MINISTRY OF FORESTS

Forest Inventory Branch

Inventory Audit Sampling Standards and Procedures

REVISED JULY 5,1996

Province of British Columbia

Ministry of Forests

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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. 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 and operability. 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.

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.

    Responsibility: Branch/Region/District/Licensee

2.2 Field Procedures And Plot Layout

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

1. **Ground Sample:**
   a) **Volume Sampling Age:** For all TSAs 50 polygons shall be selected in stands, >= 61 years of age. A sampling grid consisting of four full measure and five variable radius count plots shall be positioned randomly within the selected polygons. For small TFLs (less than 100,000 ha of total forested area) the sample size may be reduced to 40 samples, following review by the Statistical Decision Support section.

   b) **Immature Stands:** 20 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.

2. **Air Photo Sample:** An air photo sample of 30 non-productive forest polygons shall be completed by a certified photo interpreter in Victoria. The sole photo interpreter will provide consistency in assessing polygon label accuracy, using air photo interpretation techniques.

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).
- A total of 50 polygons shall be sampled. These stands are seen as the greatest contributors in the next 20 to 50 years of timber supply for British Columbia. Both label and volume accuracy shall be assessed. 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 Statistical Decision Support staff.

2. Immature Stands

- Productive immature stands shall be identified as less than 61 years of total age with a minimum age related to the silvicultural classification of free growing.
- Stands will only be sampled that have attained free growing status. The free growing status will be confirmed by the District Silviculturist or licensee. If free growing information is not available, attempt to determine if the stand is of sufficient age/height to measure site index. This decision is based on local knowledge or recent air photos. If stands are selected that are too young to accurately assess site index in the field, this is still acceptable as the other label attribute information will be assessed.
- A total of 20 stands shall be sampled. These stands have been identified as having the greatest contribution to the long run sustainable yield harvest level for the management area. Only label accuracy shall be assessed.

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.

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 (eg. 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***

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***
- 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

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.

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

b) Identifying Area of Polygon to be Sampled

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

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.

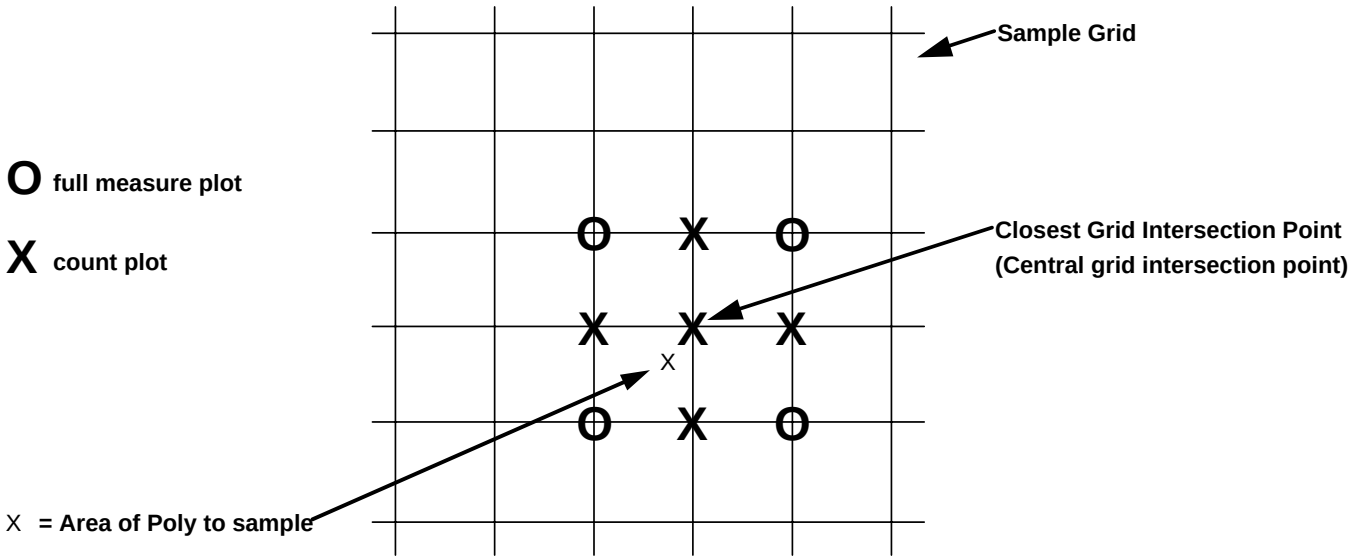

Figure 3.4.1 Sample grid positioning

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.

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

b) Identifying Area of Polygon to be Sampled

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

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.

ii 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.

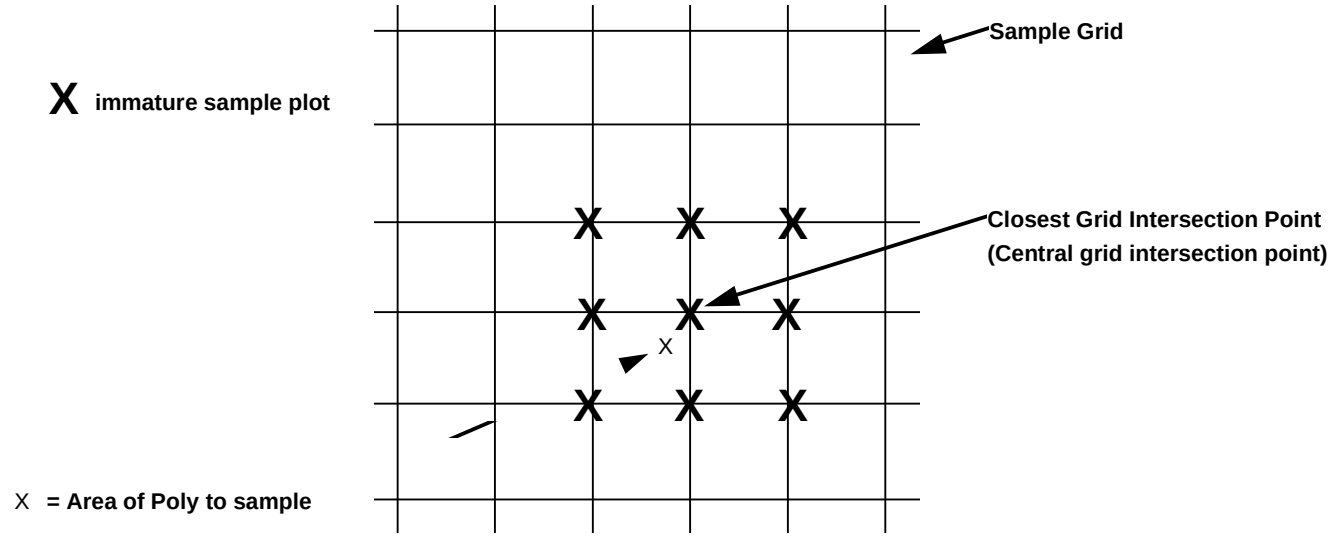

Figure 3.4.2 Immature sample grid positioning

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 rockface, steep slopes where personal safety is in question.

   Long distances to and from plots are not consider safety issues unless there is unsafe physical barriers preventing field crews from reaching their objectives.

   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	MAPSHT 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.
MAPSHT 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:

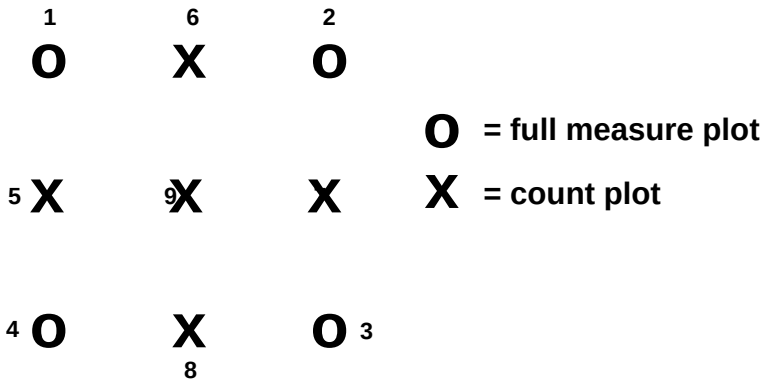

Figure 3.5.1 Plot Numbering

- 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)

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

The qualifications and standards with regard to hover exit procedures have recently come into question. The Canadian Aviation Regulations are currently being revised to allow limited hover exits. Those revised standards are not currently complete, however field work for 1996 will be subject to the revised standards.

The following tentative procedures should be followed.

All ministry of Forests Staff involved in field sampling require hover exit training. Training for all staff shall be completed before the 1996 field season. Resources Branch will arrange the training.

Contractors may also require hover exit training. Due to the potential liability of having contractors using MoF supported helicopter contractors it is recommended that contractors negotioate their own helicopter contractors. These changes will be reflected in the 1996 RFP and contract documention.

Resources Branch will attempt to identify hover exit training contractors that will help to ensure all field contract personell have access to training.

Hover exits will be allowed in the 1996 inventory audit program. 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.

3.7 Contract Viewing

Provincial contract viewing shall be conducted on Wednesday, March 6, 1996 at the Best Western Inn in Kamloops.

4.0 General Field Procedures

4.1 General Quality Assurance Standards

Sampling Procedures and Quality Control Standards for Volume Age Sampling Stands shall comply with the Current Ministry of Forests Provincial Cruising Manual, unless otherwise stated.

At the start of all contracts, MOF staff 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 Ministry of Forests quality assurance staff. Quality assurance will be assessed on a batch plot basis. The number of plots per batch shall be determined by the contract officer.

Quality assurance by MOF staff will involve submitting an Inventory Audit Quality Assurance Report containing each contractor measured field plot with the quality control measured plot. A summary report describing the quality of the work shall be prepared by the MOF contract supervisor (see Appendix 5 for quality assurance report).

The following standards shall be followed:

Field Measurement Standards

1. Volume Age Stands

a) Strip Lines/Tie Lines

Field Line Measurement attributes

Lines	+Bearings	+Horizontal Distance
Tie Lines	2 degrees	3%
Strip Lines	2 degrees	3%

Line accuracy is applicable to the cumulative/total length surveyed.

The last 50 m horizontal distance of all strip chainages must be within ±2 degrees for bearings and ± 2% for horizontal distance.

b) Plot measurement attributes for individual plots

The following standards represent the desired allowances for individual plot attributes. These allowances are the target for individual plot measurements, and will be reported in

the quality assurance assessment report. It should be noted however that the decision to accept or reject the batch of plot measurements shall be based on the cumulative plot assessment standards.

Dbh Height	±5%
Dbh	>= 90% of all trees within 2% of true
Measured Height	>= 90% of all trees within 5% of true
Estimated Height	>= 75% within 10% of true
Age	>= 95% of the sampled trees in the correct maturity class

c) Plot measurement attribute standards for combined plots

The following section describes the standards for plot acceptance. Please note that individual and combined plot standards are included. (A detailed quality assurance report is presented in Appendix 5).

1. General Check Items:

a) Plot cards legible Yes_____ No_____

2. Species

a) Species correct .5% (1 tree in 200) Yes_____ No_____

3. Stem Count

a) Number of trees tallied (measure and count)
- Number of "in" trees missed _____
- Number of "out" trees tallied _____

b) Number of stem difference_____ % error difference_____

Objective: Allow 1 missed stem in 50. Therefore we have a 2.0% error allowance (i.e. 1/50=2.0%)

Formula to determine % error missed trees;

$$\text{Error \%} = \frac{\text{check cruise stem count - original cruise stem count}}{\text{check cruise stem count}} \times 100$$

Note that dead useless trees are not included in this parameter

- If the result is greater than 2.0 % the polygon fails.
- If less than 50 stems are in the check cruise and the 2.0 % has been exceeded, then combine the tree count with another polygon.

4. Height Samples

a) Measured

Number checked_____ No. 5% high _____
No. 5% low _____

% within 5% individually (minimum allowance= 90%) _____

Estimated

Number checked_____ No.10% high_____
No.10% low _____

% within 10% individually (minimum allowance = 75%)_____

b) Sum of heights checked (m) Original_____ Checked_____ Difference_____

c) Height Variation (difference) _____ % (Total of all stems checked must be within 3% of the true height - F.S. calculation)

For rejection of the height samples both allowances in items 4a and 4b must be exceeded.

d) Top Height

Top height trees correctly assessed Yes_____ No_____

Note1: For rejection of heights only, 15 stems should be checked unless instrument is faulty.

Note2: The absolute variation method of height accuracy used in the current valuation manual is not being used in the audit standard.

5. Diameters

a) Number checked_____ Number 2% high_____
Number 2% low_____

b) Percentage within 2% individually(minimum allowance= 90%)_____

c) Sum of diameters: Original____ check____ (Allowance = 2%)_____

d) Number of trees on which breast height was out by more than 5%_____

6. Pathological Indicators (See appendix 12)

a) Number of stems checked _____ Risk group classed high on _____ stems
Risk group classed low on_____ stems

b) Number of plots on which more than one tree was placed in the wrong risk group_____

c) Total trees checked for path _____
Number of trees with RG change _____
Percentage with RG change (maximum allowance 5%) _____

7. Measurement of Distance

a) Strip lines and/or tie lines to plots (+/- 3% of horizontal distance /+- 2% bearing
Yes_____ No _____

b) Last 50 m within 2% horizontal distance/ bearing Yes_____ No _____

8. Ages

a) Number of Sample trees _____
Ages should be within 10% of check. Increased care should be taken on maturity class breakpoint ages.

9. Additional Comments

_____
_____
_____

10. Recommendation

Accept _____ Reject_____

Signature _____
Check Cruiser _____

When multiple quality assurance conditions exist, the worst case scenario will be used for quality assurance. For example, the cruiser calls a tree dead potential and the check cruiser calls it living tree class 2, this would be assessed as a missed tree and not a risk group change.

Ensure check tally cards and photocopies of original tally cards are attached to the quality assurance check report.

Field Measurement Standards (continued)

2. Measurement standards for immature stands

Immature stand data shall be collected on MoF FS205 and summarized on MoF 806 Forest Classification Ground call forms. For more detail on the collection procedures see Data Collection Summarization 4.2.

a) Strip Lines

Field Strip Line Measurement attributes

Lines	+/-Bearings	+/-Horizontal Distance
Tie Lines	2 degrees	3%
Lines	2 degrees	3%

Line accuracy is applicable to the cumulative/total length surveyed.

b) Plot measurement Attributes

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

It should be noted that extra consideration should be exercised in collecting the age and height information in immature stands. This information will be used to derive ground based estimates of site index. If the stand is too young to bore trees for age then the field crew must determine the most appropriate method of determining stand breast height age. Age may be assessed by counting branch whorls on determinate species or by destructively measuring a suitable top height tree, off the plot centre. Regardless of the method of determining stand breast height age, the method must be clearly documented on the plot card. Breast height age must be recroded/determined, total age measurement only will not be accepted.

3. Non-productive / Non-forest classification

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 Volume Age Stands

a) MOF FS 205 Plot Cards

The Ministry of Forest FS 205 Cruise Tally Card or similarly formated 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	_____		____		___

All data must be clearly legible. Plot cards with illegible data shall not be accepted. Data shall be keypunched and compiled by Resources Inventory Branch. Age Correction must be determined using the site curves represented in the Inventory Field book, Classification and Sampling, 1992.

2 Immature Stands

Immature Sampling Overview

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 (%) is determined by stem count from either a fixed area or variable radius sample plot. 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 accomodate 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 prefered 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 acccuracy 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 in each of the nine sample plots. 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 ralevent 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 sampling procedures.

For more detail on the specific site index measurement procedures refer to the "Growth Intercept Method for Silviculture Surveys, August 1995, prepared by B.C. Ministry of Forests Silviculture Practices Branch.

3. Non Productive/Non-forested Stands

Classification accuracy of these stands are office checked in accordance with the *Forest Inventory Manual, Forest Classification /Sampling and environmentally Sensitive Areas* (Volume 2), Appendix, pg. 157.

4. Data Collection Standards for plots that do not sample the desired polygon.

The inventory audit program recognizes various plot establishment situations that vary from the conventional cruising standard. The situations occur when a plot is established and no trees are tallied. These plots shall be identified with the word **No Trees Tallied-Opening** written clearly across the face of the plot sheet, with a clear description of why the plot was void. It is important for the audit program to identify void plots to ensure that estimates of polygon volume can accurately be determined. The following section describes these situations and the procedures required to complete the sampling in void plots. 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 situations *a plot card shall 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 centre established 2m NE of spur road 9G centre 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 void plots and the coding required. In all cases the plot shall be described with the following coding (detailed examples are included in Appendix 10):

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

In the situation of a plot landing on or near a road or right of way, that would not allow the establishment of a full half 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 centre to the centre 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 landed clearly outside the polygon, the field crew should clearly write across the face of the plot sheet **"VOID PLOT OUT OF POLYGON"**. The situation of a plot landing outside the polygon can be caused by either an error in the type line on the map or an error with the field crew locating the plot. Note that in the case of an error in the type line this does not invalidate the plot, it simply means that the field crew should indicate that the plot does not represent the sample type. By recording this information it will allow an assessment of the volume differences due to type line / stratification errors. All plots landing outside the polygon should be verified by the field crew that all chainages and tie points are correct. Additional ties to physical mapped features will assist in verifying the plot location. Field crews should also attempt to locate the physical features on photos. The field crew should indicate in the compass notes the position of the plot to the expected type line and indicate any reasons they feel would explain why the plot fell out of the polygon A complete plot must be established with all the pertinent measurements taken even though this is a void plot. By collecting the plot data this will allow multiple plot compilations to be performed. **The full measure / count plot status should NOT be changed if the plot appears out of the polygon.**

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.

5. 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-half plot split so each one-half can be compiled separately if needed. Also measure and record the distance from the plot centre 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. Border 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, pls 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 inaccessable 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.

6. 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.

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.

7. 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 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 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 centre stakes shall be located exactly where they fall and shall not be moved to a nearby sapling.
- 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 Establisment

After selection of a re-locatable 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 co-ordinated with land owner or licensee.

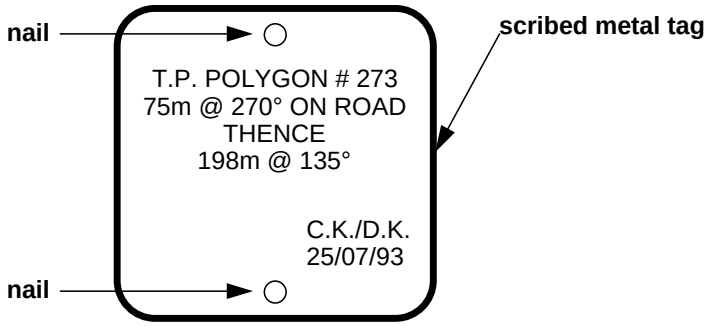

Figure 4.4.1 Tie Point Tree Tag

4.5 Photo Tie Point Establisment

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:

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 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 may be established with the use of a string machine as long as accuracy can be maintained.
- The tie line must be measured with the use of a nylon chain (tight-chained) if obstacles prevent accurate measure with a string machine.
- Distance to be measured to the nearest meter.
- Standards:
  - bearing to be correct within two degrees,

- distance to be correct within + or - three percent of total distance,
- tie line to 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.

4.7 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.
- See appendix 9 for the minimum standards for compass notes.

4.8 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 Centre 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 centre stake shall be established for all count 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 centre 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 centre for volume age sampling. The following procedures shall be followed:

   - Reference trees are **NOT** required for count plots or immature plots.
   - Choose a reference tree within a short distance of the plot centre.
   - 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 centre stake measured from the tree to the stake. Record the bearing and distance from the reference tree to the centre stake on the appropriate plot card.

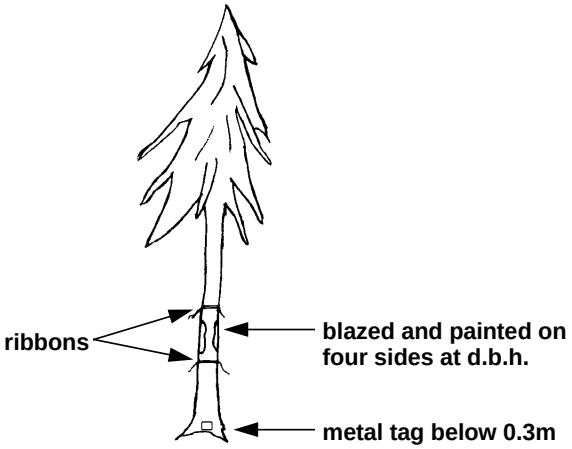

Figure 4.8.1 Reference Tree Marking

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
- Count plot (variable radius)
- Half plot (variable radius)
- Fixed Area
- Immature: ground call samples

5.2 Attributes Measured For Volume Age Plots, Unless Otherwise Stated

1. **Completion of Plot Tally Cards** The following procedures shall be used when recording field data:
   - The standard MOF FS 205 field sheet be used when recording data on variable radius plots and that a FS 806 be used for fixed area plots.
   - **All data shall be neatly recorded.**
   - All calculations (heights) **shall** be completed in the field.

2. **Tree Count** 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 and dead potential shall also be sampled as per cruising standards.
     - Once a BAF is selected it will be maintained throughout the grid cluster.
     - 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 centre to the centre of the tree and the % slope shall be recorded on the field sheet for all borderline trees on both count and full measure plots.

3. **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.

3.1 Enhanced Count Plots

- If a count plot contains a species not already tallied in a measure plot, then ensure that all of the stems of that new species in the count plot have data recorded 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.

4. **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 centre.
   - All measured **out** trees in both full measure and count plots with be clearly marked with an X.

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

6. **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.
   - Dbhs **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, while fixed area plots for immature samples will follow the criteria identified in Appendix 8. Check with the contract officer for minimum diameter limit specifications.

7. **Tree Heights**
   a) **Top Height** Top height trees shall be selected using the following procedures.
      - At the full measure plot centre point position, establish a fixed area subplot of **0.010 ha (5.64 m radius).** For immature stands establish this radius for all plots(9).
      - Select the largest **suitable** diameter tree of the leading species (determined by the average basal area per hectare for all count and full measure plots at the minimum utilization level (12.5 or17.5 cm + **for the entire polygon**). Immature utilization may vary depending on the selected utilization level. Measure the height and breast height age. There will only be one top height species summarized for the polygon. Note that for immature samples two top height species may be required Suitable trees are:
        - largest diameter tree,
        - dominant or co-dominant,
        - have not been 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.
- For volume age stands, if the first tree is not suitable then select a suitable tree in the next and if necessary subsequent count plots. For volume age stands the objective is that each polygon should have a **minimum of four top height** trees measured. On the plot cards clearly indicate with a * the top height tree(s).
- For immature samples, if a plot does not contain a suitable tree, indicate that a top height tree was not available and select a tree in the next plot. It is not required that each immature sample plot has a top height tree. If possible attempt to collect a top height tree on each (9) plots.
- 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)).

b) Additional Heights All 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.

- In the case of trees with broken and missing tops, 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.
- **Ensure that all tree class 3,7 and 9 dead potential trees have a height recorded.**

c) Multilayered Stands In order to accurately assess top height in multilayered 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.

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

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

- Age measurements shall be taken on top height trees.
- Potential veteran 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 centre of the tree.

Physiological age: If a sample tree measurement was suppressed in its early years, the unsuppressed (physiological) age is to be recorded for that tree. The unsuppressed age can be determined as follows:

- Calculate the rings per cm of the unsuppressed growth.
- Apply the rings per cm of the unsuppressed 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.

10. **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 and recorded in the polygon top height/age summary.

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

12. **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 enhanced count plots only.. 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.**

13. **Tree Veterans** Ensure that all veteran trees 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.

14. **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.

15. Pathological Indicators

- Pathological indicators shall be collected as per current MOF cruising standards.
- Pathological indicators are not required for tree class 3 dead potential or tree class 4 dead useless trees.

16. 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.

17. 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).

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 claybank 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