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Remeasurement of Experimental Plots in Natural Stands

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Remeasurement of Experimental Plots in Natural Stands

To evaluate the growth and yield of different forest types, the Research Branch established permanent growth plots from 1921 until 1949. To protect this large investment from any type of disturbance, a reserve was placed around each plot. In 1957, the Research Branch transferred responsibility for 65 experimental plots (all still in a natural state) to the Forest Inventory Branch. Since then the Growth and Yield Section of the branch has continued to remeasure them periodically (10-year periods). Some of the original 65 have been abandoned owing to increased pressure on the area for other uses or to the fact that sufficient data have been collected. The standards of measurement for permanent samples are listed in Appendix 1. If not already done, all experimental samples due for remeasurement must be ecologically classified in accordance with Research Branch specifications.

Since permanent growth samples are cost intensive, their protection is of utmost importance. To ensure their protection, the buffers illustrated in Appendix 31 are recommended.

Office Preparation

Prepare field record sheets that allow room to record new measurements. If the previous measurements were recorded in imperial units, convert them to metric equivalents for diameter and height, and enter these equivalents on the field sheet for comparison with the new measurements. Obtain small-scale (1:20 000) forest cover maps showing plot locations and large-scale (1:250 000) maps for navigation as well as the most recent photos showing the original tie points. For a list of equipment used to remeasure growth and yield samples, see Appendix 17.

Field Training

⇨ All personnel involved in remeasurement must attend a brief field procedures course.

Relocation of the Plot

Location and Access Description

⇨ Originally, only a general description of access to each experimental plot was required. This occasionaly resulted in time loss. For the benefit of future remeasurement crews, describe the location and access in detail. When describing routes and distances to a tie point, always start from an easily identifiable point. On the way to the tie point, clock the kilometres from road junctions, creek crossings, and other prominent features. Describe the tie tree well, noting its species, diameter, and location.

Tie Point

Whenever possible, the reference or tie point was located close to a prominent topographic feature. The tie point was marked with a cedar post driven firmly into the ground. However, many of these posts have rotted and are difficult to find. When the tie point cannot be found, try to find the tie line by crossing back and forth, looking for blazes or flagging tape on the trees. Having found the tie line, reverse the tie line bearing and look for the location of the tie point. To aid crews in the future

relocation of the tie point, use a well marked tree, rather than a cedar post. At the time of remeasurement, choose a suitable tree near the post and attach to it two aluminum growth plot markers (see Appendix 18) at a point approximately two metres up the tree. Each marker should be in line with the tie line bearing and nailed on opposite sides of the tie tree. Also flag the tie tree with two strands of plastic flagging tape, one above and one below the markers.

Inscribe each of the aluminum growth plot markers with the following information: sample type (R), installation number (experimental plot number), sample number, plot number (1 assumed), bearing and distance to the plot, region number, compartment number, and date of plot establishment.

Note: "Date" refers to the original date of plot establishment.

To aid future measurement crews, prepare a sketch (to be attached to the sample sheets) showing the tie point, the sample location, and other significant topographic features.

Tie Line

From the tie point, the tie line was run with a hand compass, an abney and a chain, and was marked with paint or blazes on each side of trees at approximately 10-metre intervals, or at shorter intervals where undergrowth reduced visibility.

If the original tie line can be found, renew the old blazes and flag the tie line with strands of flagging tape.

Sometimes the tie point and the tie line cannot be found. To locate the plot, first find the approximate location of the tie point and follow the tie line bearing. When you have travelled the approximate distance of the tie line, begin crossing the tie line back and forth looking for metal tags, flagging, and corner posts. Within the experimental plot, tags were nailed onto trees at breast height. When the light is adequate these tags can be seen from a great distance.

If you cannot find the experimental plot, select a new tie point that is easy to recognize on the photos and on the ground. On the map, plot the tie point and measure the new bearing and distance to the experimental plot. Set the new bearing on the hand compass and run the tie line. Mark distance on the ground every 40 metres (or every 20 metres on broken terrain) and on sloping terrain use a clinometer to make an allowance for slope.

Corner Posts

At the experimental plot, locate all four corner posts. Each of the corners was marked with a cedar post driven into the ground around which a cairn was sometimes built.

Check that each post is solid enough to last another ten years and mark each one with flagging tape. When necessary, replace a post with a new one or a tubular aluminum stake. To prevent future problems with the location of the corners, build a cairn around all of the corner stakes or posts and stem map two of the diagonal corners each to three trees in the plot. Measure the bearing, slope percent, and slope distance from each of the two corners to three trees that are near the corners and record the data in the stem map columns of the growth sample field sheet (beside each tree number).

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Measurement of the Plot and Establishment of the Sub-plot

- Accurate, conscientious work is required when comparing new measurements with previous previous measurements and when rechecking measurements that appear to be out of the expected range, that is, ones showing a large increase compared with those showing little or no increase. Place a check mark against double-checked data on the field sheet. Correct errors in species identification and note them in the remarks column: for example, "Tree no. 60 is a Hw not a Fd."

  Experimental samples are either square or rectangular in shape. Single plot experimental samples range in size from 0.04 ha to 0.40 ha; the most common size is 0.16 ha. The multiple plot experimental samples range in size from 0.06 ha (2 plots) to 1.38 ha (34 plots). On file with each experimental sample is a map showing its layout.

- At the time of sample establishment, all living trees 2.5 cm and over in diameter at breast height (1.37 m) were tagged with numbered metal tags. During subsequent remeasurements, ingrowth trees (2.5 cm d.b.h. and greater at the time of remeasurement) were often disregarded. To simplify tagging, the plot was divided into sectors. Tagging was started in one corner of the plot and continued up and down each sector beginning with sector 1. Sector numbers increased toward the opposite end. The number of sectors in a plot varies among the experimental samples.

Industrial PSP Breast Height Conversion and Sub-plot Establishment

Breast Height Conversion

- Convert all industrial permanent sample plots not yet converted from imperial (1.37 m) to metric (1.3 m) breast height. The conversion entails obtaining a one base-year measurement of diameters at 1.3 m and 1.37 m above the germination point for all trees 2.0 cm d.b.h. and greater. This includes all of the originally tagged trees (including those with missing tags, and those that have died since the last measurement or have been cut down), ingrowth and sub-plot trees. For this purpose use one of two methods (the first being the preferred one) but note that only one method is to be used within a forest region.

Method 1

- Ensure that the tree number tags are nailed to each tree at 1.37 m above germination. If necessary, replace the nail and tag (with the same number) and ensure that the nail is out far enough to allow for future growth. Drive a second nail 0.07 m below the nail at 1.37 m. Measure the diameter above each nail.

Method 2

- For originally tagged trees, measure the diameter at 1.37 m and mark the metric breast height (at 0.07 m below the nail at 1.37 m). Move the nail and tag (if necessary, replace the nail and replace the tag with the same number) and place them at 1.3 m. Measure the diameter at 1.3 m above the germination point.

- For trees not previously tagged (i.e., ingrowth and sub-plot trees) mark the breast heights at 1.37 m and 1.3 m above the germination point. Nail the tag at 1.3 m and measure both diameters (at 1.37 m and 1.3 m). If method 2 is used, note it on the field sheet.

Note: If the breast height is being converted to 1.3 m at this measurement, ignore the sections in the manual that deal with measurement procedures after the one base-year measurement of diameters at 1.3 m and 1.37 m have been taken.

Sub-plot Establishment

In addition to converting breast height, a sub-plot must be established (at the centre of the square or rectangular experimental plot) in order to have some representation from trees below the tagging limit (i.e., trees less than 4.0 cm d.b.h.). The objective is to obtain a minimum of 20 commercial trees in each sub-sample that are less than 4.0 cm d.b.h. but are at least 0.3 m in height. The sub-sample size is dependent on density (see Appendix 19 for a list of sub-plot radii).

Mark the intersection of the corner post diagonals with an aluminum tubular stake and establish a circular sub-plot from the centre of the plot. Mark a large living tree close to the aluminum plot centre stake as the plot centre tree; nail two aluminum growth plot markers approximately two metres above the ground; and on these markers inscribe the sample type (R), the experimental plot number (i.e., installation number), sample number, plot number (1 assumed) on the "Centre for Growth" section of the marker as well as the region number, compartment number, and date of plot establishment on the bottom section of the marker. If this plot also serves as a tie point for the next plot complete the "Tie Point for Growth" section which includes the next plot identity as well as the bearing and distance to it. Also mark the centre tree with two strands of plastic flagging tape, one above and one below the aluminum markers.

Choose the sub-plot size and mark the sub-plot circumference with string, but ensure that the sub-plot radius is less than or equal to one-half of the length of the shortest side of the rectangle (even if less than 20 stems are obtained). Select three trees around the sub-plot centre and record the bearing and distance from the centre stake to each tree in the stem map columns.

Within the sub-plot, tag (as in Method 1 or 2 above) all living trees 2.0 cm d.b.h. and greater but less than 4.0 cm d.b.h. (d.b.h. assessed at 1.3 m above germination). In addition, count in a dot tally, the remaining trees within the sub-plot that are less than 2.0 cm d.b.h., derive their metric d.b.h. classes (i.e., either d.b.h. class 0 or 1) at 1.3 m (see Table 1), and record them on the tree count section of the field sheet (see Appendix 7).

Table 1
Metric d.b.h. classes and limits

D.B.H. Class	Limits
0	0.3 m to 1.3 m in height
1	0.0 cm to 1.9 cm in d.b.h.

D.B.H. Measurement and Tree Classification

In 1991 breast height determination changed from point of germination to the base of the tree on the uphill side. To determine breast height for trees with missing tags or ingrowth, continue using point of germination for samples established prior to 1991 and use base of the tree on the uphill side for samples established after 1990.

One base-year measurement of diameter at 1.3 m and 1.37 m above the germination point has been completed for all Ministry of Forests experimental samples. All future remeasurements will only be at 1.3 m. All missing tags at the time of remeasurement must be replaced. On the back of the field sheet on

the section titled "Notes," record the percentage of tags missing at the time of remeasurement.

At the completion of the last remeasurement (1980-1989 inclusive), all living trees 7.5 cm and greater in diameter at breast height (1.3 m) had been tagged with either aluminum tags or round blue plastic tags in one of two tagging methods (the first being the most common).

Method 1
The tree number tags were nailed to the trees at 1.37 m above germination. A second nail was driven into each tree at 1.3 m.

Method 2
The tree number tags were nailed to the trees at 1.3 m above germination.

- If method 1 was used, pull out the nail and tag (at 1.37 m). Nail the tree tag at 1.3 m (near the second nail that was previously driven in at 1.3 m). Finally, pull out the original nail that was at 1.3 m.
- If method 2 was used, it will be noted in the field sheet and the tag and nail will already be at 1.3 m.
- For all previously tagged living trees with missing tags, determine breast height at 1.3 m above germination or above the base of the tree on the uphill side (for samples established after 1990), and nail a tag with the same number.
- Measure the diameters at 1.3 m just above the nail for all numbered living trees and record them to the nearest millimetre on the field sheet for natural stands (F.S. 820, see Appendix 7). Also record the sector number of each tree on the same sheet. If a number is missing, renumber the tree as described in this section above.

To more accurately measure the diameter of trees that have grown together, (e.g., trees forked near breast height) or will have grown together by the next remeasurement, place a second nail at the halfway point around the tree from the nail holding the tree tag (1/2 wrap nails). Note this in the remarks column and, on remeasurement, ensure that the nails are pulled out enough to allow for growth until the next remeasurement.

Note 1: When remeasuring diameter, readjust the nail holding the number. Pull it out enough to allow for tree growth until the next remeasurement.

- **Note 2:** Measure the diameters at 1.3 m (and at 1.37 m if the permanent plot is being converted to metric breast height) above the nail for all previously numbered living trees that are now dead. If the dead tree is missing or has been cut down, assign the same diameter as previously recorded and record cut down trees as tree class 6.

Tree Class and Decay Indicators
Classify each numbered tree into one of the tree class codes and record it under tree class (see Table 2).

Table 2
Tree class codes

Tree class	Code
Residual	1
Suspect	2
Dead potential (standing or fallen down)	3
Dead useless (standing or fallen down)	4
Veteran	5
Dead cut down	6

Tree Class 1: Residual

If none of the suspect characters (decay indicators) are visible, classify the tree as residual (code 1). Also record tree class 1 for all tagged trees less than 2.0 cm d.b.h. since an assessment of decay indicators is not made for tagged trees in this category.

Tree Class 2: Suspect

If one or more of the decay indicators occurs on the tree, classify the tree as suspect (code 2, except veterans which are code 5). Enter the numerical decay indicator position code (see Appendix 8) to show the location on the tree being tallied of any of these decay indicators, which are defined and illustrated in Appendix 9:

Conk - usually occurs on deciduous trees in immature stands.

Blind Conk - very seldom occurs on immature trees.

Scar - must be weathered and may be grown over or open.

Fork or Crook - includes multiple leaders.

Frost Crack - may resemble a scar but it always follows the grain.

Mistletoe - can occur on the trunk and branches. Record a branch swelling that extends to the trunk of the tree as mistletoe. Because mistletoe may be a growth inhibiter, record (only in the remarks column) it if present on swollen limbs even if at some distance from the trunk, .

Rotten Branch - must have a minimum diameter of 10 cm and in immature stands should only be present on veterans.

Dead or Broken Top - includes a broken or dead leader (see Appendix 6).

Note: Do not record decay indicators in the pathological remarks section for tagged trees less than 2.0 cm d.b.h., but only note them in the remarks section. Record tagged trees less than 2.0 cm d.b.h. as tree class 1.

These abnormalities are not indicators of decay and are illustrated in Appendix 9: butt rot, flute, candelabra branch, branch fan, black knot, burl and gall, sweep, exposed root, spiral grain, dry side, sapsucker hole, and insect boring. Record their occurrence in the remarks section of the field sheet.

Select the decay indicator position code (see Appendix 8) that best describes the location by thirds of each decay indicator (including dead or broken top) on the tree and enter this code under the heading "Pathological Remarks" on the field sheet.

These examples illustrate the relationship between the decay indicator and its position code:

- Suppose that a suspect tree has scars in the lower and middle thirds, and a fork in the middle third. In the pathological remarks section under "SCAR," enter 4; and under "FK/CK," enter 2.
- Suppose that a veteran tree has a dead top, conks in the lower third, and a crook in the middle third. In the pathological remarks section under "D/B T," enter 3; under "CONK," enter 1; and under "FK/CK," enter 2.
- Suppose that a suspect tree has a fork in the middle third, a large scar extending the whole length of the tree, and the leader from the tallest fork is broken. In the pathological remarks section under "FK/CK," enter 2; under "SCAR," enter 7;

and under "D/B T," enter 3.

Tree Class 3: Dead Potential

Record tree class 3 if the tree is dead (standing or downed) and is estimated to contain at least 50% by volume in sound wood content thus making it potentially useful; that is, if the area were logged, this sound wood could be extracted along with other merchantable material. Include only stems that are greater than or equal to 10 cm d.b.h. and greater than or equal to 3 m in height or length. If it can be determined that the tree died as a result of an insect or disease, record tree class 3 (if potentially useful) as well as the primary insect or disease responsible for the death of the tree (see pest and injury portion of this section).

Tree Class 4: Dead Useless

- Record tree class 4 if the tree is dead (standing or downed) and is estimated to contain less than 50% by volume in sound wood content.. If a previously tagged tree cannot be found after a reasonable time, assume that it is dead (it is most likely buried under windfall) and note on the field sheet that it has not been found and is assumed to be dead.
- If it can be determined that the tree died as a result of an insect or disease, record the primary insect or disease responsible for the death of the tree (see pest and injury portion of this section).

Tree Class 5: Veteran Tree

If a tree in question proves to be at least 40 years older than the mean age of the main stand, record it as a veteran (tree class code 5). Also, record a "V" in the layer column of the field sheet (F.S. 820). For veteran trees (tree class code 5) record decay indicators in the same way as for other trees. Veterans belong to a distinctly older age class than that of the main stand being sampled. In growth sampling, it is important that veterans be properly classified, and the increment borer be used to determine the age of trees that appear to be veterans. A veteran is not always an old tree: for example, a 20-year old stand could have 60-year old veterans which are remnants of a stand destroyed by fire. For a veteran component to be recognized, the veterans must have an estimated crown closure of less than 6% for a sample. Veterans are not recognized in stands 121 years or older except in lodgepole pine stands, which may have a veteran component of Douglas-fir or larch.

Tree Class 6: Dead, Cut Down

Record tree class 6 if the tree is dead as a result of being cut down. In addition, record "cut down" in the remarks section.

A tree can be properly classified only when it has been viewed from all sides. Because most defects in the upper portion of a tree are not visible to an observer standing at the base, it is important that the recorder move around each tree until the crown being classified is clearly visible. The person measuring d.b.h. should move far enough away from the tree to be able to classify the lower third of the stem; whereas the recorder is responsible for classifying the upper two thirds.

Pest and Injury Codes

To quantify the effects of insect, disease and injury on tree growth, the Growth and Yield section has been requested to collect insect, disease and injury data during the remeasurement of permanent growth samples.

For each tree affected, record the primary pest, or injury code (see Appendix 30) in columns 61 to 64 of the field sheet. Identify (if possible) the pest species and, if the observer is suitably trained, assess the severity of pest

attach (for pests listed within the table) using the rating system identified in the *Quantification of Damage* section of the *Pest and Injury Codes* table. For other pests, consult an appropriate specialist for a rating system. If the observer is not suitably trained, assess the severity of pest attack using the following subjective assessment codes:
L = Low, M = Moderate, S = Severe, and P = Past attacks.

If the observer is not able to identify the insect or disease species, a shorter incomplete label is still useful. For example, an observer may identify a defoliating insect and assess the percent defoliation for the tree as 30%. This would be recorded as ID__3 in columns 61 to 64.

In addition to recording the primary pest or injury for each tree affected, make a general assessment of the primary pest or injury for the total sample and record it in the sample header section (stand disturbance, columns 57 to 67 of card type 1) of the field sheet. If known, also record the year of attack.

Crown Class

Crown class refers to the position of the crown of a tree relative to all other trees within the general plot area (not the whole stand). Each tagged tree classed as tree class 1, 2 or 5 is assigned a crown class code. The six recognized crown classes are dominant, codominant, intermediate, suppressed, veteran, and understory and their respective crown class codes are 1, 2, 3, 4, 5, 6 (see Appendix 10).

Record the crown class in column 39 of the field sheet (F.S. 820).

Note: Crown class 6 should be used sparingly (i.e., do not confuse it with crown class 4) since it is only intended for use in older stands (60 years +) in which the understory trees (usually shade tolerant) are clearly of a much younger age than the main stand.

Live-crown Length

Live-crown length is the length from the top (if alive) of the tree or from the top of the live portion (if top dead) to the base of the lowest contiguous live crown as a percentage of the total tree height. When determining the base of the lowest contiguous live crown, do not consider forks originating below breast height or epicormic branches. As the tops of defoliated trees may appear dead at the time of live-crown assessment, care must be taken so that the live-crown length is not underestimated.

⇨ Assign to each live tagged tree a live-crown length estimated to the nearest 10%. Record live-crown length (as 1 for 10%, 2 for 20%, etc.) in column 66 of the growth sample record sheet (F.S. 820).

Ingrowth

Ingrowth refers to commercial and non-commercial trees that were below the tagging limit in diameter at the last measurement and are now 4.0 cm d.b.h. and greater at 1.3 metres above the germination point (or above the base of the tree on the uphill side for samples established from 1991). When all previously numbered trees have been remeasured, tag all commercial and non-commercial living trees that are now 4.0 cm d.b.h. and greater by consecutive number for the plot.

Special rules govern the tagging of forked trees:

- If the fork occurs at or above 1.3 m, tag the stem as a single tree provided it has a d.b.h. of at least 4.0 cm.
- If the fork occurs below 1.3 m, and two or more stems of the fork are 4.0 cm or greater in d.b.h, tag each stem separately using consecutive numbers. When the diameters are recorded on the tally sheet, bracket the numbers of the stems making up the fork(s).
- If the fork occurs below 1.3 m, and only one of the stems is 4.0 cm or greater, tag it as a single tree.

For tagging ingrowth trees, use consecutive pre-numbered blue plastic tags if a large number of ingrowth trees are present or use aluminum tags (inscribe the consecutive tree number for the plot) if few are present.

Nail the tag to the tree 1.3 m above the germination point (or above the base of the tree on the uphill side for samples established from 1991).

For each of these ingrowth trees, on the front of the field sheet record: measurement number, tree number, species, sector number, measured diameter at 1.3 m to the nearest millimetre, tree class, decay indicators, crown class, live-crown length, pest or injury code (if applicable), and the number of the closest previously numbered living tree.

Sub-plot and Tree Count

To have some representation from trees below the plot tagging limit, a circular sub-plot was established at the centre (i.e., at the intersection of the corner post diagonals) of the square or rectangular experimental plot and its centre was marked with an aluminum tubular stake.

If the plot centre tree (i.e., tree with aluminum markers close to the aluminum plot centre stake) is missing, either through natural mortality or man's activity, select another centre tree near the plot centre and mark it properly; nail two aluminum growth plot markers approximately two metres above the ground and inscribe on them the sample type (R), installation number (experimental plot number), sample number, plot number (1 assumed), region number, compartment number, and the original date of plot establishment. Also mark the centre tree with two strands of plastic flagging tape, one above and one below the aluminum markers.

If the centre tree is present but its markers are missing or illegible, replace them at remeasurement. The sub-plot size was dependent upon the density of small trees on the plot as the aim was to obtain 30 living stems (minimum number accepted is 20) that are 0.3 m and greater in height but less than the plot tagging limit. The sub-plot size was selected from Appendix 19, however, the sub-plot radius was less or equal to one-half of the length of the shortest side of the rectangle; that is, the circular plot had to stay within the rectangular plot, even if less than 20 stems were obtained. The bearing and distance from the centre stake to each of three trees around the sub-plot centre were recorded in the stem map columns. Use this information in relocating the position of a centre stake that has been pulled out.

Within the sub-plot, all living commercial trees 2.0 cm d.b.h. and greater but less than the plot tagging limit were tagged as in either method 1 or method 2 previously mentioned (see the *D.B.H. Measurement and Tree Classification* section of this chapter). Trees of

commercial species less than 2.0 cm but 0.3 m in height had their tags wired onto either a branch or the main stem. The tagging of trees less than 2.0 cm (i.e., tags wired) was discontinued (except in very young stands in which the major component was in stems less than 2.0 cm d.b.h.) because many tags fell off soon after tagging and, for many stands, the importance of this data was insignificant.

- For trees 2.0 cm d.b.h. and greater previously tagged within the sub-plot, use the same method (method 1 or 2) of re-tagging that was used for trees previously tagged within the plot (see the *Industrial PSP Breast Height Conversion and Sub-plot Establishment* section of this chapter). If a tree was less than 2.0 cm d.b.h. at the time of previous measurement (i.e., total height was measured instead of d.b.h.) but is now 2.0 cm d.b.h. or greater, attach the tag to the tree with a nail at breast height (1.3 m). If a tree was less than 2.0 cm d.b.h. at the time of previous measurement (i.e., has tag wired on) and it is still less than 2.0 cm d.b.h., remove its tag and include this tree in the dot count.

  Special rules govern the tagging of forked trees that are at least 2.0 cm d.b.h. but less than 4.0 cm d.b.h. within the sub-plots:

  - If the fork occurs at or above 1.3 m, tag the stem as a single tree.
  - If the fork occurs below 1.3 m, tag each fork as a tree provided each is 2.0 cm d.b.h. and greater.

- For each tagged tree in the sub-plot that is at least 2.0 cm d.b.h. but less than 4.0 cm d.b.h., record on the field sheet: measurement number, tree number, species, sector number, measured diameter at 1.3 m to the nearest millimetre, tree class, decay indicators, crown class, live-crown length, pest or injury code (if applicable) and the number of the closest previously numbered intermediate, codominant, or dominant living tree.

- Count in a dot tally, the remaining sub-plot trees and record them as d.b.h. class 0 or 1 (see Table 1 and Appendix 7) by species.

- Give special attention to the method of tagging or counting forked trees less than 2.0 cm d.b.h. To avoid tagging or counting numerous leaders of trees that have been severely browsed, for example, count only the tallest leader. See Appendix 6 for further explanation.

Now and then, unusual live trees are encountered within the sub-plot. Special rules apply to the measurement of the height of these abnormal trees that are less than 2.0 cm d.b.h. (see Appendix 6).

Stand Structure

Stand structure is the physical arrangement or pattern of organization of the stand. Stand structure is described and classified according to recognizable differences in age and in height.

The stand structures recognized are:

A. Single layer

   1. Simple structure (even age, even height)

      a) Without veterans
      b) With veterans

   2. Complex structure (uneven age, uneven height)

      a) Without veterans
      b) With veterans

B. Multi-layer

   A multi-layered stand has two distinct

layers:

1. Layer 1 (top layer)
2. Layer 2 (bottom layer)

For further details on stand structure, see Appendix 11.

For each tagged tree, identify the layer to which it belongs. For single-layered stands, leave the layer column (column 65) blank (including veterans) as 1 is assumed for trees in the main stand and tree class 5 identifies the veteran layer. For multi-layered stands, record the layer code for each tagged tree in column 65: codes 1 and 2 for layer 1 and layer 2, respectively.

Sample Trees

Sample Trees for Height

Local height-diameter curves are constructed from growth sample data before samples are compiled. To construct reliable curves, a substantial number of heights is needed for each species and the number is dependent on the stand composition which, ultimately, is based on gross volume. If available, determine the composition from the volume summary. If the volume summary is not available or there has been a substantial change in composition, use the calculated basal area for stand composition if possible; otherwise, the fifty-percent rule (see Appendix 44) is acceptable. For a single layered stand or for each layer (1 and 2) in a multi-layered stand (succession is now becoming visible in some experimental plots), select height sample trees for each sample as follows:

A. For each major species (20% or greater by composition) select the following:

1. Top Height Trees

It is critical that top height trees be selected in a non-biased, spatially distributed fashion. To avoid resectoring plots that do not contain 0.01 ha sectors, combine existing sectors (see Appendix 45) so that the combined area of the sectors is as close to 0.01 ha as possible but within the range of 0.005 ha to 0.0149 ha.

Single-plot sample sizes of 0.06 ha and larger with 4 sectors (see Appendix 45) need to be resectored into 8 (each original sector divided into two by a line perpendicular to the tagging direction),

Select the required number of top height trees to a maximum of ten. Top height is the average height of a sample of suitable (i.e., largest diameter living tree, free of major defects with a crown class of 1 or 2) trees, each selected from a non-empty (i.e., plot with a suitable tree) 0.1 hectare plot/sector. For example, on a 0.1 ha sample, ten top height trees (if suitable) would be measured (i.e., the largest d.b.h. tree from each top height sector). In the same way, four top height trees would be measured in a 0.04 ha sample.

2. Remaining Range

Select an additional 15 trees distributed evenly throughout the remaining range of d.b.h. down to 2.0 cm.

B. For each minor species (10 to 19% by composition) and scattered species (less than 10% by composition), select 15 height sample trees (if present and suitable). Distribute them evenly throughout the d.b.h. range down to 2.0 cm.

C. For the Veteran layer, select for height measurement one sample tree from each

species present. Estimate the height of all the other veterans and record it in the small tree or Vet height section (colums 27 to 29 of card type 3) and write "estimated" in the remarks column.

- Ensure that height sample trees previously taken are remeasured for height (unless no longer suitable) even if the resultant distribution over the d.b.h. classes is not optimum. However, ensure that the full range of diameters down to 2.0 cm d.b.h. is covered.
- Whenever possible, select residual trees (tree class 1) for height measurements, otherwise select trees that do not have major suspect characteristics such as a major fork which affects the true height or a major scar at breast height which affects its true diameter.
- Do not use trees with estimated diameters and trees with leans or sweeps greater than five degrees.

  For good height measurements, the top and the bottom of the tree must be clearly visible and the reading of the Suunto percent scale should not exceed 90%. The bottom reading should be taken at the tree tag height for the correction of 1.3 metres.
- In some areas it may not be possible to meet the height requirements if only "suitable" sample trees are taken. In this situation take the best of the "poor" height trees to try and meet the requirements unless the individual tree height is at least 10% shorter than it would be without the defect (e.g., lean, fork, broken top, etc.) Make a note of the amount (in metres) that the top height has been underestimated due to using less suitable top height trees.
- **Note:** Reconfirm height measurements of trees that decreased or increased excessively since the last measurement.
- To ensure accurate and consistent measurements of suppressed trees with flattened tops (common with hemlock), sight on the highest point of the top and keep the top reading as low as possible (less than 60%). Even though lateral branches are often higher than the tiny (not very visible) leader of suppressed cedar trees, ensure that the top reading is taken on the tiny leader and not on the lateral branch that may be higher.
- **Note:** To ensure that the height measurement is consistently taken from the same location, paint a blue spot at the base of the tree to indicate the direction from which the height measurement was made.

Sample Trees for Age

- As a result of changing to top height and breast height age for site determination, breast height ages are required for the top height trees (i.e., a one-time measurement).
- In single layer single structure stands (pure and mixed) average age is determined from the ages of the top height trees of the leading major species on the sample. In mixed stands, take one additional age for the second major species to determine if it is in the same age class. If the second major belongs to a different age class, and its volume is within 10% of the first, then also take the same number of ages for it. The age of the second major is not included in the calculation of average sample age, but the presence and the age of it are noted in the stand description.
- The sample mean age is derived only from the top height trees of the leading species even if some cores have rot. By estimating the rot portion, a total age can be derived and used in the calculation of the mean age.
- In single layer complex structure stands,

average age is also determined from the ages of the top height trees of the leading major species.

- In multi-layered stands select sample trees for age as above for each layer. The top height method for determining site index is more suited to even-aged stands. However, for simplification, select age sample trees for both layers of a multi-layered stand using the top height requirements as above.
- Bore trees selected for age at 1.3 m (breast height) above the base of the tree on the uphill side. Half the cores taken must include the pith. If the pith is included, record Y in the pith column of the field sheet. If the pith is missed by more than an estimated three years on a tree under 100 years old, or by 5 years on a tree over 100 years old, then rebore the tree. Count ages in the field and record them on the field sheet. Then measure the radial increment for the last 10 to 20 years (to the nearest millimetre) and record the measurements in the radial increment section of the field sheet.
- If any sample tree has rot, count the rings on the sound portion of the core, estimate the years in the rotton portion, then add to those in the sound portion. On the field sheet, record total breast height age in the boring age section, columns 46 to 48 and R for rot in column 56 of card type 4.
- **Note:** If it is not possible to bore a small tree (i.e., tree less than 5.0 cm d.b.h.) for age without damaging it, select an outside-plot tree and bore it. Assign tree numbers 980 to 999 to outside-plot trees. Paint a blue spot on each tree at breast height and include a diagram (in the remarks section of card type 4) showing the plot and the approximate location of the tree.

Crown Closure and Slope Position

Crown Closure

Crown closure is the percentage of ground area covered by the vertically projected tree crowns. Estimate crown closure for each plot by layer to the nearest 10%, and record in the crown closure column of the field sheet. Record crown closure for the veteran component to the nearest percent. Crown closure for the veteran component in the sample must be less than 6% or it must be classified as a separate layer.

Slope Position

- Slope position is the relative position of the sample within a catchment (water) area. The recognized slope position categories (see Figure 1) are Crest, Upper, Mid, Lower, Toe, Flat (level) and Depression. Record the slope position below the slope percent (%) columns as C, U, M, L, T, F and D respectively.

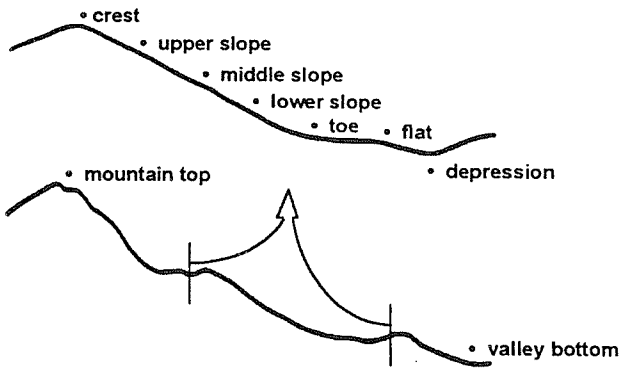

Figure 1 Slope position categories

Growth Sample Field Sheet (F.S. 820)

Column	Item	Instruction
Front of the Growth Sample Field Sheet (see Appendix 7)		
Card Type 1 - Sample Data		
1 to 2	Region No.	Entered previously.
3 to 5	Compt. No.	Entered previously.
6	Compt. Letter	Entered previously, when applicable.
7 to 9	Sample No.	Entered previously.
10	Sample Type	Enter **R** if not entered.
11	Plot No.	Entered at establishment.
12	No. of Plots in Sample	Enter **1** or **3** if not entered.
13	Card Type	Card type **1** is entered.
14	Measurement No.	Enter **1** for the first remeasurement, **2** for the second, and so on.
15	Agency	Enter **I** for Company sample or leave blank if Ministry sample.
16	St. Str. Code	Enter **1** for simple stand structure, **2** for complex stand structure, and **3** for multi-layer.
17	Primary Layer	Enter Primary Layer (**1** or **2**) if multi-layer stand structure.
18 to 30	Ecosystem	Enter the ecosystem if ecologically classified.
30 to 33	Mean Age (Layer 1)	Add the number of years since the last measurement to the previous age.
34 to 36	Mean Age (Layer 2)	As above (if applicable).
37 to 39	Mean Age (Layer V)	As above (if applicable).
40 to 45	Age Range	As above (if applicable).
46	Sel. Logged	Enter **S** if the sample is in a stand that has been selectively logged.
47	Stem Map	If the sample is not stem mapped, enter **N**; if it is stem mapped, enter **Y**.
48 to 50	Top Height (Layer 1)	Leave blank.
51 to 53	Top Height (Layer 2)	Leave blank.

54 to 56	Top Height (Layer V)	Leave blank.
57 to 60	Complete Disturbance	Record the complete disturbance type and year.
61 to 67	Partial Disturbance	Record the partial disturbance type, species, year, and degree.

Card Type 2 - Plot Data

13		
14	Measurement No.	Enter **1** for the first remeasurement, **2** for the second remeasurement, and so on.
15	F.I.Z.	Enter the Forest Inventory Zone.
16 to 19	Plot Size	Entered at establishment.
20 to 23	Plot Radius	Entered at establishment.
24 to 27	Sub-plot Size	Entered previously.
28 to 31	Sub-plot Radius	Entered previously.
32 to 34	Aspect	Entered at establishment.
35 to 37	Slope	Entered at establishment.
	Slope Position	Record the slope position category (**C**, **U**, **M**, **L**, **T**, **D**, and **F**) of the sample just below the slope percent columns.
38 to 41	Elevation	Entered at establishment.
42 to 44	Crown Closure (Layer 1)	Enter the crown closure of the plot (for Layer 1) to the nearest 10%.
45 to 47	Crown Closure (Layer 2)	Enter the crown closure of the plot (for Layer 2 if applicable) to the nearest 10%.
48	Crown Closure (Layer V)	Enter the crown closure of the plot for the veteran component (must not less than 5%).
49	Plot Status	Enter the status of the plot (**A** = active, **D** = inactive - abandoned, **X** = destroyed, **L** = lost in field, **B** = badly disturbed).
50	Stand Origin	Enter the stand origin (**C** = coppice, **F** = fill planted, **G** = genetic, **N** = natural, **P** = planted, **R** = residual stand, **S** = seeded).
51 to 56	Date of Measurement	Enter the date of plot measurement (year-month-day).
57 to 64	Map No.	Enter the B.C.G.S. map sheet number.

	65 to 72	Photo No.	Enter the B.C. flight number and photo number.
⇨	73 to 74	Year of Plantation	For silviculturally treated samples only.
⇨	75	Stock Age	For silviculturally treated samples only.
⇨	76 to 77	Tagging Limit	For silviculturally treated samples only.
	78	Tagging Limit Code	Enter the tagging limit code (**H** = ht, **D** = diameter).
	13	*Card Type 3 - Tree Data*	
	14	Measurement No.	Enter **1** for the first remeasurement, **2** for the second, and so on.
	15 to 18	Tree No.	Enter the tag number of the tree being examined.
	19 to 20	Species	Enter the commercial or non-commercial species code of the tree being examined. For species codes, see Appendix 14.
	21 to 22	Sector No.	Enter the sector in which each tagged tree is located.
⇨	23 to 26	D.B.H. (1.3 m)	Enter the diameter at breast height (1.3 m above germination point or above the base of the tree on the uphill side) of each tagged tree 2.0 cm d.b.h. and greater to the nearest millimetre.
⇨	27 to 29	Small Tree or Vet Height	Record the estimated or measured height for veteran trees. The small tree height is not applicable.
	30	Tree Class	Enter the tree class code: residual (**1**), suspect (**2**), dead potential (**3**), dead useless (**4**), veteran (**5**), or dead cut down (**6**). For tagged trees less than 2.0 cm d.b.h., always record tree class code 1.
	31 to 38	Pathological Remarks	Record decay indicators present on each tree.
	39	Crown Class	Record the crown class (**1 to 6**) of each tree.
	40 to 48	Stem Mapping	Record the stem-mapping information for each tree.
	49 to 55	Stumps	Do not use.
⇨	56 to 59	Near Tree No.	Record the tree number of the closest sequentially numbered living tree to the ingrowth or sub-plot tree being measured.
⇨	60	Sub-plot Tree	Leave blank.

61 to 64	Pest	Record the pest code and severity if injury or pests are present on the tree.
65	Layer	If the stand has more than one layer, enter the layer to which that tree belongs (for single-layered stands, the layer column must be left blank). For veteran trees (tree class 5), record **V**.
66	Live-crown Length	Enter the length of the live crown expressed as a percentage of the total length of the tree (to the nearest 10%).
67	Missed Tree and Out of Plot	Enter **M** if the tree was missed at previous measurement, estimate the d.b.h. at previous measurement and record the d.b.h. in the remarks column. Enter **D** if the tree is to be dropped because it is determined to be outside of the plot.
68	Nat., Plant	Enter **P** if tree was planted. Leave blank if tree regenerated naturally.
69 to 74	Remarks	Enter pertinent tree information not recorded in preceding columns.

Back of the Growth Sample Field Sheet (see Appendix 7)

Card Type 4 - Sample Tree Data

1 to 12	Plot Identity	Entered previously (region no., comp. no., letter, sample no., sample type, plot no., no. of plots in sample).
13	Card Type	Card type **4** is entered.
14	Measurement No.	Enter **1** for the first remeasurement, **2** for the second, and so on.
15 to 18	Tree No.	Enter the tree number of the sample tree.
19 to 20	Species	Enter the species of the sample tree.
21 to 23	Top	Enter the top Suunto reading (% scale).
24 to 26	Bottom	Enter the bottom Suunto reading (% scale, + or -).
27 to 29	Total	Enter the total of top and bottom readings.
30 to 32	Slope Dist.	Enter the slope distance from the tree to the measurer.
33 to 34	Slope %	Enter the slope percent.
35 to 37	Horiz. Dist.	Enter the horizontal distance between the tree and the measurer.

38 to 40	Height	Enter the calculated height.
41 to 42	Height Correction	Enter the height correction (normally **1.3 m**).
43 to 45	Total Height	Enter the total height.
46 to 48	Boring Age	Enter the boring age.
49 to 50	Boring Height	Enter the boring height (**1.3 m**).
51 to 52	Age Correction	Enter the age correction.
53 to 55	Total Age	Enter the total age.
56	Pith	If the pith is included, enter **Y**, if missed leave blank, and if the core has rot enter **R**.
57 to 62	Rad. Inc. (mm)	Record the radial increment (to the nearest mm) during the last 10 and 20 years for trees bored for age.
63	Comp. Age	Record **A** if the tree is to be included in the sample average age calculation.
64	Comp. Ht.	Record **H** if the tree is to be included in the top height calculation.
65 to 66	Remarks	Enter pertinent remarks.

Card Type 5 - Tree Count Summary Data

13	Card Type	Card type **5** is entered.
14 to 15	Species	Enter the species symbol (see Appendix 14).
16	Measurement No.	Enter **1** for the first remeasurement, **2** for the second, and so on.
17 to 19	Dot Tally	Enter the number of trees in d.b.h. class 0 by species (dot tally).
20 to 21	D.B.H. Class 0	Enter the number of trees in d.b.h. class 0.
22 to 24	Dot Tally	Enter the number of trees in d.b.h. class 1 by species (dot tally).
25 to 26	D.B.H. Class 1	Enter the number of trees in d.b.h. class 1.
27 to 29	Total	Enter the total number of trees in d.b.h. class 0 and 1.
30 to 43	Tree Count	As for columns 16 to 29 for a second remeasurement.

Card Type 6 - Stem Mapping Data

(13 to 23)	Stem Mapping	Record the necessary information for stem-mapped samples.
13	Card Type	Card type **6** is entered.
14	Measurement No.	Enter **0** which is the code for the initial sample measurement.
15	Compass at PLT Centre Y = 1 N = 2	If the staff compass was set up at plot centre, record **1**, and if it was set up elsewhere, record **2**.
16 to 18	Bearing From Compass to Plot (0 to 360°)	If the compass was not set up at plot centre, record the bearing (**0 to 360°**) from the compass to the plot centre.
19 to 20	Slope (%)	Only if the compass was not set up at plot centre, record the slope percent from the compass to plot centre. If the slope is zero, record **0**.
21 to 23	Slope Distance (0.01 m)	If the compass was not set up at plot centre, record the slope distance from the compass to plot centre.
	Sector Diagram	Sketch the layout of the plot sectors for future reference.
	Location and Access	If access to the sample has changed, describe the revised access.
	Notes	Record remarks in this area. Note whether the plot centre stake was in or out at remeasurement.
	Meas. No. ___ by ___	Record the measurement number and have the measurer sign the sample.

Quality Control

Refer to Appendix 1 for the standards of measurement, which state the non-sampling error or variation allowed. Sampling crews should emphasize accuracy of measurement and then production.

⇨ Regular crew inspections must be carried out to ensure that recommended procedures are understood and being followed. Inspect at least 10% of all samples remeasured. If a growth sample is unacceptable, the original crew may be required to redo it.

Office Checking of Experimental Plots

All field sheets must be office checked before sending them to the Growth and Yield section, at the Forest Inventory Branch. To office check them properly:

A. Check that all information recorded is legible and dark enough for clear photocopying.

B. Check that the region number,

compartment number, compartment letter, sample number, sample type (R), plot number, number of plots in the sample and measurement number were recorded on every page and the tree information is complete, recorded in the proper column, and correctly justified (numbers are right-justified and letters are left-justified).

C. Check that a general summary on the condition of the sample has been recorded in the "Notes" section of the field sheet. For example:

1980 - Corner posts were all in place
- 10% of the original tags were missing

D. Check that for each plot, the bearings, slopes and distances from plot centre to three tagged, living trees have been recorded in the stem-map columns. In addition, check that the bearings, slopes and distances from each corner to three trees have been recorded for each of the two diagonal corners required to be stem mapped.

E. For plots that have been stem mapped, check that the required information on the location of the staff compass has been recorded for card type 6.

F. Check that a zero has been recorded in the slope percent column, that is, for stem-map and height measurements, if the distance measured is a horizontal distance.

G. Check that the assignment of tree class meets these criteria:

Tree class 1 - Tree has no decay indicators.

Tree class 2 - Tree has one or more decay indicators.

Tree class 3 - Tree is dead potential.

Tree class 4 - Tree is dead useless.

Tree class 5 - Tree is a veteran and may or may not have decay indicators.

Tree class 6 - Tree was cut down.

H. Check that the latest remeasurements of diameter compare to the previous measurement. If a diameter has remained the same, decreased or increased more than normal, make sure that it is rechecked and a check mark is placed in the remarks column.

I. Check that sample trees have been selected in accordance with the specifications in this manual (see the *Sample Trees* section of this chapter).

J. Check height calculations and compare the results with those of the previous measurement. If the height has decreased or increased excessively, make sure that the crew rechecked the diameter and placed a check mark in the margin.

K. For each ingrowth or sub-plot tagged tree, check that the sector in which it is located and the tree number of the closest tagged living tree have been recorded in the appropriate column of the field sheet.

L. Check that a tree count (if applicabel) has been recorded.

M. Check that mean sample age and mean sample height have been calculated correctly and recorded only on the first sheet for each plot.

N. Check that the following are recorded only on the first sheet of each plot: agency, stand structure code, primary layer (if multi-layered stand); ecosystem, stand disturbance, age range, F.I.Z., selectively logged code if applicable; stem map code,

plot and sub-plot sizes and radii, crown closure, plot status, stand origin, map number, photo number and the date of remeasurement.

Q. Check that the pages have been numbered properly and the tallyperson has signed the sample.

Plot Inspection Procedures

Pre-field Inspection

A. Randomly select one plot that has been office checked according to the procedures in the *Office Checking of Experimental Plots* section of this chapter.

B. Randomly select seven trees from the tree detail section (card type 3) of the field sheet and transcribe their respective measurements onto the top section of the plot inspection report (see Appendix 15). Of the seven, one must be selected from the newly tagged ingrowth trees and another must be selected from the newly tagged sub-plot trees.

⇨ C. Randomly select five trees from the sample tree section (card type 4) of the field sheet and transcribe their height measurements onto the sample tree section of plot inspection report.

D. Select two trees for age (i.e., two of the five selected for height) from the sample tree section and transcribe the age measurements into the sample tree section of the natural stands plot inspection report.

E. Transcribe the crown closure of the plot into the appropriate section of the plot inspection report.

F. Transcribe the sample identity (region, compartment, sample, sample type, plot), plot and sub-plot sizes, sub-plot radii, inspection date, original tally crew, and date of measurement at the top of the plot inspection report.

G. Randomly select (from the tree count summary section) one diameter class to check (in the field) that the dot tally is correct for that class.

Field Inspection

A. Use the access notes to get to the plot.

B. If a new tie tree has been selected on remeasurement, check that it has been marked as specified in the *Tie Point* section of this chapter.

C. If a new tie line was run, verify that the tie line bearing and distance have been run within the allowable standards.

D. Check that the information on the aluminum plot centre markers is correct and the plot centre stake is protected with a cairn.

E. Check that the bearing and distance from plot centre and from the two diagonal corners to the three stem-mapped trees are correct.

F. Check the plot and sub-plot perimeters each at a minimum of three different locations for trees that should have been included or excluded from the plot or sub-plot. Also, check that trees away from the perimeters, but within the plot and sub-plot, that are larger than the tagging limits, were not missed. Flag with a circled asterisk any tree missed or tallied when it should have been included or excluded respectively.

G. Check that all sub-plot trees less than 4.0 cm d.b.h. but at least 0.3 m in height were either tagged or counted in the dot tally.

H. Carefully measure all the selected trees recorded on the plot inspection report for:

1. *Tree identification*

Check that the genus or species of each tree inspected is correct and place a circled asterisk beside a tree that was incorrectly identified.

2. *Tree tag height*

Check the tag height of the selected ingrowth and sub-plot trees to verify that breast heights (if applicable) have been located at 1.3 m above the germination point (for plots established prior to 1991) or at 1.3 m above the base of the tree on the uphill side (for plots established from 1991). At the same time, make sure that the nails have been securely driven into the trees and the nail with the tag has been driven in at a slight angle so that the tag hangs away from the tree.

3. *Diameter and pathological remarks (decay indicators)*

Measure the seven selected trees for d.b.h. and classify them.

4. *Sample tree heights*

Measure the five selected trees for height.

5. *Sample tree ages*

Count the age of the two trees selected for age.

6. *Stem mapping*

If the sample was stem mapped, check the seven selected trees for bearing, distance, and percent slope.

Also, assess crown closure for the plot. Compare all of these measurements with the previous measurements and give the crew the benefit of the doubt on any slight discrepancy.

I. Check that the results conform to the standards of measurement (see Appendix 1).

J. Use an asterisk in the margin to indicate that the difference between two measurements is greater than the allowable error.

K. Use a circled asterisk in the margin to indicate that the error is greater than two times the allowable error.

L. Complete the inspection items section of the inspection report.

M. Rate the quality of the work done on the plot using the weighting system in Appendix 16.

N. Record the plot rating and any other comments in the remarks section of the plot inspection report.

Post Field Inspection

A. Discuss the results of the plot inspection with the original tally crew.

B. Make recommendations to the original field crew, when necessary, for improvement of their work.

C. Change, on the original field sheets, all data flagged with an asterisk or circled asterisk.

Damage to the Experimental Plot

Even though reserves were placed around the experimental plots, some have been disturbed. Samples may be damaged by certain events from nature such as slides, windthrow, snow, fungi, insects, disease, and fire. A sample that has received any level of this type of damage should still be remeasured since it can be utilized in the Protection matrix.

Samples may also be damaged by activities from man such as logging, road building, right of way (pipe-line, power line) clearing, and escaped fires. Remeasure a sample that has received this type of damage if at least 50% of the initially measured trees are still alive and attach a detailed description of the damage to the field sheet. If a sample is to be destroyed, remeasure it one last time (if at least three years have elapsed since the last measurement), ecologically classify it, and ensure that the plot centre can be re-located after logging so that the long term productivity effects can be determined.

Return of the Growth Sample Field Sheets (F.S. 820)

- Once the field sheets have been office checked and corrected, make good legible photocopies before sending the originals to the Growth and Yield section at the Forest Inventory Branch. Store the photocopies in the forest region for security and reference. Include a cover letter with the originals that lists the samples sent, and keep a duplicate for field office records. Send by registered mail if using Canada Post.