F.R.I. PROJECT RECORD

NO. 2092

MINIMUM STANDARDS FOR COLLECTION OF GROWTH DATA FROM PERMANENT SAMPLE PLOTS

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Preface

The following manual is a revision of the 1987 edition and includes the amendments proposed by the PSP Future Strategy Committee (1991). In particular, two further minimum measurement requirements, green crown and predominant mean height, have been included. There is also a requirement to record the seedlot number of each plot.

This work has been initiated by the Stand Growth Modelling Research Co-operative (1986). In the 1986 February meeting, the committee recommended that minimum standards were set for members wishing to establish plots for growth modelling data. The manual describes the minimum standards in establishing and measuring fixed area plots; the data from which is to be contributed to the co-operative's national growth modelling data base. The report is divided into four sections which describe the location, establishment, measurement, and remeasurement of sample plots. Two further phases of this work, a national sampling strategy and appropriate field trial designs, are covered in SGMC Report No. 22, PSP Future Strategy Committee Report, July, 1991.

The principal contributors (working groups) for the production of this manual are from N Z F P Forests Ltd., Tasman Forestry Ltd., N Z Timberlands Ltd., and the Forest Research Institute. However, within and outside of these organisations, many individuals have contributed to the methodology of permanent sample plot establishment and measurement.

1986	1991
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1 LOCATION

1.1 Number of Plots

Each forest owner should question whether, for their forest resource, the number of growth model plots is sufficient for each species, stocking regime, site type and age class. Each stratum[1] should be sampled by an adequate number of plots and plot measurements. Details of the sampling strategy for the whole country will be presented in a separate document. Information on existing regional sample distribution is currently best obtained from the Technical Manager of the Stand Growth Modelling Cooperative.

Given the objectives for the number of plots to be established in each stratum, the following section gives guidance on the methods used to physically locate each plot in the field.

1.2 Location on Map

Plots may be established at any time in the life of a stand of trees. Preferably, plots are established before the first thinning or pruning operations, thus valuable information on the unthinned or previous state of the stand is not lost.

(a). Growth model plots

These are plots which are treated in exactly the same way as the surrounding stand.

Single plots are located completely randomly, systematically using grid intersections, or subjectively in a way that gives a good representation of the range of variability in the stratum or stand.

A list of compartments or stand areas should be compiled first. Map(s) will then be required for the area to be considered for plot establishment. The initial location is first done in the office with reference to the relevant stand map(s).

The map area should then be stratified in two steps; firstly, for known differences in:

* Species
* Regime
* Age class

[1] Stratum is a population sub group, usually chosen to identify major differences in altitude or site.

and secondly, for differences in:

* Soil type
* Altitude
* Aspect
* Stocking variation

Theoretical positions of plots may then be marked on the map.

(b). Experimental plots

These are plots which are treated separately from the remainder of the stand, and a buffer area should exist between the stand and the plots.

The plots are contained in trials which are established using one of a number of standard statistical designs. Generally, they consist of two or more treatments, each replicated several times and often on a range of sites. The requirement for a uniform site limits the areas in most forests where such trials can be located. For statistical and logical reasons the plots should be grouped together.

The information from experimental plots should be used with caution unless the trial has been designed specifically to provide information for growth modelling.

1.3 Location Within Stand

The exact location of the plot in the field must be modified by the actual conditions within the stand. The main rules in locating a plot centre are:

(a). Plot edge must be at least 15 m from the stand edge or an open area.

(b). Avoid old skid sites or internal logging tracks.

(c). Avoid gaps and windthrown areas.

(d). Avoid exposed ridges and places where height measurement is difficult.

The exact plot centre is then marked by driving a peg into the ground.

1.4 Identification.

Clear a path between the plot centre peg and the road. Locate the nearest dominant (main crop tree) on the roadside. On this "witness" tree paint two yellow bands at breast height and the plot number above this.

Record magnetic compass bearings, back bearings and distances from stand edge to centre peg. The date, plot area, radius, and compass declination should also be recorded and marked on a map.

2 ESTABLISHMENT

2.1 Plot Shape

The shape of permanent sample plots may be circular or diamond[2]. Circular plots are preferred because they have the smallest perimeter for a given area. The diamond plot has advantages where there is heavy undergrowth or steep slope.

2.2 Plot Size

The size of plot is designed to include a minimum of 20-25 trees for the life of the plot. Once the plot is established its size should be retained, and any change in size documented. Thus the size of plot should be based on the number of trees per hectare at final stocking or at the end of the plot life. A plot area is to be corrected for slope, so it is always correct on the horizontal plane. The minimum plot size (0.04 hectare) and recommended plot sizes are shown as follows:

Final stocking (spha)	Plot size (ha)	Radius (m)	1/2 diagonal (m)
> 600	0.04	11.28	14.14
300 - 600	0.08	15.96	20.00
200 - 300	0.10	17.84	22.36
< 200	0.20	25.23	31.62

2.3 Survey

The plot survey phase fixes the plot boundaries and records the surveyed bearings and distances. The methods of survey are different for circular and diamond plots.

[2] This is a square plot with one diagonal aligned with the planted rows of trees.

(a). Circular plots (see over)

* Start at the plot centre peg.

* Use a hypsometer to find the average slope of the area in which the plot is to be established.

* The average slope is the mean of: the maximum slope from the plot centre and the slope at 180° to the line of maximum slope (ignoring plus and minus).

* If the slope of the area is less than 10°, measure the radius by holding the tape horizontally (using the radius for level ground).

* If the average slope is greater than 10°, use the tables for slope correction (App B) to obtain the correct ground radius for plot size.

(b). Diamond plots (see over)

* Work begins at the plot centre peg.

* Each plot consists of four half diagonals.

* Find the line of maximum slope which passes through centre peg. Use a hypsometer to find the average slope[3] of this line which will form the first half diagonals of the plot. Note that trees are often planted on the line of maximum slope. The other half diagonals are placed at 90° to the first and should be along the contour (slope zero).

* If the slope of the diagonals is less than 10°, measure the half diagonals by holding the tape horizontally and use the distance for level ground.

* If the diagonals of maximum slope exceed 10°, use the slope correction tables (App B) with the appropriate angle to obtain the correct ground radius. The diagonals on the contour will use the distance for level ground.

* Place a corner peg at the end of each diagonal. A path should then be cleared between each corner peg on the plot boundary.

[3]Use definition of average slope for circular plots 2.3(a)

2.4 Tree Numbering

(a). Locate the plot boundary trees.

For trees on the plot boundary note the following, to decide whether a tree is in or out.

* The plot boundary and line of sight is at a level of 1.40 metres above ground.

* A tree is in the plot if more than half of the tree diameter at breast height is included.

* Trees which fork below breast height should have any stem within the plot included as a tree.

(b). Number each tree in the plot.

Each tree should have a unique number within each plot. Trees which fork below breast height are considered to be separate stems. In circular plots numbering should begin with the tree closest to magnetic north and proceed tree by tree in a clockwise direction. Numbers should be seen from the centre peg. Where a tree consists of several stems forked below breast height) only one tree number should be used. Each stem should be recognised by a letter code (for example: 22A, 22B). In a diamond plot, trees are best numbered row by row, starting at one side of the plot. Numbers should face uphill on sloping ground. Tree numbers should be printed on plastic tags[4] which are then stapled (using a staplegun) to the tree. Numbers must be printed with waterproof ink or paint. Tags should be placed above the breast height band. Staples (13mm-alloy) should be aligned vertically, not across the stem.

Quadrant numbering, where used, should not be printed on the trees.

(c). Mark each tree at breast height and paint a breast height band on each tree.
Breast height is defined as 1.40 metres above ground measured with a staff on the uphill side of the tree. Ground level is the bare ground after removal of slash but avoiding placing the height staff in a hole. Where breast height occurs on a swelling (or irregularity), shift the breast height to the nearest normal position. But, if this is more than 15cm from 1.4m level, then a band is to be painted above and below the 1.4 metre level.

[4] "Allflex" tags and marker pens are recommended.

Two bands cannot be used if a tree forks at exactly 1.4 metres. Some judgement will be required to decide whether it is one tree (band below the fork) or two or more trees with bands on each stem.

3 MEASUREMENT

Stand growth model data is dependent on accurate consecutive tree measurements. Basic standards for data collection, abbreviations, precision and calibration are set (App A and C), because the data is eventually to be pooled from many forestry organisations.

Data errors are reduced considerably if the data recorder reads back each reading to the measurer as work proceeds. Errors are also reduced by comparing each reading with any previous measurement recorded on computer or field sheet.

There are six minimum measurements required in each plot, plus a plot attribute requirement.

3.1 Tree Count

Every tree with a diameter at breast height in the plot should be accounted for. The number of any missing tree(s) should be determined and the correct code (App A.6.2) placed against its last DBH measurement.

3.2 Diameter At Breast Height

Diameter is measured over the breast height band of every tree in the plot. A girth tape is to be used with diameter units (girth/*pi*) recorded to the nearest millimetre. If there are two bands painted, the average of two measurements should be recorded. Marked beside the recorded diameter there should be a code (App A.6.2) recording the status of the tree at the time of measurement.

3.3 Sample Height Trees

* In each plot at least 12 trees, including predominant height trees, must be measured for both height and diameter.

* Sample trees must be alive, be of normal form, not be forked, or have excessive lean, a broken or dead top.

* The sample trees should be selected to cover the diameter range of the plot.

* After selecting the sample trees, each tree should be measured for height (App A.2), then recorded along with the tree number and height code (S).

* Sample trees, once selected at the first measurement, should be retained throughout the life of the plot. Substitute trees may have to be re-selected if a sample tree is damaged or felled.

3.4 Predominant Height Trees

Predominant height trees, the tallest in each 0.01 ha quadrant (App A.4), are to be part of the total number of height trees. The measured height of the predominant trees is to be recorded with tree number and code PS (or PN if the tree is not of suitable form). Predominant height trees should be re-selected at each measurement as they may not always remain predominant in height.

3.5 Pruned Height

The pruned height (to nearest half metre) is the height to the lowest unpruned or partly pruned whorl on each tree in the plot. The measurement is taken from ground level on the uphill side of the tree.

3.6 Green Crown Height

Green crown height (App C.1) is to be measured for sample height trees at all measurements :-

(a) up to 18m MTH;
or (b) where there is incomplete crown closure after 18m MTH.

(Incomplete crown closure after 18m MTH occurs, either, when there has been a late thinning, or when there was a very wide initial spacing)

3.7 Seedlot number

The complete registered seedlot number is to be recorded as an attribute of each plot (see FRI Bulletin 144).

4 RE-MEASUREMENT

4.1 Measurement Timing

Without exception, all permanent sample plots must be measured during the dormant growing months. This period usually occurs between May and August. For regions where the dormant growth period is not so well defined, in the Northland region, for instance, plot measurement should be scheduled for the same winter month in each measurement year.

Plot identification and marking should be maintained at each measurement.

4.2 Frequency Guidelines

Where there is a commitment to long term maintenance and measurement of permanent plots, the following re-measurement schedule can be used as a guideline:

Stand age	Measurement schedule
0 - 10	Annual
11 - 16	Every 2 years
16 +	Every 3 years

This schedule is only a guideline intended to maximise growth information for a minimum cost. However, it should be the forest owner's responsibility to schedule re-measurement based on the maturity of their forests and the number of plots to be measured.

4.3 Re-measurement Frequency With Silviculture

* Where there is a plot thinning and pruning, a pre-thin plot measurement should be carried out prior to the thinning/pruning and a subsequent plot visit arranged after thinning to record the residual trees.

* Annual re-measurements are recommended during the following two measurement seasons.

* Where a plot is pruned only, pruned height should be recorded at the next dormant season re-measurement.

* A re-measurement should be carried out before a plot is abandoned.

APPENDIX A FIELD INFORMATION

A.1 EQUIPMENT NEEDED

A.1.1 Plot Establishment And Maintenance

* Centre pegs 1.5m x 50mm x 50mm ground durable
* Corner pegs 1.5m x 75mm x 50mm ground durable
* Axe and Slasher
* Chainsaw with fuel, oil, and tools
* Staple gun and staples
* Rolls of plastic tape or twine
* Paint (yellow) and brushes or aerosol cans
* Allflex plastic tags and marker pens or printed permolat numbers
* First aid kit

A.1.2 Plot Documentation And Measurement

* Clipboard, folder, plot sheets, maps, and writing equipment
* Field computer (if this is used plot sheets may not be required)
* Programmable calculator
* Manual and height tables
* 30m and 50m fibreglass length tapes
* Height pole (telescopic)
* Hypsometer (Suunto) and Compass
* Diameter tapes (steel and fibreglass)

A.2 HEIGHT MEASUREMENT

For definition of height see Appendix C.1.

Height poles are used to measure trees up to 10 metres in height. Trees that are taller than this should be measured with a hypsometer, held in the hand.

A.2.1 Pole Technique

The pole should be placed vertically against the tree stem. An observer should be positioned away from the tree and at right angles to the measurer. The observer can then indicate when the top of the pole is at the same level as the tree tip. Extreme care should be taken in adding together the length of the pole sections and the height of the pole base from ground level.

A.2.2 Hypsometer Technique

(a) Determine the direction of lean of the tree to be measured for height. Plan a path of measurement at right angles to any lean, and preferably on the uphill side of the tree.

(b) The measurement location should be such that the upper angle (sight line to tree top) is not greater that +50° or less than +30°. The lower angle (sight line to tree base or datum) should not be less than -30° or greater than +10° (see figures Table 7). Plus or minus should be called with any observed lower or upper readings.

(c) Find an exact position where the top of the tree and the base of the tree (or datum) can be seen. Some clearing of scrub may be required and a sighting point (datum) may be used within reach of ground level. Where a rangefinder staff is used the datum height is always measured to the upper plate.

(d) Sometimes it is not possible to measure tree height at right angles to its lean. There are three ways of avoiding large errors:

* Measure distance from observer to a point vertically beneath the tree top.

* Take two measurements of height from opposite sides (at 180°) of the tree and derive an average height.

* Take all measurements for the tree from one position; marked by a peg or compass bearing and distance from the tree.

A.2.3 The Methods

1. **Degrees scale and length tape.**

* The observer finds a position where the top of the tree and a datum point within easy reach of ground level can be seen.

* The observer and assistant measure and record the distance between the observer's eye and the datum which is vertically beneath the tree tip. With a leaning tree this may be some distance from the tree stem.

* The observer measures and the assistant records the lower angle to the datum and the upper angle to the tree tip. The assistant also records the height of the datum above ground level.

* Tree height is derived from Height Method 1 or calculated on a programmed calculator.

Example:

Slope dist = 25.5 m (d)
Upper angle = 49.5° (A)
Lower angle = 4° (B)
Datum = 4 m (c)

(a) Using Tree Height Method 1 (App C.2)

$$H = 25.5 \times \cos 4 \, (\tan 49.5 - \tan 4) + 4$$
$$= 32.0 \; m$$

(b) Using Table 2 Method 1 (App B)

Look up table entry for lower angle of +4 and upper angle between 49 (1.08) and 50 (1.12)

= 1.10

Multiply this by slope distance.

= 1.10 x 25.5
= 28.1

Add datum = 28.1 + 4

Total height = 32.1 m

2. Percent scale and length tape.

Use the instructions for method 1 except for the following:

* Readings of upper and lower angles are in percentages.

* Tree height is derived from Height Method 2 or calculated on a programmed calculator.

Example:

Slope dist = 25.5 m (d)
Upper angle = 118 % (P)
Lower angle = 8 % (Q)
Datum = 4 m (c)

(a) Using Tree Height Method 2 (App C.2)

$$H = 25.5 \times (118 - 8) / \sqrt{10000 + 8^2} + 4$$
$$= 32.0\ m$$

(b) Using Table 3 Method 2 (App B)

Look up table entry for lower angle of +8 and upper angle of 118.

= 1.10

Multiply this by slope distance.

= 1.10 x 25.5
= 28.1
Add datum = 28.1 + 4

Total height = 32.1 m

3. The 45 degree method.

Tree height is obtained directly by this method with no calculation required. This method is best used on flat ground or on slopes less than 5°:

* Find a position from where the top of the tree can be seen at an upper angle of exactly 45° or 100 %, and where a horizontal lower angle intersects the stem at a point within 2 metres of ground level.

* Measure the horizontal distance to the tree and add the stem length below the horizontal by continuing the tape down the stem to ground level.

* Total tree height is the (above) horizontal distance including datum height.

Example:

Horizontal dist	= 18.0 m
Datum	= 1.4 m
Total height	= 19.4 m

4. **Set scales and target staff.**

Tree height may be obtained directly from scales provided on hypsometers such as the Suunto or Blume-Leiss:

* The assistant holds or hangs the staff vertically underneath the tree top. With a leaning tree this may be some distance from the tree stem.

* The observer chooses one of the set distances (15 or 20m) or multiples of these. The observer adjusts their distance from the tree, while viewing the staff through the hypsometer's rangefinder, until the reversed double image of the plates coincide.

* The assistant then notes the rangefinder scale that is being used.

* The observer reads the lower angle (to upper plate of staff) of the appropriate scale in degrees or percent. If this reading is greater than 5° (9%) plus or minus, then consult methods 5 or 6 and use the appropriate tables. If the lower reading is within the above limits, then read off the appropriate hypsometer scale in metres and call the reading to the assistant who records it.

* The observer then reads the upper angle (to the tree top) from the same scale and calls the reading to the assistant who records it.

* The assistant records the datum height above ground level.

* Tree height is worked out directly, without the aid of a calculator or tables.

Example:

Distance	= 40 m
Scale used	= 20 m
Upper reading	= +23.5 m
Lower reading	= -1.5 m
Datum	= 4 m
Upper - Lower	= 23.5 - (-1.5)
	= 25.0

Multiply this by distance/scale (40/20=2)

	= 25 x 2
	= 50
Add datum	= 50 + 4
Total height	= 54 m

5. **Degrees scale and adjustable rangefinder.**

* The assistant holds or hangs the staff vertically underneath the tree top. With a leaning tree this may be some distance from the tree stem.

* While the observer views the staff through the rangefinder of the hypsometer, the assistant slowly moves the adjustable lower plate until the observer indicates that the reversed double image of the plates coincide.

* The assistant records the rangefinder distance as shown on the staff.

* The observer reads the lower angle (to upper plate of the staff) in degrees. This reading is called to the assistant who records it.

* The observer reads the upper angle (to the tree top) in degrees and calls the reading to the assistant who records it.

* The assistant records the datum height above ground level.

* Tree height is derived from Height Method 5 or calculated on a programmed calculator.

Example:

Slope dist = 26 m (d)
Upper angle = +47.5° (A)
Lower angle = -1.5° (B)
Datum = 2 m (c)

(a) Using Tree Height Method 5 (App C.2)

$$H = 26 \times Cos^2(-1.5) \left[Tan\ 47.5 - Tan(-1.5)\right] (1 + 0.03 \times Tan\ 47.5) + 2$$
$$= 31.0\ m$$

(b) Using Table 4 Method 5 (App B)

Look up table entry for lower angle of -2 and upper angle of between 47 (11.0) and 48 (11.4)
= 11.2

Multiply this by slope distance / 10

= 11.2 x 26 / 10
= 29.1
Add datum = 29.1 + 2

Total height = 31.1 m

6. **Percent scale and adjustable rangefinder.**

Use the instructions for Method 5 except for the following:

* Readings of upper and lower angles are in percentages.

* Tree height is derived from Height Method 6 or calculated on a programmed calculator.

Example:

Slope dist = 26 m (d)
Upper angle = +110 % (P)
Lower angle = -3 % (Q)
Datum = 2 m (c)

(a) Using Tree Height Method 6 (App C.2)

$$H = 26 \times \left[(110 - (-3)) \times (100 + 0.03 \times (-3)) / (10000 + (-3)^2)\right] + 2$$
$$= 31.3\ m$$

(b) Using Table 5 Method 6 (App B)

Look up table entry for lower angle of -3 and upper angle of 110.
= 11.3

Multiply this by slope distance/10.

= 11.3 x 26 / 10
= 29.4
Add datum = 29.4 + 2

Total height = 31.4 m

A.3 DIAMETER MEASUREMENT

DBH measurements should be made with a girth tape with readings in millimetres * 3.14159. The tape should be held at right angles to the stem axis. Fibreglass tapes are satisfactory for trees up to 60cm in diameter but steel tapes should be used for anything larger.

A.4 PREDOMINANT MEAN HEIGHT (PMH)

A.4.1 Construct Quadrants

* To derive PMH, each plot (circular or diamond) has to be divided into 0.01 hectare (100 sq.m) quadrants.

* There should be at least four quadrants to each plot and in large and variable plots more quadrants should be used.

* Plots of 0.04 hectares :

  Divide plot into four equal sectors by using half diagonals or radii at 90° to demarcate the boundaries.

* Plots greater than 0.04 hectares :

  Theoretically construct a 0.04 hectare circular plot within the larger plot, by measuring along the existing radii or diagonals, and proceed as above.

A.4.2 Choose Tallest Tree

Select the tallest tree in each quadrant. Where it is difficult to decide the tallest of two trees, place yourself in a position of equal distance from both trees and along a line at right angles to a line linking the two trees. The tallest trees may change from year to year so re-selection must be done at each measurement.

A.4.3 Measure Height

Measure each selected "predominant" tree for height using one of the methods described in Appendix A.2. Record each tree height with the tree number and code (App A.6.3). A predominant may be a forked tree, have a broken top and other abnormalities in form or taper; as long as it is alive to its measured tip.

A.5 CALIBRATION CHECKS

All measuring equipment must be checked before the start of a measuring season. Checks involve comparing an instrument with a known standard as indicated.

A.5.1 Length Tapes

These should be compared with a survey chain or steel tape over at least 20m. The accepted tolerance is 2mm.

A.5.2 Diameter Tapes

The numbers on diameter tapes generally wear out before these tapes give incorrect measurements. However, fibreglass tapes can be checked against a steel tape. The total length of the tape should be ± 0.5mm of the true length.

A.5.3 Hypsometers And Compasses

Height measuring equipment, which combines the use of a hypsometer and range-finder or tape, should be checked against an accurately measured vertical pole or side of a building. The standard should be at least 18 metres in height. Estimated height should be within ± 2% of true height.

Angle measuring instruments can also be checked for their accuracy in measuring angles (elevation, depression, and horizontal). A bench test, if available, should prove that the instrument can measure an angle within a quarter of a degree over 8 metres.

A.6 STANDARD CODING

Plots should have an experiment and plot number. Sub experiments and subplots should be used only where necessary because of a statistical design.

When the growth modelling data is pooled, the plot index information, abbreviations and codes will need to be standardised. The codes used at present in the F.R.I. PSP system are as follows:

1. Plot identification - a 13 character field consisting of:

   2 alphabetic
   4 numeric (experiment)
   2 numeric (sub exp)
   3 numeric (plot)
   2 numeric (sub plot)

2. Tree status

blank	= normal living
X	= dead
F	= thinned or felled
W	= windthrow

3. Height tree classification

P	= predominant tree
PS	= predominant and sample tree
S	= sample tree
N	= not suitable as a sample tree
PN	= predominant tree, bad form

4. Plot index

Controller	4 alphabetic
Species	5 alphabetic
Seedlot	20 alphanumeric
Forest	4 alphabetic
Compartment	4 numeric
Stand no	4 numeric
Year planted	4 numeric
Spacing	8 numeric
Volume table	4 : 1 alpha 3 numeric
Height model	3 : 1 alpha 2 numeric
Latitude	4 numeric
Longitude	4 numeric
Altitude	4 numeric
Plot type	4 alphabetic
Plot status	1 alphabetic

APPENDIX B TABLES

TABLE 1 : Slope Corrections (for plot radii and diagonals)

Slope in degrees	Radius for circular plots (m)				Half diagonals for diamond plots (m)			
	Plot size in hectares				Plot size in hectares			
	0.04	0.08	0.10	0.20	0.04	0.08	0.10	0.20
0	11.28	15.96	17.84	25.23	14.14	20.00	22.36	31.62
1	11.28	15.96	17.84	25.23	14.14	20.00	22.36	31.63
2	11.29	15.96	17.85	25.24	14.15	20.01	22.37	31.64
3	11.29	15.97	17.85	25.25	14.16	20.03	22.39	31.67
4	11.30	15.98	17.86	25.26	14.18	20.05	22.42	31.70
5	11.31	15.99	17.88	25.28	14.20	20.08	22.45	31.74
6	11.31	16.00	17.89	25.30	14.22	20.11	22.48	31.80
7	11.33	16.02	17.91	25.33	14.25	20.15	22.53	31.86
8	11.34	16.04	17.93	25.36	14.28	20.20	22.58	31.93
9	11.35	16.06	17.95	25.39	14.32	20.25	22.64	32.02
10	11.37	16.08	17.98	25.43	14.36	20.31	22.71	32.11
11	11.39	16.11	18.01	25.47	14.41	20.37	22.78	32.21
12	11.41	16.13	18.04	25.51	14.46	20.45	22.86	32.33
13	11.43	16.17	18.07	25.56	14.51	20.53	22.95	32.45
14	11.46	16.20	18.11	25.61	14.58	20.61	23.05	32.59
15	11.48	16.24	18.15	25.67	14.64	20.71	23.15	32.74
16	11.51	16.28	18.20	25.73	14.71	20.81	23.26	32.90
17	11.54	16.32	18.24	25.80	14.79	20.91	23.38	33.07
18	11.57	16.36	18.29	25.87	14.87	21.03	23.51	33.25
19	11.60	16.41	18.35	25.95	14.96	21.15	23.65	33.44
20	11.64	16.46	18.40	26.03	15.05	21.28	23.80	33.65
21	11.68	16.52	18.46	26.11	15.15	21.42	23.95	33.87
22	11.72	16.57	18.53	26.20	15.25	21.57	24.12	34.11
23	11.76	16.63	18.60	26.30	15.36	21.73	24.29	34.35
24	11.81	16.70	18.67	26.40	15.48	21.89	24.48	34.62
25	11.85	16.76	18.74	26.50	15.60	22.07	24.67	34.89
26	11.90	16.83	18.82	26.61	15.73	22.25	24.88	35.18
27	11.95	16.91	18.90	26.73	15.87	22.45	25.10	35.49
28	12.01	16.98	18.99	26.85	16.02	22.65	25.33	35.82
29	12.07	17.06	19.08	26.98	16.17	22.87	25.57	36.16
30	12.13	17.15	19.17	27.11	16.33	23.09	25.82	36.51
31	12.19	17.24	19.27	27.25	16.50	23.33	26.09	36.89
32	12.25	17.33	19.37	27.40	16.68	23.58	26.37	37.29
33	12.32	17.43	19.48	27.55	16.86	23.85	26.66	37.71
34	12.39	17.53	19.59	27.71	17.06	24.12	26.97	38.14
35	12.47	17.63	19.71	27.88	17.26	24.42	27.30	38.60
36	12.55	17.74	19.84	28.05	17.48	24.72	27.64	39.09
37	12.63	17.86	19.96	28.23	17.71	25.04	28.00	39.60
38	12.71	17.98	20.10	28.42	17.95	25.38	28.38	40.13
39	12.80	18.10	20.24	28.62	18.20	25.74	28.77	40.69
40	12.89	18.23	20.38	28.83	18.46	26.11	29.19	41.28
41	12.99	18.37	20.54	29.04	18.74	26.50	29.63	41.90
42	13.09	18.51	20.70	29.27	19.03	26.91	30.09	42.55
43	13.19	18.66	20.86	29.50	19.34	27.35	30.57	43.24
44	13.30	18.81	21.04	29.75	19.66	27.80	31.09	43.96
45	13.42	18.98	21.22	30.01	20.00	28.28	31.62	44.72

TABLE 2 : Height Method 1 (Degrees)

Height in Metres for 1 m **Tape** Distance with Upper and Lower Angles in **Degrees**

Lower Angle	Upper Angle																				
	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
-30	1.00	1.02	1.04	1.06	1.08	1.11	1.13	1.15	1.18	1.20	1.23	1.25	1.28	1.31	1.34	1.37	1.40	1.43	1.46	1.50	1.53
-29	0.99	1.01	1.03	1.05	1.07	1.10	1.12	1.14	1.17	1.19	1.22	1.25	1.27	1.30	1.33	1.36	1.39	1.42	1.46	1.49	1.53
-28	0.98	1.00	1.02	1.04	1.07	1.09	1.11	1.13	1.16	1.18	1.21	1.24	1.26	1.29	1.32	1.35	1.38	1.42	1.45	1.49	1.52
-27	0.97	0.99	1.01	1.03	1.05	1.08	1.10	1.13	1.15	1.18	1.20	1.23	1.26	1.28	1.31	1.34	1.38	1.41	1.44	1.48	1.52
-26	0.96	0.98	1.00	1.02	1.04	1.07	1.09	1.12	1.14	1.17	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.40	1.44	1.47	1.51
-25	0.95	0.97	0.99	1.01	1.03	1.06	1.08	1.11	1.13	1.16	1.18	1.21	1.24	1.27	1.30	1.33	1.36	1.39	1.43	1.47	1.50
-24	0.93	0.96	0.98	1.00	1.02	1.05	1.07	1.10	1.12	1.15	1.17	1.20	1.23	1.26	1.29	1.32	1.35	1.39	1.42	1.46	1.50
-23	0.92	0.94	0.97	0.99	1.01	1.04	1.06	1.08	1.11	1.14	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45	1.49
-22	0.91	0.93	0.95	0.98	1.00	1.02	1.05	1.07	1.10	1.13	1.15	1.18	1.21	1.24	1.27	1.30	1.33	1.37	1.40	1.44	1.48
-21	0.90	0.92	0.94	0.96	0.99	1.01	1.04	1.06	1.09	1.11	1.14	1.17	1.20	1.23	1.26	1.29	1.33	1.36	1.40	1.43	1.47
-20	0.88	0.91	0.93	0.95	0.98	1.00	1.02	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.32	1.35	1.39	1.42	1.46
-19	0.87	0.89	0.92	0.94	0.96	0.99	1.01	1.04	1.06	1.09	1.12	1.15	1.18	1.21	1.24	1.27	1.30	1.34	1.38	1.41	1.45
-18	0.86	0.88	0.90	0.93	0.95	0.97	1.00	1.03	1.05	1.08	1.11	1.14	1.17	1.20	1.23	1.26	1.29	1.33	1.37	1.40	1.44
-17	0.84	0.87	0.89	0.91	0.94	0.96	0.99	1.01	1.04	1.07	1.09	1.12	1.15	1.18	1.22	1.25	1.28	1.32	1.35	1.39	1.43
-16	0.83	0.85	0.88	0.90	0.92	0.95	0.97	1.00	1.03	1.05	1.08	1.11	1.14	1.17	1.20	1.24	1.27	1.31	1.34	1.38	1.42
-15	0.82	0.84	0.86	0.89	0.91	0.94	0.96	0.99	1.01	1.04	1.07	1.10	1.13	1.16	1.19	1.22	1.26	1.29	1.33	1.37	1.41
-14	0.80	0.82	0.85	0.87	0.90	0.92	0.95	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.18	1.21	1.25	1.28	1.32	1.36	1.40
-13	0.79	0.81	0.83	0.86	0.88	0.91	0.93	0.96	0.99	1.01	1.04	1.07	1.10	1.13	1.17	1.20	1.23	1.27	1.31	1.35	1.39
-12	0.77	0.80	0.82	0.84	0.87	0.89	0.92	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.19	1.22	1.26	1.29	1.33	1.37
-11	0.76	0.78	0.80	0.83	0.85	0.88	0.90	0.93	0.96	0.99	1.01	1.04	1.07	1.11	1.14	1.17	1.21	1.24	1.28	1.32	1.36
-10	0.74	0.77	0.79	0.81	0.84	0.86	0.89	0.92	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.16	1.19	1.23	1.27	1.31	1.35
-9	0.73	0.75	0.77	0.80	0.82	0.85	0.87	0.90	0.93	0.96	0.99	1.02	1.05	1.08	1.11	1.14	1.18	1.22	1.25	1.29	1.33
-8	0.71	0.73	0.76	0.78	0.81	0.83	0.86	0.89	0.91	0.94	0.97	1.00	1.03	1.06	1.10	1.13	1.16	1.20	1.24	1.28	1.32
-7	0.69	0.72	0.74	0.77	0.79	0.82	0.84	0.87	0.90	0.93	0.95	0.98	1.02	1.05	1.08	1.11	1.15	1.19	1.22	1.26	1.30
-6	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.06	1.10	1.13	1.17	1.21	1.25	1.29
-5	0.66	0.69	0.71	0.73	0.76	0.78	0.81	0.84	0.87	0.89	0.92	0.95	0.98	1.02	1.05	1.08	1.12	1.16	1.19	1.23	1.27
-4	0.65	0.67	0.69	0.72	0.74	0.77	0.79	0.82	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.07	1.10	1.14	1.18	1.22	1.26
-3	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.86	0.89	0.92	0.95	0.98	1.02	1.05	1.09	1.12	1.16	1.20	1.24
-2	0.61	0.64	0.66	0.68	0.71	0.73	0.76	0.79	0.82	0.84	0.87	0.90	0.93	0.97	1.00	1.03	1.07	1.11	1.14	1.18	1.23
-1	0.59	0.62	0.64	0.67	0.69	0.72	0.74	0.77	0.80	0.83	0.86	0.89	0.92	0.95	0.98	1.02	1.05	1.09	1.13	1.17	1.21
0	0.58	0.60	0.62	0.65	0.67	0.70	0.73	0.75	0.78	0.81	0.84	0.87	0.90	0.93	0.97	1.00	1.04	1.07	1.11	1.15	1.19
1	0.56	0.58	0.61	0.63	0.66	0.68	0.71	0.74	0.76	0.79	0.82	0.85	0.88	0.91	0.95	0.98	1.02	1.05	1.09	1.13	1.17
2	0.54	0.57	0.59	0.61	0.64	0.66	0.69	0.72	0.75	0.77	0.80	0.83	0.86	0.90	0.93	0.96	1.00	1.04	1.08	1.11	1.16
3	0.52	0.55	0.57	0.60	0.62	0.65	0.67	0.70	0.73	0.76	0.79	0.82	0.85	0.88	0.91	0.95	0.98	1.02	1.06	1.10	1.14
4	0.51	0.53	0.55	0.58	0.60	0.63	0.66	0.68	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.08	1.12
5	0.49	0.51	0.54	0.56	0.58	0.61	0.64	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.87	0.91	0.94	0.98	1.02	1.06	1.10
6	0.47	0.49	0.52	0.54	0.57	0.59	0.62	0.64	0.67	0.70	0.73	0.76	0.79	0.82	0.86	0.89	0.93	0.96	1.00	1.04	1.08
7	0.45	0.47	0.50	0.52	0.55	0.57	0.60	0.63	0.65	0.68	0.71	0.74	0.77	0.80	0.84	0.87	0.91	0.94	0.98	1.02	1.06
8	0.43	0.46	0.48	0.50	0.53	0.55	0.58	0.61	0.63	0.66	0.69	0.72	0.75	0.78	0.82	0.85	0.89	0.92	0.96	1.00	1.04
9	0.41	0.44	0.46	0.48	0.51	0.54	0.56	0.59	0.62	0.64	0.67	0.70	0.73	0.76	0.80	0.83	0.87	0.90	0.94	0.98	1.02
10	0.39	0.42	0.44	0.47	0.49	0.52	0.54	0.57	0.60	0.62	0.65	0.68	0.71	0.74	0.78	0.81	0.85	0.88	0.92	0.96	1.00

NOTE: Multiply tape distance by table value and add datum to obtain total tree height.

TABLE 3 : Height Method 2 (Percent)

Height in Metres for 1 m Tape Distance with Upper and Lower Readings in Percent

Lower Angle	Upper Angle																		
	46	50	54	58	62	66	70	74	78	82	86	90	94	98	102	106	110	114	118
-58	0.90	0.93	0.97	1.00	1.04	1.07	1.11	1.14	1.18	1.21	1.25	1.28	1.31	1.35	1.38	1.42	1.45	1.49	1.52
-56	0.89	0.92	0.96	0.99	1.03	1.06	1.10	1.13	1.17	1.20	1.24	1.27	1.31	1.34	1.38	1.41	1.45	1.48	1.52
-54	0.88	0.92	0.95	0.99	1.02	1.06	1.09	1.13	1.16	1.20	1.23	1.27	1.30	1.34	1.37	1.41	1.44	1.48	1.51
-52	0.87	0.90	0.94	0.98	1.01	1.05	1.08	1.12	1.15	1.19	1.22	1.26	1.30	1.33	1.37	1.40	1.44	1.47	1.51
-50	0.86	0.89	0.93	0.97	1.00	1.04	1.07	1.11	1.14	1.18	1.22	1.25	1.29	1.32	1.36	1.40	1.43	1.47	1.50
-48	0.85	0.88	0.92	0.96	0.99	1.03	1.06	1.10	1.14	1.17	1.21	1.24	1.28	1.32	1.35	1.39	1.42	1.46	1.50
-46	0.84	0.87	0.91	0.94	0.98	1.02	1.05	1.09	1.13	1.16	1.20	1.24	1.27	1.31	1.34	1.38	1.42	1.45	1.49
-44	0.82	0.86	0.90	0.93	0.97	1.01	1.04	1.08	1.12	1.15	1.19	1.23	1.26	1.30	1.34	1.37	1.41	1.45	1.48
-42	0.81	0.85	0.89	0.92	0.96	1.00	1.03	1.07	1.11	1.14	1.18	1.22	1.25	1.29	1.33	1.36	1.40	1.44	1.48
-40	0.80	0.84	0.87	0.91	0.95	0.98	1.02	1.06	1.10	1.13	1.17	1.21	1.24	1.28	1.32	1.36	1.39	1.43	1.47
-38	0.79	0.82	0.86	0.90	0.93	0.97	1.01	1.05	1.08	1.12	1.16	1.20	1.23	1.27	1.31	1.35	1.38	1.42	1.46
-36	0.77	0.81	0.85	0.88	0.92	0.96	1.00	1.03	1.07	1.11	1.15	1.19	1.22	1.26	1.30	1.34	1.37	1.41	1.45
-34	0.76	0.80	0.83	0.87	0.91	0.95	0.98	1.02	1.06	1.10	1.14	1.17	1.21	1.25	1.29	1.33	1.36	1.40	1.44
-32	0.74	0.78	0.82	0.86	0.90	0.93	0.97	1.01	1.05	1.09	1.12	1.16	1.20	1.24	1.28	1.31	1.35	1.39	1.43
-30	0.73	0.77	0.80	0.84	0.88	0.92	0.96	1.00	1.03	1.07	1.11	1.15	1.19	1.23	1.26	1.30	1.34	1.38	1.42
-28	0.71	0.75	0.79	0.83	0.87	0.91	0.94	0.98	1.02	1.06	1.10	1.14	1.17	1.21	1.25	1.29	1.33	1.37	1.41
-26	0.70	0.74	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.35	1.39
-24	0.68	0.72	0.76	0.80	0.84	0.88	0.91	0.95	0.99	1.03	1.07	1.11	1.15	1.19	1.23	1.26	1.30	1.34	1.38
-22	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.05	1.09	1.13	1.17	1.21	1.25	1.29	1.33	1.37
-20	0.65	0.69	0.73	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.27	1.31	1.35
-18	0.63	0.67	0.71	0.75	0.79	0.83	0.87	0.91	0.94	0.98	1.02	1.06	1.10	1.14	1.18	1.22	1.26	1.30	1.34
-16	0.61	0.65	0.69	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05	1.09	1.13	1.17	1.20	1.24	1.28	1.32
-14	0.59	0.63	0.67	0.71	0.75	0.79	0.83	0.87	0.91	0.95	0.99	1.03	1.07	1.11	1.15	1.19	1.23	1.27	1.31
-12	0.58	0.62	0.66	0.70	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05	1.09	1.13	1.17	1.21	1.25	1.29
-10	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.03	1.07	1.11	1.15	1.19	1.23	1.27
-8	0.54	0.58	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.06	1.10	1.14	1.18	1.22	1.26
-6	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16	1.20	1.24
-4	0.50	0.54	0.58	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.06	1.10	1.14	1.18	1.22
-2	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16	1.20
0	0.46	0.50	0.54	0.58	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.06	1.10	1.14	1.18
2	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16
4	0.42	0.46	0.50	0.54	0.58	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.06	1.10	1.14
6	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12
8	0.38	0.42	0.46	0.50	0.54	0.58	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.06	1.10
10	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.03	1.07
12	0.34	0.38	0.42	0.46	0.50	0.54	0.58	0.62	0.66	0.70	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05
14	0.32	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.67	0.71	0.75	0.79	0.83	0.87	0.91	0.95	0.99	1.03
16	0.30	0.34	0.38	0.41	0.45	0.49	0.53	0.57	0.61	0.65	0.69	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01
18	0.28	0.31	0.35	0.39	0.43	0.47	0.51	0.55	0.59	0.63	0.67	0.71	0.75	0.79	0.83	0.87	0.91	0.94	0.98

NOTE: Multiply tape distance by table value and add datum height to obtain total tree height.

TABLE 4 : Height Method 5

Height in Metres for 10 m **Rangefinder** Distance with Upper and Lower Angles in **Degrees**

	upper angle																							
	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
-30	8.5	8.7	8.9	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.7	10.9	11.1	11.4	11.6	11.9	12.2	12.4	12.7	13.0	13.4	13.7	14.0
-29	8.5	8.7	8.9	9.1	9.2	9.4	9.6	9.8	10.0	10.3	10.5	10.7	10.9	11.2	11.4	11.7	12.0	12.2	12.5	12.8	13.1	13.5	13.8	14.2
-28	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	11.0	11.2	11.5	11.8	12.0	12.3	12.6	12.9	13.2	13.6	13.9	14.3
-27	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.8	11.0	11.3	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	14.0	14.4
-26	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.6	10.8	11.0	11.3	11.6	11.8	12.1	12.4	12.7	13.0	13.4	13.7	14.1	14.4
-25	8.5	8.6	8.8	9.0	9.2	9.4	9.7	9.9	10.1	10.3	10.6	10.8	11.1	11.3	11.6	11.9	12.2	12.5	12.8	13.1	13.4	13.8	14.1	14.5
-24	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.9	10.1	10.3	10.6	10.8	11.1	11.3	11.6	11.9	12.2	12.5	12.8	13.1	13.5	13.8	14.2	14.6
-23	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.9	10.1	10.3	10.6	10.8	11.1	11.4	11.6	11.9	12.2	12.5	12.8	13.2	13.5	13.9	14.3	14.7
-22	8.3	8.5	8.7	8.9	9.2	9.4	9.6	9.8	10.1	10.3	10.6	10.8	11.1	11.4	11.6	11.9	12.2	12.5	12.9	13.2	13.6	13.9	14.3	14.7
-21	8.3	8.5	8.7	8.9	9.1	9.3	9.6	9.8	10.0	10.3	10.5	10.8	11.1	11.3	11.6	11.9	12.2	12.5	12.9	13.2	13.6	13.9	14.3	14.7
-20	8.2	8.4	8.6	8.9	9.1	9.3	9.5	9.8	10.0	10.3	10.5	10.8	11.0	11.3	11.6	11.9	12.2	12.5	12.9	13.2	13.6	14.0	14.4	14.8
-19	8.2	8.4	8.6	8.8	9.0	9.2	9.5	9.7	10.0	10.2	10.5	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.9	13.2	13.6	14.0	14.4	14.8
-18	8.1	8.3	8.5	8.7	9.0	9.2	9.4	9.7	9.9	10.2	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.9	13.2	13.6	14.0	14.4	14.8
-17	8.0	8.2	8.4	8.7	8.9	9.1	9.4	9.6	9.8	10.1	10.4	10.6	10.9	11.2	11.5	11.8	12.2	12.5	12.8	13.2	13.6	14.0	14.4	14.8
-16	7.9	8.1	8.4	8.6	8.8	9.0	9.3	9.5	9.8	10.0	10.3	10.6	10.9	11.2	11.5	11.8	12.1	12.5	12.8	13.2	13.5	13.9	14.4	14.8
-15	7.8	8.0	8.3	8.5	8.7	9.0	9.2	9.5	9.7	10.0	10.2	10.5	10.8	11.1	11.4	11.7	12.1	12.4	12.8	13.1	13.5	13.9	14.3	14.8
-14	7.7	7.9	8.2	8.4	8.6	8.9	9.1	9.4	9.6	9.9	10.2	10.5	10.7	11.0	11.4	11.7	12.0	12.4	12.7	13.1	13.5	13.9	14.3	14.7
-13	7.6	7.8	8.1	8.3	8.5	8.8	9.0	9.3	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.3	12.6	13.0	13.4	13.8	14.2	14.7
-12	7.5	7.7	8.0	8.2	8.4	8.7	8.9	9.2	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.5	11.9	12.2	12.6	13.0	13.4	13.8	14.2	14.6
-11	7.4	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.8	12.1	12.5	12.9	13.3	13.7	14.1	14.6
-10	7.3	7.5	7.7	8.0	8.2	8.5	8.7	9.0	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.7	12.0	12.4	12.8	13.2	13.6	14.0	14.5
-9	7.1	7.4	7.6	7.8	8.1	8.3	8.6	8.9	9.1	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.6	11.9	12.3	12.7	13.1	13.5	14.0	14.4
-8	7.0	7.2	7.5	7.7	8.0	8.2	8.5	8.7	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.5	11.8	12.2	12.6	13.0	13.4	13.9	14.3
-7	6.9	7.1	7.3	7.6	7.8	8.1	8.3	8.6	8.9	9.2	9.4	9.7	10.0	10.4	10.7	11.0	11.4	11.7	12.1	12.5	12.9	13.3	13.8	14.2
-6	6.7	7.0	7.2	7.4	7.7	7.9	8.2	8.5	8.7	9.0	9.3	9.6	9.9	10.2	10.6	10.9	11.2	11.6	12.0	12.4	12.8	13.2	13.7	14.1
-5	6.6	6.8	7.1	7.3	7.5	7.8	8.1	8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.8	11.1	11.5	11.9	12.3	12.7	13.1	13.5	14.0
-4	6.4	6.7	6.9	7.1	7.4	7.6	7.9	8.2	8.5	8.7	9.0	9.3	9.6	10.0	10.3	10.6	11.0	11.3	11.7	12.1	12.5	13.0	13.4	13.9
-3	6.3	6.5	6.7	7.0	7.2	7.5	7.8	8.0	8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.5	10.8	11.2	11.6	12.0	12.4	12.8	13.3	13.7
-2	6.1	6.3	6.6	6.8	7.1	7.3	7.6	7.9	8.1	8.4	8.7	9.0	9.3	9.7	10.0	10.3	10.7	11.0	11.4	11.8	12.2	12.7	13.1	13.6
-1	5.9	6.2	6.4	6.7	6.9	7.2	7.4	7.7	8.0	8.3	8.6	8.9	9.2	9.5	9.8	10.2	10.5	10.9	11.3	11.7	12.1	12.5	13.0	13.4
0	5.8	6.0	6.2	6.5	6.7	7.0	7.3	7.5	7.8	8.1	8.4	8.7	9.0	9.3	9.7	10.0	10.4	10.7	11.1	11.5	11.9	12.3	12.8	13.3
1	5.6	5.8	6.1	6.3	6.6	6.8	7.1	7.4	7.6	7.9	8.2	8.5	8.8	9.2	9.5	9.8	10.2	10.6	10.9	11.3	11.7	12.2	12.6	13.1
2	5.4	5.7	5.9	6.1	6.4	6.7	6.9	7.2	7.5	7.7	8.0	8.3	8.7	9.0	9.3	9.6	10.0	10.4	10.8	11.2	11.6	12.0	12.4	12.9
3	5.2	5.5	5.7	6.0	6.2	6.5	6.7	7.0	7.3	7.6	7.9	8.2	8.5	8.8	9.1	9.5	9.8	10.2	10.6	11.0	11.4	11.8	12.3	12.7
4	5.1	5.3	5.5	5.8	6.0	6.3	6.5	6.8	7.1	7.4	7.7	8.0	8.3	8.6	8.9	9.3	9.6	10.0	10.4	10.8	11.2	11.6	12.1	12.5
5	4.9	5.1	5.3	5.6	5.8	6.1	6.4	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.1	9.4	9.8	10.2	10.6	11.0	11.4	11.9	12.3
6	4.7	4.9	5.2	5.4	5.6	5.9	6.2	6.4	6.7	7.0	7.3	7.6	7.9	8.2	8.5	8.9	9.2	9.6	10.0	10.4	10.8	11.2	11.7	12.1
7	4.5	4.7	5.0	5.2	5.5	5.7	6.0	6.2	6.5	6.8	7.1	7.4	7.7	8.0	8.3	8.7	9.0	9.4	9.8	10.2	10.6	11.0	11.4	11.9
8	4.3	4.5	4.8	5.0	5.3	5.5	5.8	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.5	8.8	9.2	9.6	9.9	10.4	10.8	11.2	11.7
9	4.1	4.3	4.6	4.8	5.1	5.3	5.6	5.8	6.1	6.4	6.7	7.0	7.3	7.6	7.9	8.2	8.6	9.0	9.3	9.7	10.1	10.6	11.0	11.5
10	3.9	4.1	4.4	4.6	4.9	5.1	5.4	5.6	5.9	6.2	6.5	6.8	7.1	7.4	7.7	8.0	8.4	8.7	9.1	9.5	9.9	10.3	10.8	11.2
11	3.7	3.9	4.2	4.4	4.7	4.9	5.2	5.4	5.7	6.0	6.2	6.5	6.8	7.2	7.5	7.8	8.2	8.5	8.9	9.3	9.7	10.1	10.5	11.0
12	3.5	3.7	4.0	4.2	4.4	4.7	4.9	5.2	5.5	5.8	6.0	6.3	6.6	6.9	7.3	7.6	7.9	8.3	8.6	9.0	9.4	9.8	10.3	10.7
13	3.3	3.5	3.8	4.0	4.2	4.5	4.7	5.0	5.3	5.5	5.8	6.1	6.4	6.7	7.0	7.4	7.7	8.0	8.4	8.8	9.2	9.6	10.0	10.5
14	3.1	3.3	3.6	3.8	4.0	4.3	4.5	4.8	5.0	5.3	5.6	5.9	6.2	6.5	6.8	7.1	7.5	7.8	8.2	8.5	8.9	9.3	9.8	10.2
15	2.9	3.1	3.4	3.6	3.8	4.1	4.3	4.6	4.8	5.1	5.4	5.7	5.9	6.3	6.6	6.9	7.2	7.6	7.9	8.3	8.7	9.1	9.5	10.0

TABLE 5 : Height Method 6

Height in Metres for 10 m **Rangefinder** Distance with Upper and Lower Angles in **Percent**

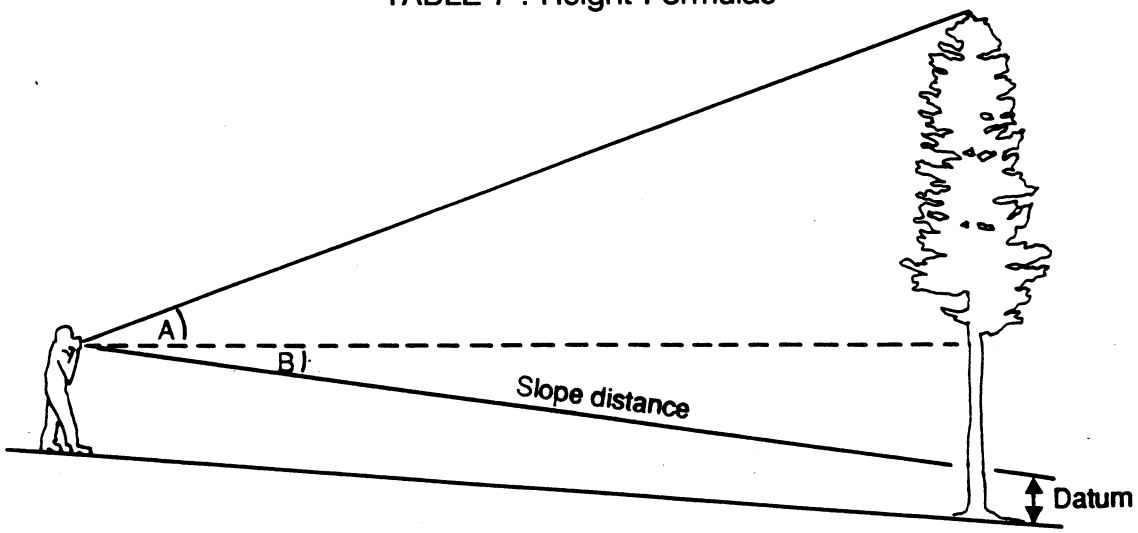
	upper angle																						
	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
-50	7.6	7.7	7.8	7.9	8.0	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.1	9.1	9.2	9.3	9.4	9.5
-49	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.3	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.1	9.1	9.2	9.3	9.4	9.5
-48	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.3	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.1	9.1	9.2	9.3	9.4	9.5
-47	7.6	7.7	7.8	7.8	7.9	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.2	9.3	9.4	9.4
-46	7.6	7.7	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.5	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.2	9.3	9.4	9.4
-45	7.5	7.6	7.7	7.8	7.9	8.0	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8	8.9	8.9	9.0	9.1	9.2	9.3	9.4	9.4
-44	7.5	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8	8.8	8.9	9.0	9.1	9.2	9.3	9.3	9.4
-43	7.5	7.6	7.7	7.7	7.8	7.9	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.1	9.2	9.2	9.3	9.4
-42	7.5	7.6	7.6	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.1	9.1	9.2	9.3	9.4
-41	7.4	7.5	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.5	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.2	9.3	9.4
-40	7.4	7.5	7.6	7.7	7.8	7.8	7.9	8.0	8.1	8.2	8.3	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.9	9.0	9.1	9.2	9.3	9.4
-39	7.4	7.5	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4
-38	7.3	7.4	7.5	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.2	9.3
-37	7.3	7.4	7.5	7.6	7.7	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.2	9.3
-36	7.3	7.4	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.8	8.9	9.0	9.1	9.2	9.3
-35	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3
-34	7.2	7.3	7.4	7.5	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.2
-33	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.8	8.9	9.0	9.1	9.2
-32	7.1	7.2	7.3	7.4	7.5	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2
-31	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.9	9.0	9.1
-30	7.0	7.1	7.2	7.3	7.4	7.5	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.5	8.6	8.7	8.8	8.9	9.0	9.1
-29	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1
-28	6.9	7.0	7.1	7.2	7.3	7.4	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9	9.0
-27	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0
-26	6.8	6.9	7.0	7.1	7.2	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9
-25	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9
-24	6.7	6.8	6.9	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8
-23	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8
-22	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.6	8.7
-21	6.5	6.6	6.7	6.8	6.9	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7
-20	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6
-19	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.3	8.4	8.5
-18	6.3	6.4	6.5	6.6	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5
-17	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4
-16	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.2	8.3
-15	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3
-14	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2
-13	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1
-12	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1
-11	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0
-10	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9
-9	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8
-8	5.5	5.6	5.7	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7
-7	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.1	7.2	7.3	7.4	7.5	7.6
-6	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6
-5	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5
-4	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4
-3	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3
-2	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2
-1	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1
0	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0
1	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9
2	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8
3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7
4	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6
5	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5
6	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4
7	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3
8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2
9	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1
10	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0
11	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.7	5.8
12	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7
13	3.4	3.5	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6
14	3.3	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5
15	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4
16	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3
17	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2
18	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1
19	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
20	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.8
21	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7
22	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6
23	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5
24	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4
25	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3

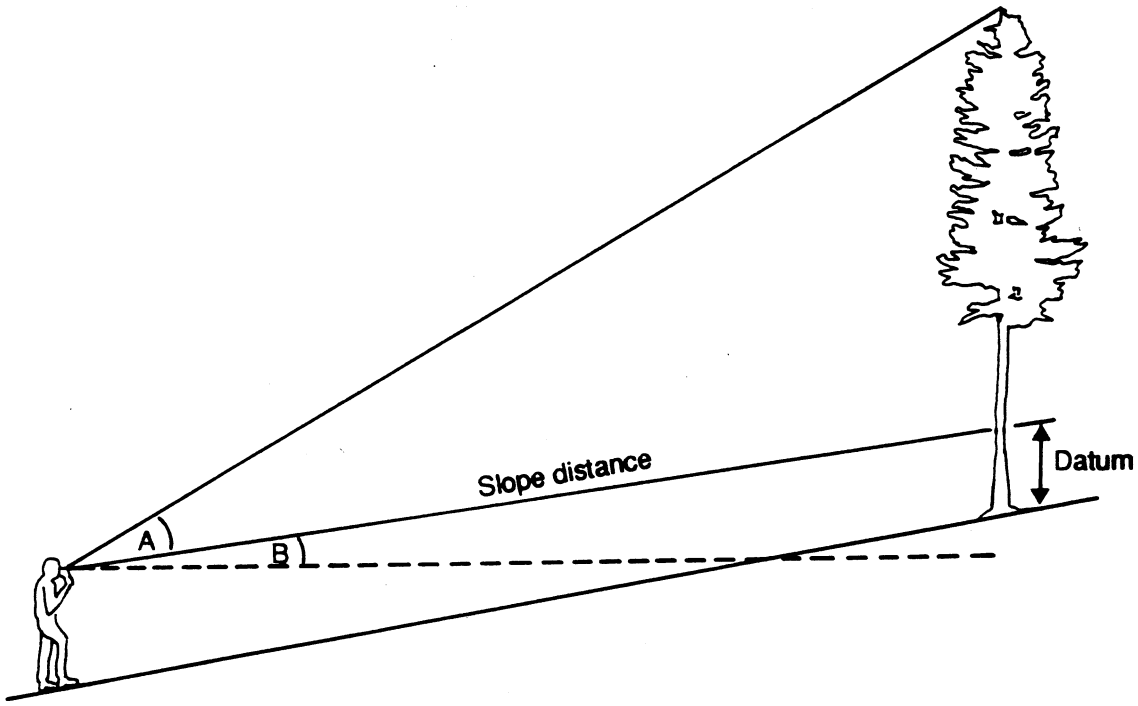
TABLE 6 : Height Method 6 cont.

Height in Metres for 10 m **Rangefinder** Distance with Upper and Lower Angles in **Percent**

	upper angle																						
	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118
-50	9.6	9.8	9.9	10.1	10.2	10.4	10.6	10.7	10.9	11.0	11.2	11.3	11.5	11.7	11.8	12.0	12.1	12.3	12.5	12.6	12.8	12.9	13.1	13.2
-49	9.6	9.8	9.9	10.1	10.2	10.4	10.6	10.7	10.9	11.0	11.2	11.4	11.5	11.7	11.8	12.0	12.2	12.3	12.5	12.6	12.8	13.0	13.1	13.3
-48	9.6	9.8	9.9	10.1	10.3	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.5	11.7	11.9	12.0	12.2	12.3	12.5	12.7	12.8	13.0	13.1	13.3
-47	9.6	9.8	9.9	10.1	10.3	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.5	11.7	11.9	12.0	12.2	12.4	12.5	12.7	12.8	13.0	13.2	13.3
-46	9.6	9.8	9.9	10.1	10.3	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.7	11.9	12.0	12.2	12.4	12.5	12.7	12.9	13.0	13.2	13.3
-45	9.6	9.8	9.9	10.1	10.3	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.7	11.9	12.1	12.2	12.4	12.6	12.7	12.9	13.0	13.2	13.4
-44	9.6	9.8	9.9	10.1	10.3	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.7	11.9	12.1	12.2	12.4	12.6	12.7	12.9	13.1	13.2	13.4
-43	9.6	9.7	9.9	10.1	10.2	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.7	11.9	12.1	12.2	12.4	12.6	12.7	12.9	13.1	13.2	13.4
-42	9.6	9.7	9.9	10.1	10.2	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.8	11.9	12.1	12.3	12.4	12.6	12.8	12.9	13.1	13.3	13.4
-41	9.6	9.7	9.9	10.1	10.2	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.8	11.9	12.1	12.3	12.4	12.6	12.8	12.9	13.1	13.3	13.4
-40	9.5	9.7	9.9	10.1	10.2	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.8	11.9	12.1	12.3	12.4	12.6	12.8	12.9	13.1	13.3	13.5
-39	9.5	9.7	9.9	10.0	10.2	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.6	11.8	11.9	12.1	12.3	12.4	12.6	12.8	13.0	13.1	13.3	13.5
-38	9.5	9.7	9.8	10.0	10.2	10.4	10.5	10.7	10.9	11.1	11.2	11.4	11.6	11.7	11.9	12.1	12.3	12.4	12.6	12.8	13.0	13.1	13.3	13.5
-37	9.5	9.7	9.8	10.0	10.2	10.4	10.5	10.7	10.9	11.0	11.2	11.4	11.6	11.7	11.9	12.1	12.3	12.4	12.6	12.8	13.0	13.1	13.3	13.5
-36	9.5	9.6	9.8	10.0	10.2	10.3	10.5	10.7	10.9	11.0	11.2	11.4	11.6	11.7	11.9	12.1	12.3	12.4	12.6	12.8	13.0	13.1	13.3	13.5
-35	9.4	9.6	9.8	10.0	10.1	10.3	10.5	10.7	10.8	11.0	11.2	11.4	11.5	11.7	11.9	12.1	12.3	12.4	12.6	12.8	13.0	13.1	13.3	13.5
-34	9.4	9.6	9.8	9.9	10.1	10.3	10.5	10.6	10.8	11.0	11.2	11.4	11.5	11.7	11.9	12.1	12.2	12.4	12.6	12.8	13.0	13.1	13.3	13.5
-33	9.4	9.6	9.7	9.9	10.1	10.3	10.4	10.6	10.8	11.0	11.2	11.3	11.5	11.7	11.9	12.1	12.2	12.4	12.6	12.8	12.9	13.1	13.3	13.5
-32	9.3	9.5	9.7	9.9	10.1	10.2	10.4	10.6	10.8	11.0	11.1	11.3	11.5	11.7	11.9	12.0	12.2	12.4	12.6	12.8	12.9	13.1	13.3	13.5
-31	9.3	9.5	9.7	9.9	10.0	10.2	10.4	10.6	10.8	10.9	11.1	11.3	11.5	11.7	11.8	12.0	12.2	12.4	12.6	12.7	12.9	13.1	13.3	13.5
-30	9.3	9.5	9.6	9.8	10.0	10.2	10.4	10.5	10.7	10.9	11.1	11.3	11.5	11.6	11.8	12.0	12.2	12.4	12.5	12.7	12.9	13.1	13.3	13.5
-29	9.2	9.4	9.6	9.8	10.0	10.1	10.3	10.5	10.7	10.9	11.1	11.2	11.4	11.6	11.8	12.0	12.2	12.3	12.5	12.7	12.9	13.1	13.3	13.4
-28	9.2	9.4	9.6	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.0	11.2	11.4	11.6	11.8	12.0	12.1	12.3	12.5	12.7	12.9	13.1	13.2	13.4
-27	9.2	9.3	9.5	9.7	9.9	10.1	10.3	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.7	11.9	12.1	12.3	12.5	12.7	12.9	13.0	13.2	13.4
-26	9.1	9.3	9.5	9.7	9.9	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.6	12.8	13.0	13.2	13.4
-25	9.1	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.2	12.4	12.6	12.8	13.0	13.2	13.4
-24	9.0	9.2	9.4	9.6	9.8	10.0	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.1	13.3
-23	9.0	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.5	12.7	12.9	13.1	13.3
-22	8.9	9.1	9.3	9.5	9.7	9.9	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.7	11.9	12.1	12.3	12.5	12.7	12.9	13.1	13.3
-21	8.9	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.7	12.8	13.0	13.2
-20	8.8	9.0	9.2	9.4	9.6	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.0	12.2	12.4	12.6	12.8	13.0	13.2
-19	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.1
-18	8.7	8.9	9.1	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	11.9	12.1	12.3	12.5	12.7	12.9	13.1
-17	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.7	12.9	13.1
-16	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0
-15	8.5	8.7	8.9	9.1	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	12.9
-14	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.7	12.9
-13	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.0	12.2	12.4	12.6	12.8
-12	8.3	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8
-11	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.7
-10	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.6	11.8	12.0	12.2	12.4	12.6
-9	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6
-8	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5
-7	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4
-6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3
-5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3
-4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2
-3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1
-2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0
-1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	11.9
0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8
1	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7
2	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6
3	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5
4	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4
5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3
6	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2
7	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1
8	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0
9	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8
10	6.2	6.4	6.6	6.8	7.0	7.2	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7
11	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6
12	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5
13	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4
14	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.8	10.0	10.2
15	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1
16	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0
17	5.4	5.6	5.8	6.0	6.2	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9
18	5.3	5.5	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.3	9.5	9.7
19	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.4	8.6	8.8	9.0	9.2	9.4	9.6
20	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5
21	4.9	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.3
22	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.4	8.6	8.8	9.0	9.2
23	4.7	4.9	5.1	5.3	5.5	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1
24	4.6	4.8	5.0	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0
25	4.5	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.2	8.4	8.6	8.8

TABLE 7 : Height Formulae





Method 1. $H = d \times Cos\ B\ (Tan\ A - TanB) + c$

Method 2. $H = d \times (P - Q) / \sqrt{10000 + Q^2} + c$

Method 5. $H = d \times Cos^2\ B\ (Tan\ A - Tan\ B)\ (1 + 0.03 \times Tan\ B) + c$

Method 6. $H = d \times (P - Q)\ (100 + 0.03 \times Q) / (10000 + Q^2) + c$

where	H	=	total tree height in metres
	d	=	slope distance (m) by range finder or tape
	A and P	=	angle in degrees and angle in percent to top of tree
	B and Q	=	angle in degrees and angle in percent to datum
	c	=	datum or height (m) above ground level of lower reading

APPENDIX C DEFINITIONS, FORMULAE, PRECISION

C.1 MEASUREMENTS AND DEFINITIONS

Ground level

A horizontal level at the base of the tree on the uphill side after slash and loose material has been removed.

Diameter at breast height (DBH)

Diameter on breast height mark on tree or overbark diameter at 1.4 metres above ground level.

Total tree height

Vertical distance from ground level to uppermost green foliage on tree.

Sample height tree

Living tree of normal form that is measured for height.

Mean DBH

Diameter derived from the average basal area of the plot.

Mean Top DBH

Mean DBH (as above) for the largest by DBH 100 trees/hectare.

Mean Top Height (MTH)

The height for the Mean Top DBH derived from the height/diameter regression.

Predominant Mean Height (PMH)

A predominant is the tallest tree on an area of 0.01 hectare. Predominant mean height is the mean height of at least four predominants.

Green Crown Height

The base of the green crown is the point midway between the lowest green branch and the lowest whorl where the majority of branches are green. In all cases, the height should be measured to the line of foliage where any irregularities of shape are balanced out on all sides.

Pruned Height

Vertical distance (rounded to nearest tenth-metre) from ground level to first unpruned or partly pruned whorl.

Diameter over stubs (DOS)

Diameter over branch stubs of the largest pruned whorl.

DOS Height

The height (to nearest tenth metre) from ground level to the largest pruned whorl.

C.2 FORMULAE

(a) **Plot area**

Circular

$$A = \pi \times r^2$$

$$r = \sqrt{\frac{A}{\pi}}$$

$$R = \frac{r}{\sqrt{\cos s}}$$

Diamond

$$A = 2 \times d_o \times d_s$$

$$d_s = \frac{d_o}{\cos s}$$

where

A	=	area of plot (sq. m)
π	=	3.14159
r	=	horizontal radius (m)
s	=	slope in degrees
R	=	radius on slope s
cos s	=	cosine of s
d_o	=	half diagonal on level ground (m)
d_s	=	half diagonal on line of maximum slope (m)

(b) **Tree girth** $\pi \times D$

(c) **Basal area** $\pi \times D \times \frac{D}{4}$

(d) **Plot basal area** $\frac{\pi}{4} \times \sum D^2$

(e) **Sample tree volume**

$$V = \exp[a \times \ln(D) + b \times \ln (H^2 / (H - 1.4)) + c]$$

where
V = tree volume (underbark) in cu.m.
D = DBH overbark in cm
H = total tree height in metres
ln = natural logarithm
exp = antilog
a, b, c are constants dependent on species and locality

(f) **Tree height**

Method 1. Degree scale - Length tape

$$H = d \times Cos\ B\ (Tan\ A - TanB) + c$$

Method 2. Percent scale - Length tape

$$H = d \times (P - Q) / \sqrt{10000 + Q^2} + c$$

Method 5. Degree scale - Adjustable rangefinder

$$H = d \times Cos^2\ B\ (Tan\ A - Tan\ B)\ (1 + 0.03 \times Tan\ B) + c$$

Method 6. Percent scale - Adjustable rangefinder

$$H = d \times (P - Q)\ (100 + 0.03 \times Q) / (10000 + Q^2) + c$$

where
H = total tree height in metres
d = range finder or tape distance (m)
A ; P = angle in degrees ; angle in percent to top of tree
B ; Q = angle in degrees ; angle in percent to datum
c = datum or height (m) above ground level of lower reading (zero if tree reading is to the tree base)
Cos, Tan Cosine and tangent of angle in degrees

(g) **Mean DBH**

$$\sqrt{\frac{1}{n} \times \sum D^2}$$

C.3 STANDARDS OF PRECISION

Source	Precision (+ or -)
Plot area	1%
Plot radius or 1/2 diagonal	10cm
Bearings (angle of 90 degrees)	0.5dg
Tree girth	1%
Tree basal area (girth tape)	3%
Tree height (hypsometer)	3%
Crown depth (hypsometer)	3%
Sample tree volume (single tree)	12%
Plot volume (12 trees)	6%
Mean top height	0.5m
Assessment of growing stock using 2D volume equation (20 plots of 12 sample trees each)	12%