useless (tree class 6) trees may have the diameter and borderline status estimated.
- All borderline trees shall be measured using a steel or cloth tape corrected for slope.
- The appropriate factors will be used in determining which trees are **"in or out"**.
- The horizontal distance from plot center to the center of the tree and the % slope shall be recorded on the field sheet for all borderline trees on both count and full measure plots.

ii) Count Plots The following conditions shall be followed regarding count plots:

- All count plots will indicate genus and species.
- It is recommended that trees will be recorded in 5 cm dbh classes as per the *Inventory Branch Field Pocket Manual* Table 7a (Calculations and Tables), with due care taken on the 12.5, 17.5, 22.5 and 27.5 cm dbh classes. The class name shall be the midpoint of the dbh range, for example dbh class 20 will have range of 17.5 to 22.49 cm, the next dbh class will be 25 with a range of 22.5 to 27.49, and so on. Actual measurements are also acceptable.
- All trees bordering 12.5, 17.5, 22.5 and 27.5 cm utilization dbh classes should be checked to ensure they are in the correct class. Errors in dbh class assignment outside of the given utilization levels are not checkable items. Actual measured diameters are acceptable. All borderline trees should be measured.
- **All trees will have tree class recorded as per the standard 9 tree class codes. However for count plots only tree class codes 3,5,7 and 9 are checkable items.**
- **All veteran (TC 5), dead potential (TC 3) and immature trees in a mature stand (TC 8) will be identified on the plot sheets to ensure correct compilation (See 5.2 (14)).**
- Tree class 1 and 2 are not checkable items.

iii) Enhanced Count Plots

- If a count plot contains a species not already tallied in a measure plot, then ensure that the first tree encountered, (in a north-east prism sweep from plot center) of that new species, has data collected to the same level as a full measure plot (i.e. tree number, species, actual dbh, estimated or measured height, path, tree class and age in tens). Tree classes 3,7,9 are also considered enhanced species and should be tallied as any other tree class 1 and 2.

iv) Fixed Area

a) Immature
   - Fixed area plots will only be used for immature stand sampling in age class 1 and 2.

Note : Age class 3 stands will use variable radius plots with procedures consistent with the volume age component. In the event that the conditions in an age 3 stand will not provide a reliable stem count (in terms of the number of stems, utilization level and the reliability of the count) a fixed area plot can be established with standards consistent with age class 1 and 2. Volume will not be compiled for these samples.

- Data is collected on a per plot basis on an FS 205 and summarized on a FS 806 Forest Classification Ground Call Short Form.

- It should be noted that the existing inventory manual specifications regarding immature sampling implies minimum dbh sampling levels of 7.5 cm dbh and 0.3 m in height. In order to accommodate stand conditions where these minimum tagging levels would result in either unacceptably high or low stem counts, or provide information that would identify an unacceptable top height species, alternate minimum tagging limits are to be used. The acceptable minimum tagging limits are, in order of preferred selection, 7.5, 4.0, 2.0 and 0.0 cm dbh and 0.3 m in height. It should be stressed that the tagging limit and plot size shall be maintained consistently for all plots within the cluster.

2. Tree Numbering Trees are to be marked in such a manner as to be easily relocated; therefore care is required in tree numbering. The following conditions shall be applied:

- When ever possible tree numbering will be initiated due North from the plot center for all trees in the full measure plot and progress in a clockwise direction. For enhanced count plots with multiple enhanced species the tree numbering pattern is critical, as the first encountered enhanced species is to be selected.
- Whenever possible, count plots will have **in** trees marked with a painted dot or tree number facing plot center.
- All measured **out** trees in both full measure and count plots with be clearly marked with an X.

3. Tree Species Tree species shall be identified as per the **Current** MOF *Cruising Manual*.

4. Diameter Breast Height The following standards shall apply when establishing and recording dbh:

- A line to indicate where diameter breast height was measured should be painted facing plot center.
- All dbhs will be measured from the high side of the tree at 1.30 meters to the nearest 0.1 cm.
- DBH **will** be measured using a marked DBH pole if accuracy is not maintained without it's usage.
- The minimum dbh will be 12.5 for the interior and 17.5 cm for the coast for variable radius plots.

5. Tree Heights

i) Top Height: Top height trees shall be selected using the following procedures for both volume age and immature stands, unless otherwise noted.

- At the center position, establish a fixed area subplot of **0.010 ha (5.64 m radius).** For borderline trees assess the borderline status at dbh and not the point of germination.
  - Select the largest *suitable* diameter tree of the *leading species* determined by the specified utilization for the *entire* polygon). Note that tree class 4 and *6* do not contribute to species composition. Measure the height and breast height age. Suitable trees are:
    - largest diameter tree,
    - dominant or co-dominant,
    - not suppressed,
    - not a veteran tree,
    - leading species,
    - free of major forks or crooks,
    - trees must be alive,
    - dead tops are acceptable, in only exceptional circumstances (e.g., coastal mature cedar stands).
  - If the leading species cannot be accurately assessed it may be necessary to collect top height data on several species in order to ensure that at the end of the cruise the correct species was selected for top height.
  - Top height trees will have measured heights only.
  - On the plot cards clearly indicate with a * the top height tree(s).
  - If the top height tree is not included in the tree count for the plot, but is within the 0.010 ha plot, then record the measured tree height and age and number the tree # 99 on the tally card.
  - Final polygon summaries shall require an average top height/age summary (see Data Collection/Summarization, 4.2 (b)).

a) Volume Age :

- Four (4) top height trees (and ages) will be collected in *each polygon*. If a full measure plot does not contain a suitable top height tree, a top height tree should be selected from the next encountered count plot. All top height summaries should contain 4 top height trees. A top height sample of less than 4 trees is also acceptable.
- Leading species is based on (basal area) stem count of all count and full measure plots.

b) Immature:

- Nine (9) top height trees (and ages) will be collected in each *polygon*. Age class 3 stands will also require 9 top height trees. Crews should attempt to collect the full number of top height trees, however if suitable trees are not present a lesser tree count is also acceptable.
- Top height trees (and ages) are required for the ground leading species *and* the label leading species, if they are different.

- Leading species is based on percent leading species determined from the FS806 for age class 1 and 2 stands and (basal area) stem count of all count and full measure plots in age class 3 stands.

ii) Additional Heights All full measure plots must contain a minimum of two trees measured for height (top height and one other reference tree). All other trees will have heights estimated in the field.

- Indicate in the tree height data section of the plot cards if a laser or sonar based height measurement device was used.
- ***In the case of trees with broken and missing tops (tree class 2 and 3), estimate the height to the original top. Note that for tree class 4 dead useless trees height is estimated to the existing top.***
- Paint an S on those trees measured for height in the direction in which the height is measured. (Immature age class 3 only)
- **Ensure that all tree class 3,7 and 9 dead potential trees in full measure plots have a height recorded.**

c) Multi-layered Stands In order to accurately assess top height in multi-layered stands, where the second layer is rank 1, top height data will be collected for both layers. The procedure will involve collecting the primary top height data as per normal convention; in the second layer, the top height tree will be selected on the largest suitable diameter tree in the layer 2 stand component. Record the age of both top height trees.

6. Quality/Grading Remarks Quality remarks shall not be recorded.

7. Age Measurement The following procedures shall be applied when determining polygon age:

- Age measurements shall be taken on top height trees.
- Potential veteran and immature trees **must** have their age verified. This is critical as veteran trees shall not be compiled in the standard polygon volume summary.
- On large trees or trees that have a rotten center count the age of the sound portion and measure the length of core and calculate the average number of years per centimeter. Apply this average growth per centimeter to the remaining uncounted portion. Be careful to only consider inside bark diameter. Record on the field sheet the dimensions measured. That is:

  Tree #5 190 years in 26 cm and total age 320 years

  If the growth rings are not uniform, the cruiser can make the best estimate, if the whorls of growth are evident count these and record as the correction for total age.

  On the field sheet, record:

  - counted age
  - length of counted core

- estimated length from the end of the sound wood portion to the estimated center of the tree.

Physiological age: (Immature Samples only age class 1,2 3 only) If a sample tree measurement was suppressed in its early years, the non suppressed (physiological) age is to be recorded for that tree. The non suppressed age can be determined as follows:

- Calculate the rings per cm of the non suppressed growth.
- Apply the rings per cm of the non suppressed to the suppressed portion and calculate the age.

Field crews should be looking for suppressed tree growth and should indicate potential suppression on the field cards. The issue of suppression is critical in the determination of site index in young stands (B/Hw especially.). If the crew is uncertain on the issue of suppression pls return age cores to the contract officer for verification. **Field crews must clearly indicate in the top height summary if physiological ages were recorded.**

8. **Ecological Data** Ecological data will be collected for each polygon so as to summarize the Biogeoclimatic zone and subzone. This data would be taken from a Biogeoclimatic map or appropriate inventory planning file (FIP) and recorded in the polygon top height/age summary.

9. **Ground Slope** Record ground slope as per the current Ministry of Forests Cruising standards.

10. **Age in Tens** Age in tens is assessed on a plot basis. Age in tens shall be assessed as the total age of the plot in tens, determined by the top height tree age of the rank 1 layer. Age in tens is required for all full measure and enhanced count plots. If the crew is uncertain about the age, a suitable tree should be bored for age.

Plot cards will not be accepted that do not contain an appropriate age in tens value.

11. **Tree Veterans** Ensure that all veteran trees, and immature trees in a mature stand (tree class 8), are carefully assessed in the field. If there is any doubt as to the correct tree class, ensure that an age is taken on questionable trees.

12. **Tree Class**

- In all cases, the valuation definition of tree class (1 to 9) shall appear in column 36 of the cruise tally card for all full measure and count plots. Note that for count plots tree class 1,2 6, and are not checkable items.
- Tree class 6 live useless should be assessed as per current valuation cruising standards. i.e. considered the same as tree class 4 and not included in count plots.
- Current cruising standards state that trees that have **recently** died or are blow-down (contain red or green needles) should be assessed as tree class 1 or 2.
- Pathological indicators shall be collected as per current MOF cruising standards.

- Pathological indicators are not required for tree class 3 dead potential, tree class 4 dead useless trees, *tree class 7 veteran dead potential, or tree class 9 immature dead potential.*
- Note that tree class 3 and 4 misidentification is considered a missed or added tree, and that tree class 1 or 2 called tree class 3 or 4 is also considered a missed or added tree.

13. Damage codes: All damage code (insect/disease/fire) data must be collected. *Blowdown codes are not required for coastal audits.*

14. Access Notes

Access notes are to be completed for all ground access polygons in a format similar to that used by Growth and Yield program. The final format used by the contractor must be approved by the Ministry of Forests before the field work is started.

15. Minimum Mapping Requirements

The Ministry of Forests shall provide operationally scaled maps showing the exact plot positions and a suggested tie point and tie line to the plots. Contractors may change the tie point/tie line, but under **no circumstances may they change the plot locations.** The final map produced after the field work has been completed must show the tie point/tie line as laid out in the field.

The following minimum mapping requirements shall be required for each completed polygon. Contractors shall provide the following:

a) Overview Map:
An overview map (1:250,000±) shall be required showing the final location of all sampled polygons. The base map shall be provided by the Ministry of Forests.

b) Polygon Specific Maps:
A single (11 by 14 in) envelope shall contain a polygon specific map, suitably scaled (1:10,000±), showing all tie line, strip lines and plot positions as located in the field. Original base maps for these areas shall be supplied by the MOF (Appendix 4).

c) GPS Map
A 1:20,000 scale map is required showing the location of the GPS tie point and plot position.

Glossary

accuracy: A measure of the closeness of an estimate to the true value.

annual allowable cut: The rate of timber harvesting specified for an area of land.

bias: The quality of a measurement device or procedures that tends to result in a misrepresentation of what is being measured in a particular direction.

diameter at breast height (dbh): The stem diameter (out-side-bark) of a tree measured at breast height to the nearest millimeter.

fir: Forest Inventory Reporting System software which generates various reports describing the various levels of forest management units.

fip file: The Forest Inventory Planning file, contains attribute information on the forest cover. It also contains history data and resultant statistical information. A FIP file exists for every digital design file.

free growing (crop): A crop of healthy trees, the growth of which is not impeded by competition from plants, shrubs or other trees.

growth type groups (GTG): A designation of species composition as one of 17 growth types (A to Q).

non-forest land: Land not primarily intended for growing, or supporting, forest. Includes alpine, rock, slide, non-productive burn, non-productive brush, swamp or muskeg, cultivated, cleared, urban, open range, wild hay meadow, and other categories of non-forest land such as clay bank and gravel bar.

non-sufficiently restocked (NSR): Understocked. In yield determination, NSR is excluded because the area out of production in any one year is considered to be constant.

pre-inventory analyses: Pre-inventory analyses are inventory activities to evaluate the existing forest inventory as the basis for deciding whether to re-inventory or update the current inventory, and to document the existing inventory, maps and photos to support the execution of the re-inventory or update if required.

sampling: The process of selecting observations.

site index: A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.

timber supply analysis: The technical process of amalgamating land management information into computer systems that predict the amount of timber available for harvest over given time periods.

timber supply areas (TSA): An integrated resource management unit established in accordance with section 6 of the *Forest Act*.

tree farm licenses (TFL): An integrated resource management unit established in accordance with section 28 of the *Forest Act*.

Appendix

Appendix 1 FIR Polygon Selection Images

Appendix 2 Sample Selection GRIDS

Appendix 3 Access Summary

Appendix 4 Sample Map

Appendix 5 Quality Assurance Report

Appendix 6 Inventory Audit Plot Sheet Example for Volume Age Samples (FS205)
- Normal Volume Age Plot
- Half Plot
- Count Plot
- Enhanced Plot

Appendix 7 Polygon Top Height/Age Summary for Mature and Immature

Appendix 8 Inventory Audit Plot Sheet Example for Immature Samples (FS806)
- Sample 51
    - Forest Classification Ground Class Short Form
    - Forest Classification Sample Summary Sheet
- Sample 53
    - Forest Classification Ground Class Short Form
    - Forest Classification Sample Summary Sheet

Appendix 9 Field Notes Map

Appendix 10 Inventory Audit Collection/Sampling Examples for Void Plots

Appendix 11 Inventory Audit Collection/Sampling Examples for Border Plots

Appendix 12 Interior and Coastal Pathological Indicator Groupings by Risk Group, Species, Maturity Class and Locality

Appendix 13 How to Determine Site Index in the Inventory Audit Program

Appendix 14 Inventory Audit Program: Post Contract Evaluation

Appendix 15 Procedures for Georeferencing Inventory Audit Field Sampling Plots Using GPS Technology