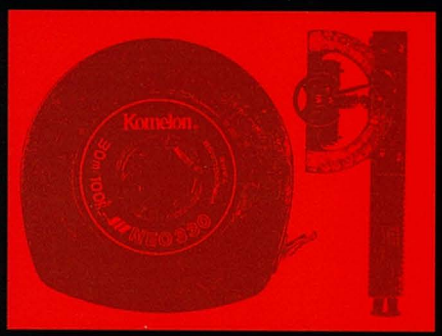
Field guide for sample plots in New Zealand forests

J. C. Ellis & J. D. Hayes



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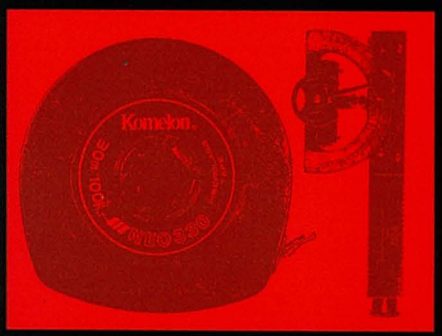

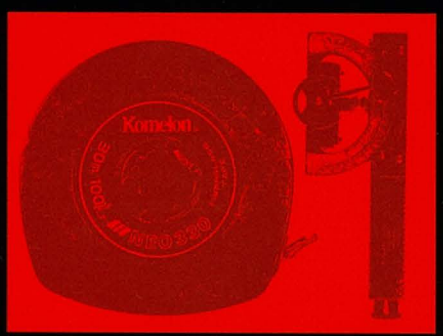

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FIELD GUIDE FOR SAMPLE PLOTS IN NEW ZEALAND FORESTS

J.C. Ellis

J.D. Hayes

New Zealand Forest Research Institute Limited
Private Bag 3020, Rotorua, New Zealand

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Photography:	Forest Mensuration field team, FRI
	David Blake Photography, Rotorua, New Zealand
Editing:	Ruth Gadgil, FRI
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CONTENTS

ABSTRACT

This is a reference book for those involved in the establishment and measurement of sample plots in New Zealand. It is designed to help forestry personnel achieve a high standard of precision in sample plot measurements.

The first sections define forestry terms and show how the basic diameter and height measurements are taken. The latter sections give guidelines for plot establishment, location, and the minimum data to be collected.

Many of the measurement errors associated with sample plots are presented, and then realistic standards of precision are suggested.

PREFACE

This manual is designed as a reference for people involved in the establishment and measurement of sample plots. It covers both growth monitoring (modelling) and experimental (research) plots.

The information used as a basis for this document was prepared for an unpublished report for the Stand Growth Modelling Research Cooperative to set minimum standards for the establishment and measurement of plots for growth modelling data. Forest research is dependent on accurate and consecutive tree measurements and basic standards are set here for the collection of data, including abbreviations, precision, and calibration. Records assembled in this way can be integrated with those of other forest organisations.

Certain standards differ from those applied in the past. We have attempted to make all measurements more objective and less open to individual interpretation.

A number of instruments are mentioned in the text. We have not attempted to cover the whole range, but describe those that are suitable for the tasks because of their size and reliability.

ACKNOWLEDGMENTS

We have drawn from the experience of many people who have worked at the NZ Forest Research Institute and for the NZ Forest Service. The adjustable target staff, now in common use in New Zealand, was designed by W.A.J. van Dijk. Principal contributors for the earlier unpublished report were NZFP Forests, Tasman Forestry, and NZ Timberlands personnel. Messrs Klitscher, Poad, and Lee were responsible for planning photographs to show the appropriate methods.

The authors are grateful to Dr A.G.D. Whyte, University of Canterbury, for his helpful suggestions on the original manuscript and to Mr I. McKinley, leader of the Forest Mensuration and Management Systems field team at FRI, for his help with practical aspects. Finally, we would like to thank people from the forest industry and Forest Technology Division of FRI who reviewed the text.

DEFINITIONS

Words in this guide printed in ***bold*** and ***italics*** are defined as follows:

Average slope

The mean of the angle of maximum slope from the plot centre and the angle of slope at 180° to the line of maximum slope (ignoring plus or minus).

Basal area

BA Sum of the cross-sectional areas at ***breast height*** of all ***stems*** in plot. Expressed in square metres per ha, it is a measure of stand density that is not dependent on ***stem*** numbers.

Breast height

BH A distance of 1.4 metres above ***ground level*** as measured vertically with rod or pole resting against base of tree.

Current annual increment

CAI The growth in ***dbh, basal area,*** volume or height in any single year, expressed per ha (e.g., nett ***CAI*** *MTH,* nett ***basal area,*** gross ***CAI*** volume). Gross ***CAI*** of volume or ***basal area*** includes thinnings and mortality, whereas the nett figures do not.

Datum

A fixed starting point for a series of measurements (in particular, tree heights).

Diameter at breast height

dbh Diameter, over bark, usually expressed in centimetres and tenths, at the ***breast height*** mark on the tree, i.e., diameter at 1.4 metres above ***ground level.***

Diameter over stubs

DOS Diameter, expressed in millimetres, of the tree measured over the branch stubs of the largest pruned whorl in the most recent pruning lift, measured within 1 month of pruning.

DOS height

The height, in metres and tenths, from ***ground level*** to the midpoint of the largest ***DOS*** whorl.

Experimental plot

A plot isolated from the rest of the stand, and from other plots, by buffer areas. Experimental treatments are specified by the personnel in charge of the investigation, usually in a Workplan or Control plan.

Green crown height

The height, in metres and tenths, from ***ground level*** to the base of the green crown, which is the position on the ***stem*** midway between the insertion point of the lowest green branch and the base of the lowest whorl that has a majority of green branches.

Ground level

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

Growth monitoring plot

A plot which receives the same treatment as the surrounding stand.

Mean annual increment

MAI The current volume per ha divided by the current age. This can either include thinnings as a gross figure or exclude thinnings to give nett ***MAI*** in cubic metres per year.

Maximum branch diameter

The horizontal inside-bark diameter, in millimetres, of the largest branch stub on the ***DOS*** whorl, measured within 1 month of pruning.

Mean dbh

Diameter derived from average ***basal area*** (Appendix A.3.7). This is the root mean square of the diameters and is not the same as the arithmetic mean. For example, the ***mean dbh*** calculated from diameters of 5 cm and 7 cm is 6.1 cm.

Mean crop height

MCH *Mean crop height* is the calculated average height, in metres and tenths, of all crop trees in a stand. It is derived either from a height/diameter formula (or graph) for the tree of ***mean dbh*** (as in the FRI ***PSP*** system) or from the arithmetic mean height of a randomly selected group of trees.

Mean top dbh

Mean dbh (derived from average ***basal area***), in centimetres and tenths, of the 100 largest stems/ha by diameter.

Mean top height

MTH The height derived from the height/diameter formula for the ***mean top dbh*** value, see ***mean top dbh*** above.

Permanent sample plot

PSP An area of land containing trees which are measured at intervals (more than once) to determine tree growth.

Predominant height

The height of the tallest tree in any 0.01 ha segment of a sample plot. Segment shape may be rectangular, triangular, circular or may take the form of a circle sector or an annulus.

Predominant mean height

PMH The mean height of ***predominant height*** trees in each 0.01 ha quadrant of a plot, and ***PMH*** is based on at least four quadrants. ***PMH*** is an important measure of height because it is independent of ***stem*** diameter.

Pruned height

Vertical distance on the uphill side of the tree from ***ground level*** to the base of the lowest remaining branch in the first unpruned or partly-pruned whorl. Branches are usually ignored if they are less than 3 mm in diameter or less than 0.3 m above ***ground level***.

Root collar diameter

Diameter, in millimetres, over bark, at ***ground level*** of a tree seedling in the nursery or before the tree is planted out. In a stand, diameter over bark at 0.3 m above ***ground level*** can be used to monitor the early stages of growth until a tree reaches ***breast height***.

Site index

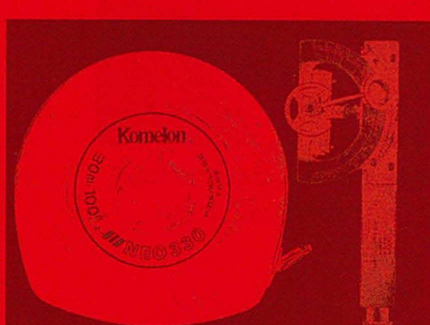
SI ***Mean top height*** at age 20 for *Pinus radiata* or age 40 for *Pseudotsuga menziesii*. This is a measure of the growth potential of a stand.

Stem A tree usually has a single ***stem*** but may consist of two or more ***stems*** if the tree forks below ***breast height***.

Total tree height

Vertical distance, in metres and tenths, from ***ground level*** to the uppermost green foliage of a tree.

SECTION 1
TREE MEASUREMENTS



SECTION 1 - TREE MEASUREMENTS

1.1 DIAMETER

1.1.1 Dbh

Figure 1. ***dbh*** is measured over the ***breast height*** band of the tree or at 1.4 m above ***ground level***. This ***dbh*** is 57.1 cm.

- A girth tape marked in diameter units (girth divided by π), is used to record diameter to the nearest mm.
- The girth tape is placed with its surface flat against the bark of the tree. Loose material such as needles and branches is not included.
- ***Dbh*** is measured at right angles to the length axis of the tree.
- Where the ***dbh*** includes an irregularity or swelling, the measurement level is shifted to the nearest normal position on the ***stem***. If this is more than 15 cm[1] from the 1.4 m level, then measurements taken above and below ***breast height*** are averaged.

[1] Tapering of a tree ***stem*** affects ***dbh*** by more than 1% if this distance is greater than 15 cm.

1.1.2 DOS

Figure 2. ***DOS*** is the maximum diameter measured over the branch stubs of the largest pruned whorl. This ***DOS*** is 19.5cm.

- A girth tape is used and measurements are recorded to the nearest mm.
- ***DOS*** is measured at right angles to the length axis of the tree.

1.1.3 Maximum Branch Diameter

Figure 3. The inside bark diameter of the largest branch in the ***DOS*** whorl is measured at right angles to the length axis of the ***stem***. In this illustration, the ***maximum branch diameter*** is 36 mm.

1.2 HEIGHT

1.2.1 Pole Technique

Figure 4. To measure ***pruned height*** or ***total tree height*** of a standing tree <10 m tall a pole may be used.

- The pole is placed vertically against the tree.
- An observer stands at a distance from the tree greater than the tree height in a position from which both measurement point and the top of the pole can be seen. The observer indicates when the top of the pole is at the same level as the tree tip or the end of the pruned section.
- Measurements are made from ***ground level***.
- If the height pole does not display total height, the user must exercise care when adding together each section length and the height of the pole base from ***ground level***.
- Height is measured to the nearest 0.1 m.

1.2.2 Hypsometer Technique

(1) General use of the hypsometer

Figure 5.

To measure the height of a tree, the distance between the observer and the ***datum***, angles to tree tip and ***datum***, and its height above ***ground level*** are required .

- A line of sight is found at right angles to the plane of maximum lean (see Fig. 6) and preferably on the uphill side of the tree. The direction of lean is determined by finding the position from which the tree appears to lean away only (not to left or right) from the observer. A tree should be viewed from several angles to determine maximum lean.

- To minimise the effect of undetected lean, the measurement location is chosen so that the upper angle (sight line to tree top) is not greater than +50° (120%)[2].

- Plus or minus (i.e., angle above or below horizontal) is called with lower or upper readings.

- Angles are measured to the nearest 0.5° (1%) and distances to the nearest 0.1 m.

- Find an exact position where the top of the tree and the base of the tree (or a convenient ***datum*** within 2 m of the base of the tree) can be seen. Some clearing of scrub may be required.

- If a rangefinder or target staff is used (Fig. 11), the upper plate is always used to mark the ***datum*** height.

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[2] The magnitude of this angle determines the size of the error due to undetected lean. Tests show that skilled observers can fail to detect up to 2.5° lean which results in a height error of 5.2% for a 50° elevation.

- Sometimes it is not possible to measure height at right angles to tree lean. There are three ways of avoiding large errors:
  - Measure the distance from the observer position to a point vertically below the tree top and read the lower angle to that point (***datum***). Measure an additional angle to the base if the ***datum*** is below this ***ground level***. This 'height' to the tree base can then be subtracted.
  - Take two measurements of height from opposite sides (at 180°) of the tree and derive an average height.
  - A mark can be painted on a tree (e.g., 'H') facing the position from which an observer should measure the height at each subsequent measurement. This will not be permanent if the direction of the tree lean changes.

Figure 6. To measure the height of a leaning tree, the observer must stand at right angles to the plane of maximum lean.

(2) Specific hypsometer techniques for measuring height

(a) *Degrees scale and length tape*

Figure 7. Degrees scale and length tape method.

- The observer finds a position where the tree tip and a ***datum*** point, within 2 m 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*** (Fig. 6).
- 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***. Angle readings are recorded in degrees.
- The upper angle[3] should be between +30° and +50°. Tables cover upper angles of +30° to +53° and lower angles of -30° to +15°.
- ***Total tree height*** or the height of any position on the ***stem*** is derived from Height Method 1 (Appendix A.3.6) using a programmable calculator, or read from Table 2 (Appendix B).

[3] A minimum upper angle of 30° is set to keep the error in height within 2% if the upper angle is 0.5° out of true.

Example:

Slope distance	= 6.0 m (d)
Upper angle	= 48.0° (A)
Lower angle	= -5° (B)
Datum height	= 1.4 m (c)

(i) *Using Tree Height Method 1* (Appendix A.3.6)

$$H = 6.0 * Cos(-5) * (Tan(48.0) - Tan(-5)) + 1.4$$
$$= 8.56\,m$$
$$= 8.6\,m$$

If Cos and Tan functions require angles in radians, multiply degree angles by $\pi/180(=0.01745)$.

(ii) *Using Table 2 Method 1* (Appendix B)

Look up table entry for lower angle of -5° and upper angle of 48°
= 1.19
Multiply this by slope distance
= 1.19 * 6.0
= 7.14
Add ***datum*** height = 7.14 + 1.4

Total height = 8.5 m

(b) *Percentage scale and length tape*

Use the instructions for Method 1 except for the following:

- Readings of upper and lower angles are in percentages.
- The upper angle should be between 70% and 120%.
- Total height is derived from Height Method 2 (Appendix A.3.6) using a programmable calculator, or read from Table 3 (Appendix B).

Figure 8. Percentage scale and length tape method.
Percentage scale on right is 8% (5° on left scale).

Example:

Slope distance	= 25.5 m (d)
Upper angle	= 118 % (P)
Lower angle	= 8 % (Q)
Datum height	= 1.4 m (c)

(i) *Using Tree Height Method 2* (Appendix A.3.6)

$$H = \left(25.5 * (118 - 8) / \sqrt{10000 + 8^2}\right) + 1.4$$
$$= 29.36\,m$$
$$= 29.4\,m$$

Note that angle in percent is the Tangent of that angle multiplied by 100.

(ii) *Using Table 3 Method 2* (Appendix B)

Look up table entry for lower angle of +8% and upper angle of 118%.
= 1.10
Multiply this by slope distance
= 1.10 * 25.5
= 28.05
Add ***datum*** height = 28.05 + 1.4
= 29.45

Total height = 29.4 m

(c) *The direct method*

Total tree height is obtained directly by this method. The only calculation required is the addition of the ***datum*** height. This method is best used on flat ground or on slopes less than 5°.

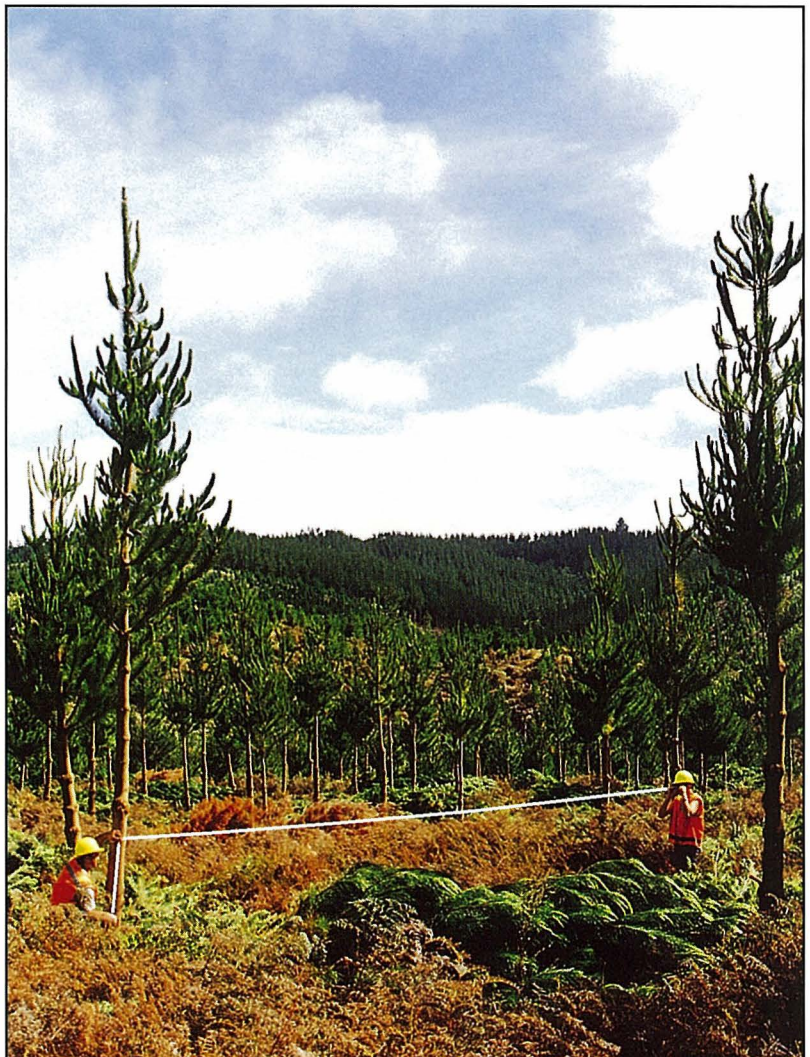


Figure 9.

The direct method.

- Find a position from which the top of the tree can be seen at an upper angle of exactly 45° or 100%, and where a horizontal or lower angle of 0° intersects the ***stem*** at a ***datum*** point within 2 m of ***ground level***.
- Measure the horizontal distance to the tree and add the ***datum*** height by continuing the tape down the ***stem*** to ***ground level***.
- Total height is the horizontal distance plus the ***datum*** height.

Example:

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

(d) *Set scales and target staff*

Height can be derived directly from scales provided on hypsometers such as the Suunto or Blume-Leiss. This method is not acceptable on steep slopes because distances used are assumed to be horizontal.

Figure 10. Observer looks through prism at target staff

- The assistant holds or hangs the target staff at a point vertically below the tree tip. With a leaning tree this may be some distance from the tree ***stem*** (Fig. 6).

- The observer chooses one of the set distances (15, 20, 30, or 40 m) and folds out the required target plates. The distance from the tree is then adjusted, while viewing the staff through the hypsometer's rangefinder, until the reversed double image of the plates coincides. The hypsometer must be held at right angles to the line of sight.

- The assistant then notes the set distance used. Alternatively, the observer may use a tape to set the distance.

- The observer reads the lower angle (to upper plate of target staff) from the appropriate set hypsometer scale. This reading should not exceed 5° (9%)[4]. For larger angles hypsometer Methods 5 or 6 should be used. The appropriate hypsometer reading is called to the assistant, who records it.

- The observer then reads the upper angle (to the tree tip) from the same scale and calls the reading to the assistant who records it. The upper angle should not be greater than +50° or 120%.

- The assistant records the ***datum*** height above ***ground level***.

[4] 5° is the maximum slope for which no correction is required.

- Total height is worked out directly, without the aid of a calculator or tables.

Figure 11.

Target staff

Example:

Distance	= 15 m	Upper angle	= +14.5 m
Scale used	= 15 m	Lower angle	= -1.5 m
Datum height	= 1.4 m		
Upper - Lower	= 14.5 - (-1.5)		
	= 16.0		
Add ***datum*** height	= 16.0 + 1.4		
Total height	= 17.4 m		

Distances double those for set scale and target staff may be used. For example, if the observer was 30 m from the tree in the above example, then its height would have been as follows:

Multiply Upper-Lower by distance/scale (30/15=2)	
	= 16 * 2
	= 32
Add ***datum*** height	= 32 + 1.4
Total height	= 33.4 m

(e) *Degrees scale and adjustable target staff*

Figure 12. Degrees scale and adjustable target staff method.
Degrees scale on right reads 38°. Scales on left are for fixed distances of 15 m and 20 m, right to left.

- The assistant holds or hangs the staff vertically below the tree tip. With a leaning tree this may be some distance from the tree ***stem*** (Fig. 6).

- 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 images of the plates coincide. The assistant moves the lower plate to the nearest half metre division and the observer position is adjusted so that the images coincide again. The hypsometer must be held at right angles to the line of sight.

- The assistant records the distance 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 lower angle[5] should be between -20° and +10°.

- The observer reads the upper angle (to the tree tip) in degrees and calls the reading to the assistant who records it. The upper angle should be between +30° and +50°.

- The assistant records the ***datum*** height (distance between ***ground level*** and the top plate of the adjustable staff).

- ***Total tree height*** is calculated from the equation in Appendix A.3.6 Method 5, in which event a programmable calculator may be used; or height is read from Appendix B Table 4 .

Example:

Rangefinder distance = 26 m (d)
Upper angle = +47.5° (A)
Lower angle = -1.5° (B)
Datum height = 2 m (c)

(i) *Using equation from Appendix A.3.6 Method 5*:

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

If Cos and Tan functions require angles in radians, degree angles are multiplied by $\pi/180$(=0.01745).

(ii) *Using Appendix B Table 4 Method 5:*

Table entry for lower angle of -2 and upper angle of between 47° (11.0) and 48° (11.4)
= 1.12
Multiply this by rangefinder distance
= 1.12 * 26
= 29.1
Add ***datum*** height = 29.1 + 2

Total height = 31.1 m

[5] Values are set for realistic viewing angles. The height formula allows for target plates not being at right angles to the line of sight.

(f) *Percentage scale and adjustable target staff*

Figure 13. Percentage scale and adjustable target staff method.

Method 5 is followed, but upper and lower angles are recorded in percentages:

- The upper reading should be between 70% and 120%.
- The lower reading should be between -35% and +20%
- ***Total tree height*** is calculated from the equation in Appendix A.3.6 Method 6 in which event a programmable calculator may be used; or height is read from Appendix B Table 5.

Example:

Rangefinder distance = 26 m (d)
Upper angle = +110% (P)
Lower angle = -3% (Q)
Datum height = 2 m (c)

(i) *Using equation from Appendix A.3.6 Method 6*:

$$H = 26 * (110 - (-3)) * (100 + 0.03 * (-3)) / (10000 + (-3)^2) + 2$$
$$= 31.33\,m$$
$$= 31.3\,m$$

Note that angle in percentage terms is the Tangent of that angle multiplied by 100.

(ii) *Using Appendix B Table 5 Method 6:*

Look up table entry for lower angle of -3% (between -2% (1.12) and -4% (1.14)) and upper angle of 110%.

= 1.13

Multiply this by rangefinder distance
= 1.13 * 26
= 29.38

Add ***datum*** height = 29.4 + 2

Total height = 31.4 m

(g) *Electronic hypsometers*

(i) *Ultrasonically measured distance*

Figure 14. The Forestor VERTEX electronic hypsometer. This uses ultrasonic technique for measuring distance.

The Forestor VERTEX hypsometer displays height from observed angles and the ultrasonically measured distance between the instrument and a transponder set up as the ***datum*** on or near the tree. A manually measured distance can be entered, if this is desirable, and three height levels can be measured on the same tree.

- The observer finds a position, at a distance from the tree that is similar to the tree height.
- The assistant fixes the transponder to the tree at the ***datum,*** which is vertically below the tree tip. For a leaning tree, the transponder is held at the appropriate point.
- The observer then follows the VERTEX prompts for measuring the angle and distance to the transponder (***datum***), and the angle to the tree tip.
- Electronically-calculated vertical distance (height) values are called to the assistant, who records them.
- Height of the ***datum*** above ***ground level*** or TRP (transponder reference point) must be the same as that entered as a constant into the VERTEX.

(ii) *Laser distance*

Figure 15. The Laser Technology IMPULSE electronic hypsometer. This uses a laser technique to measure distance.

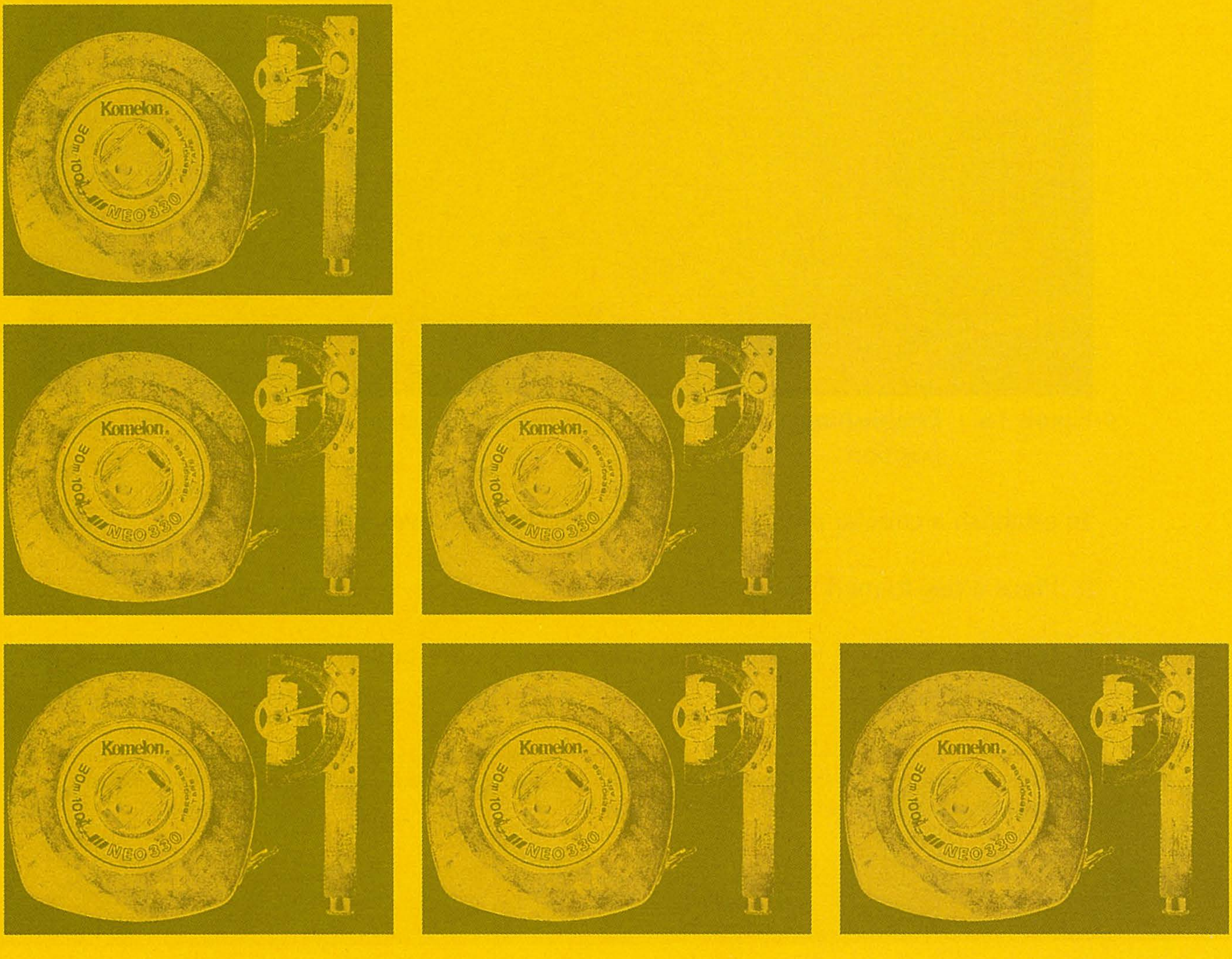
The Laser Technology IMPULSE is an electronic hypsometer which displays height from observed angles and a laser measurement of distance between the instrument and the tree or reflector target. Slope distance and vertical distance are displayed.

- The observer finds a position at a distance from the tree that is similar to the tree height.
- Height is measured in two ways. Either way, the observer should ensure that distances relate to the tree ***stem*** and not to some intervening object.

either using Height (HT) procedure, the distance to the ***datum***, angle to the ***datum*** and to the tree tip are measured. Height is displayed when the FIRE button is pressed. In dense vegetation, the FILTER ON option should be used. A suitable reflectorised target is used to mark the ***datum***,

or using Vertical Distance (VD) procedure, vertical distance between the tree tip or pruned whorl, and a horizontal plane is displayed. The vertical distance from the tree base, which may be above or below the horizontal plane is then displayed. The required height is then derived by manual addition or subtraction. For the VD procedure, tree lean can be ignored. In areas where vegetation or branches impede the line of sight, this method is not suitable. However, the GATE option will screen out unlikely readings.

SECTION 2
PLOT ESTABLISHMENT



SECTION 2 - PLOT ESTABLISHMENT

2.1 PLOT SHAPE

The most popular shapes for ***permanent sample plots*** are circles, squares, or diamonds[6]. Circular plots are often preferred because they have the smallest perimeter for a given area. A four-sided plot is favoured for areas of heavy undergrowth or on steep slopes.

2.2 SETTING OUT PLOTS

2.2.1 Circular Plots

Figure 16. Establishing a circular plot - measuring distance from the plot centre pegged position

To establish a circular plot, a radius is derived from an ***average slope.***

- Place a peg to mark the plot centre.
- Use a hypsometer to find the ***average slope*** of the area in which the plot is to be established.

[6] In New Zealand forestry the term diamond plot is a misnomer. It usually refers to a square plot with one diagonal aligned with the planted rows of trees.

- The ***average slope*** is the mean of the angle of maximum slope from the plot centre and the angle of slope at 180° to the line of maximum slope (ignoring plus and minus).
- If the ***average slope*** is less than 10°, measure the radius by holding a tape horizontally as if for level ground.
- If the ***average slope*** is greater than 10°, use a slope correction table (Appendix B, Table1) to obtain the radius from average slope angle and plot area. The slope-corrected plot radius is used to measure distance in all directions to the plot boundary.

Figure 17. A circular plot.

2.2.2 Diamond Plots

The diamond plot described here is a square plot with one diagonal usually placed between the planted rows of trees.

- Each plot consists of an area defined by four half diagonals.
- Start at a plot centre peg.

- Find the line of maximum slope which passes through the centre peg. Use a hypsometer to find the ***average slope***[7] of this line on which the first half diagonals of the plot will be located. These will usually be in alignment with the planted rows. It is important that the other diagonals are placed at exactly 90° to the first and they will usually lie along the contour (slope zero). A sighting board can be used to measure 90° angles precisely.

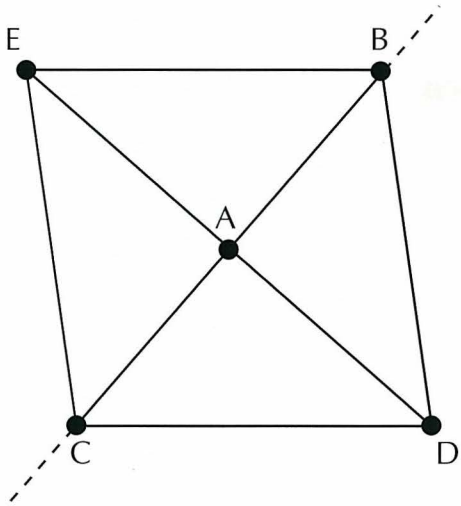
- If the slope of each diagonal is less than 10°, measure the half diagonals by holding a tape horizontally as if for level ground.

- If the maximum slope exceeds 10°, use a slope correction table (Appendix B, Table 1) to obtain the diagonal from the average slope angle and the plot area. The length of the diagonal (on the contour) is unlikely to require slope correction.

- Place corner pegs at the end of each diagonal. Then clear a path between corner pegs on the plot perimeter. The length of each side of the plot should be checked to ensure that variation does not exceed 0.2 m.

Figure 18. A diamond plot.

[7] Definition of average slope is the same as that given for circular plots



A	= Plot centre peg
B, C, D, E	= Plot corner pegs
CB	= Line of maximum slope
AB, AC	= Half-diagonals both corrected for average slope along line CB
AD, AE	= half-diagonals on contour
BD, DC, CE, EB	= Plot boundary

Figure 19. Layout of a diamond shaped plot.

2.3 TREE NUMBERING AND TREE MARKING

Figure 20. Tree ***stem*** with an aluminium tag showing its unique number. ***Breast height*** is marked with a painted band[8] at 1.4 m.

[8] Yellow colour recommended.

Each tree in a plot is marked with a unique number. The ***stem*** is also marked with a painted ***breast height*** band if the tree is tall enough at the time of plot establishment. The ***breast height*** band is painted on smaller trees at a subsequent measurement.

2.3.1 Identify Trees Located Exactly on the Plot Boundary.

To decide whether a tree is to be regarded as inside or outside the plot;

- Assume that the plot boundary and line of sight are at a level of 1.4 m above ground.
- A tree is in the plot if more than half of the tree diameter at ***breast height*** is within the plot boundary.
- Trees forked below ***breast height*** should have any ***stem*** within the plot included as a tree.

2.3.2 Number each Tree in the Plot.

Tree numbers are painted directly on the tree (with yellow paint) or printed on plastic or aluminium tags which are then stapled (using a staple gun) to the tree. Numbers must be printed with waterproof ink or paint. Tags are placed above the ***breast height*** band. Alloy staples (13 mm) are aligned vertically, not across, the ***stem***, so that the staples will not be displaced by diameter growth. Plot quadrant numbering, where used, should not appear with the painted or printed number.

In circular plots, numbering begins with the first tree to the east of magnetic north, and proceeds tree by tree in a clockwise direction. Painted numbers or number tags should be visible from the centre peg. Where a tree consists of two or more ***stems*** due to forking below ***breast height***, one number is used and each separate ***stem*** is distinguished by a letter (for example: 22A; 22B). In a diamond plot, numbering starts at one corner of the plot and proceeds in sequence up and down alternate rows. If the ground slopes, marked numbers should be visible from the uphill side.

2.3.3 Mark each Tree with a *Breast Height* Band Using Yellow Paint.

If ***breast height*** occurs on a swelling or other ***stem*** irregularity, the band is painted in the nearest position where the ***stem*** is normal. If this is more than 15 cm from 1.4 m level, one band is painted above and another below the 1.4 m level so that the two measurements can be averaged. In an alternative approach to the problem, bias can be reduced by marking successive abnormal trees with a single band positioned in turn, either above or below the 1.4 m level. If the ***stem*** forks exactly at 1.4 m, the tree is regarded either as one unit (band below the fork), or as two or more units (bands on each ***stem***). If the tree is young it is better to consider it as one unit, since forks will often grow together later.

If a tree is not tall enough at plot establishment, the ***breast height*** band must be painted at the first measurement after the tree has reached the required height (>1.4 m).

Figure 21. ***dbh*** band shifted from 1.4 m level to 1.25 m to allow for swelling. The diameter band on the next tree with a ***stem*** abnormality at 1.4 m would be painted above 1.4 m.

2.4 IDENTIFICATION

Unless experimental treatments dictate otherwise, a path is cleared between the centre peg and the road. The nearest dominant (main crop) tree on the roadside (the "witness" tree) is painted with two yellow bands at ***breast height,*** and the plot number is painted above this. The path from the witness tree to the plot is marked with painted yellow dots, visible on entering and leaving the plot.

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

2.5 SURVEY

Because of difficulty in relocation of plots, bearings and distances are measured with compass and chain to a known point on the road line. Plot boundary positions, longitude, latitude, and altitude of the plot are also recorded.

2.6 STEM POSITIONS

If information about individual tree locations is required, ***stem*** plotting can be carried out during tree numbering (Section 2.3).

- Start at the line joining the centre peg to the northernmost point of the plot boundary and move in a clockwise (easterly) direction.
- Measure the horizontal distance, or distance and slope, to the centre of the ***breast height*** section of the tree.
- Record the compass bearing to the centre of each tree, at the ***breast height*** level.

Distances and bearings are recorded to the nearest 10 cm and 0.5° respectively.

SECTION 3
PLANNING and LOCATION

SECTION 3 - PLANNING and LOCATION

3.1 NUMBER OF GROWTH MONITORING PLOTS

Each forest owner wishes to know how many ***growth monitoring plots*** to establish in a new forest estate.

In New Zealand, there is an average of one ***permanent sample plot*** to 160 ha of radiata pine plantation. A robust growth model is based on data from plots spread over a representative range of growth conditions, stand density, genetical composition, silvicultural practice, and age. For a plot to be useful in growth modelling, at least two consecutive measurements will be required. Due to natural variability, a total of at least 360 measurement pairs is needed to predict growth behaviour in a specified area. Regional growth models based on large data sets are likely to yield more accurate information than local models with limited coverage.

As a rough guide, owners should consider establishing one plot for every 100 ha stocked.

3.2 PLOT POSITION

3.2.1 'On Map' Plot Positioning

Plots may be established at any time during the life of a stand of trees. Valuable information is gained if plots are established before the first thinning or pruning operations.

(1) Growth monitoring plots

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

Locations for single plots are determined either objectively, using random or systematic selection of grid positions, or subjectively by ensuring accurate representation of the range of variability in the stratum or stand. Existing inventory plots[9] can provide information about the variability of parts of a stand.

A list of compartments or stand areas is compiled. 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 be subdivided into smaller areas in two steps; firstly, for known differences in:

- Species
- Regime
- Age class
- Stands of latest genetic material

[9] Inventory plots are used to estimate basic stand parameters (e.g., stems/ha) for silvicultural operations, stand records, product volume yield or forest valuation.

and secondly, for differences in:

- Soil type
- Altitude
- Aspect
- Stocking variation

Possible plot positions may then be marked on the map.

(2) Experimental plots

These are treated separately from the remainder of the stand, and each measurement plot is surrounded by a buffer area which also receives the experimental treatment.

An ***experimental plot*** is the basic unit of a field research trial. Plots are established in groups using one of a number of standardised statistical trial designs. Generally, each trial investigates the effect of two or more treatments, each replicated several times at one or more sites. In most forests a strict requirement for site uniformity limits the number and size of areas suitable for experimental plot establishment.

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

3.2.2 'In Forest' Plot Positioning

The exact location of the plot in the field will depend on actual conditions within the stand. Rules for locating a plot centre are:

- The plot perimeter or plot buffer outside perimeter must be at least 15 m from any unstocked area.
- Old skid sites and internal logging tracks must be avoided.
- Gaps and windthrown areas must be avoided.
- Exposed ridges and places where height measurement is difficult must be avoided.

3.2.3 Plot Size

- The size of plot should be based on the number of trees per ha at final stocking or at the end of the life of the plot. Each plot should always contain a minimum of 20 trees. Once established, plot size should not be altered. Any unavoidable change must be documented.
- Plot area is always specified on a horizontal plane.

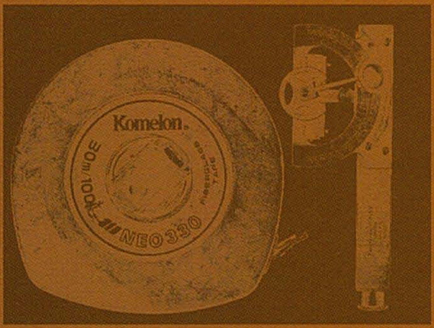
- The minimum size for growth measurement plots is 0.04 ha in stands where final stocking will exceed 600 trees/ha.

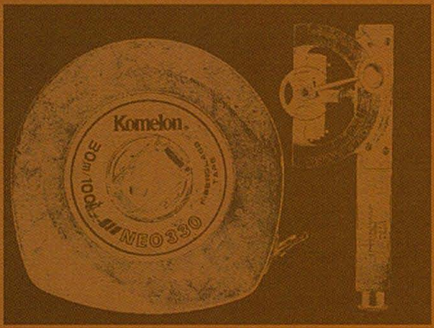
  For other final stocking rates the following plot sizes are recommended:

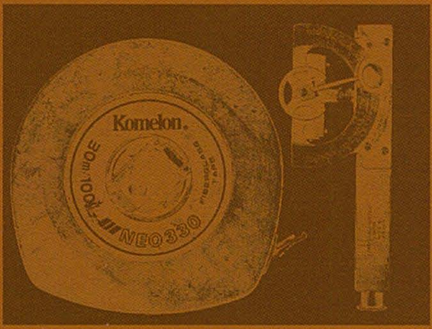
Final stocking (trees/ha)	Plot size (ha)	Radius length circular plots (m)	1/2 diagonal length[10] diamond plots (m)
> 600	0.04	11.28	14.14
300-600	0.08	15.96	20.00
200-300	0.10	17.84	22.36
< 200	0.20	25.23	31.62

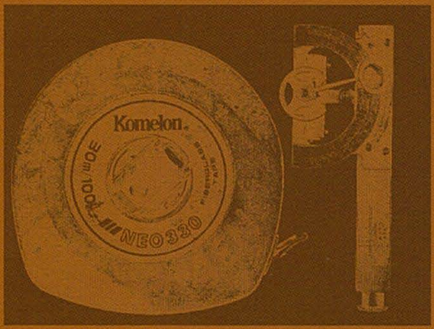
[10] It is easier to establish plots with four half-diagonals.

SECTION 4
TREE MEASUREMENTS in PLOT









SECTION 4 - TREE MEASUREMENTS in PLOT

Except for measurements made at the time of pruning and/or thinning, all ***permanent sample plots*** must be measured between May and August (the dormant season).

4.1 TREE COUNT

At each measurement, every tree within the designated plot area must be accounted for (Section 2.3).

4.2 DBH

Diameter is measured over the ***breast height*** band of every tree in the plot (Section 1.1). The status (normal, felled, dead or windthrow) of the tree (Section 6.3) is recorded at the time of measurement (a blank assumes the tree is alive).

If a tree is not tall enough to have a ***breast height*** band, a nominal diameter (e.g., 0.1 cm) is recorded. If actual values are required, then diameter over bark at 0.3 m above ***ground level*** should be used.

4.3 SAMPLE HEIGHT TREES

- In each plot at least 12 trees, including ***predominant height*** trees (Section 4.4), must be measured for both height and diameter.
- Sample height trees must be alive and must have normal form. Trees forked below ***breast height***, with excessive lean, broken or dead tops are not acceptable.
- The sample is selected to represent the diameter range of trees in the plot.
- After selection, tree number, height (to nearest 0.1 m), and height purpose code (Section 6.3) are recorded.
- Sample height trees, once identified, are measured as sample height trees throughout the life of the plot. Any substitute required due to damage or felling should be of similar diameter to the original sample tree.

4.4 PREDOMINANT HEIGHT TREES

A ***predominant height*** tree is the tallest in each 0.01 ha quadrant of the ***permanent sample plot*** irrespective of size or form. The total plot area is accurately divided into 0.01 ha quadrants (100 m^2). An 0.04 ha circular plot will have four 0.01 ha quadrants defined by radii as sectors. An 0.04 ha diamond plot will have four 0.01 ha quadrants defined by the four half-diagonals and the plot boundaries. In larger circular plots, the 0.01 ha quadrants may be sectors or annuli (Fig. 22). In larger four-sided plots, 0.01 ha quadrants are defined by sides parallel to those of the plot. If no trees are present in one or more quadrants, ***PMH*** is based on fewer trees per plot.

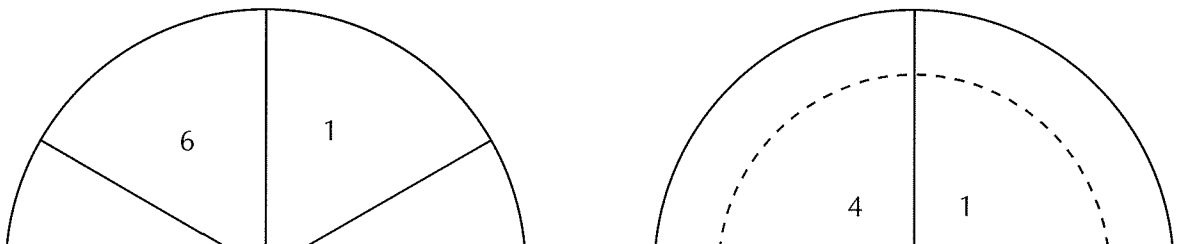


Figure 22. Circular plot of 0.06 ha showing layout of six 0.01 ha quadrants and annuli or six equal sectors.

Tree numbers are recorded with the relevant height value and a height purpose code (Section 6.3). ***Predominant height*** trees should be re-selected at each measurement as they may not always remain predominant in height.

4.5 PRUNED HEIGHT

The ***pruned height*** is measured to the nearest 0.1 m on each tree in the plot (Definitions p.9).

4.6 GREEN CROWN HEIGHT

Green crown height is measured (Fig. 23) on sample height trees until they reach 18 m ***mean top height***.

- If crown closure is incomplete due to late thinning or very wide initial spacing, measurements are made on sample trees taller than 18 m.
- If ***pruned height*** is equal to crown height, ***green crown height*** need not be recorded until there is some change in the crown level.
- The ***green crown height*** on an unpruned tree with green crown to ***ground level*** is recorded as 0.1 m.

4.7 SEEDLOT NUMBER

The complete registered seedlot number is recorded (Section 6.2).

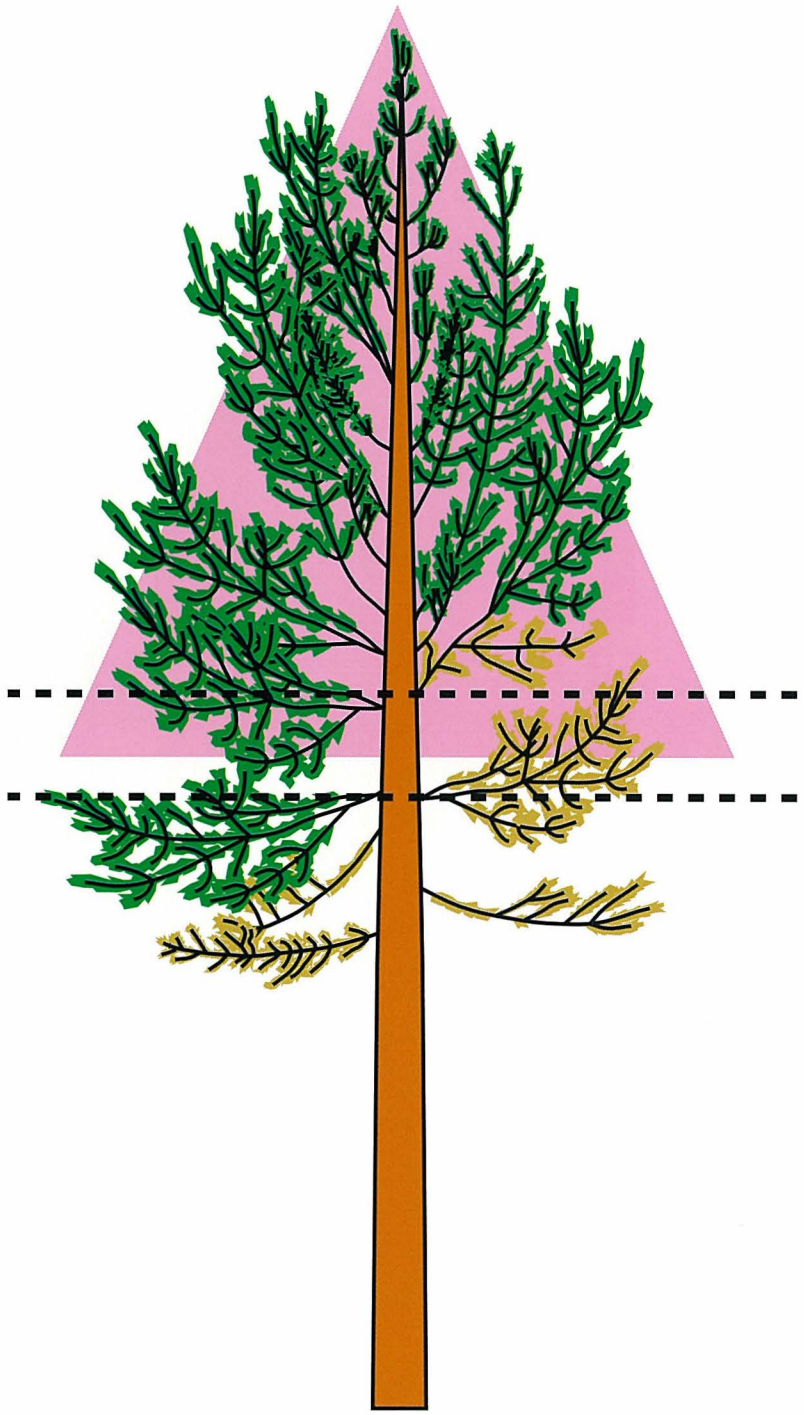
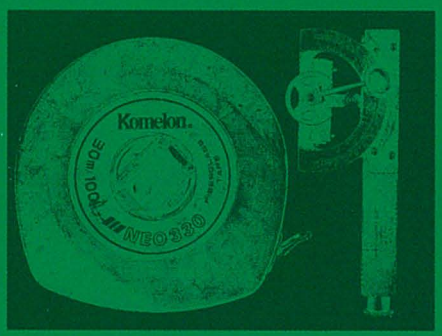
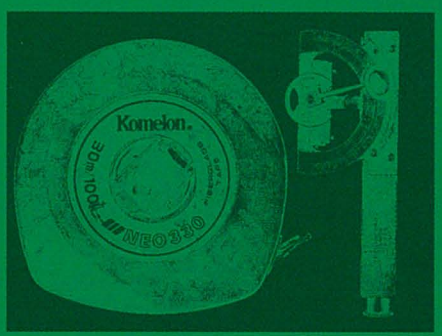


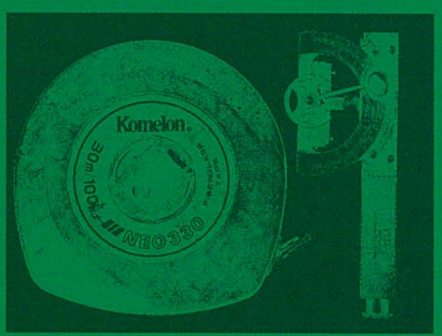
Figure 23. ***Green crown height*** measurement.

The base of the green crown is the position on the ***stem*** which is midway between the insertion point of the lowest green branch and the lowest whorl that has a majority of green branches.

SECTION 5
RE-MEASUREMENT PROCEDURES







SECTION 5 - REMEASUREMENT PROCEDURES

5.1 MAINTENANCE

Plot identification markings on the witness tree should be repainted if necessary.

Tree number markers and ***breast height*** bands should be replaced and/or repainted if they have disappeared since the last measurement. The number of any missing tree(s) should be determined and the correct tree status code (Section 6.3) recorded against the last ***dbh*** measurement.

It is recommended that a yellow colour is used for all plot and tree maintenance. Spray paint is convenient but not as durable as brushed-on paint.

5.2 TIMING

Where the dormant growth period is not well defined, plots should be remeasured in the same month of the year as the previous measurement. In Northland, re-measurement should be in the same week of the month.

5.3 FREQUENCY

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 has been devised to maximise growth information and minimise cost of measuring operations. The forest owner takes the final responsibility for frequency of measurement, basing decisions on forest maturity and the number of plots to be measured.

5.4 EFFECT OF SILVICULTURE

- A pre-thinning and/or pre-pruning measurement is carried out prior to treatment. If possible a visit is arranged soon after treatment to measure ***pruned height***, if this is required, and to make a full measurement or at least a record of diameters of the residual trees.

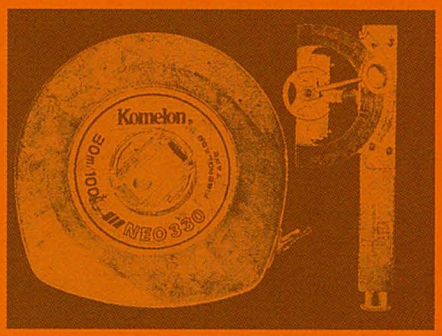
- The date and type of treatment must be entered in the plot records even if a pre-silvicultural or post-silvicultural measurement is missed.

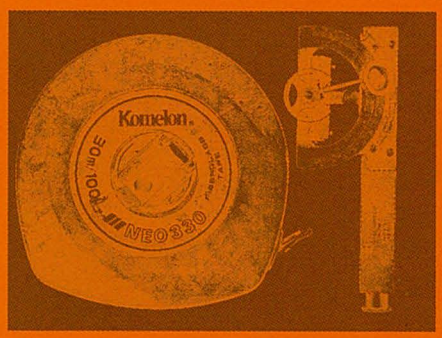
- Annual measurement is recommended for the two seasons following thinning.

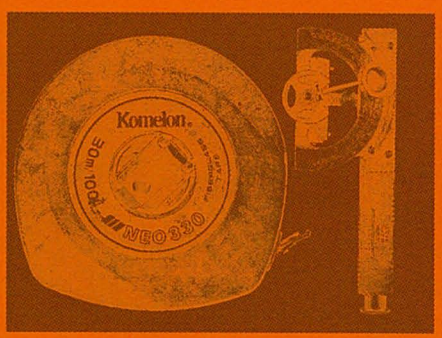
- If a plot is pruned only, ***pruned height*** should be recorded at the next scheduled re-measurement.

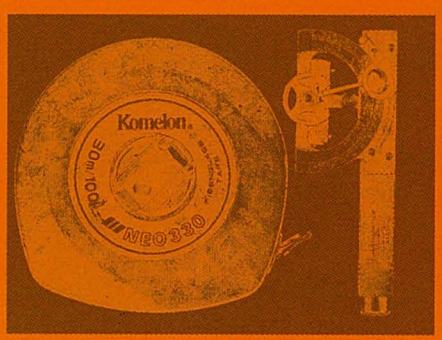
- Plots should be re-measured before they are abandoned or clearfelled.

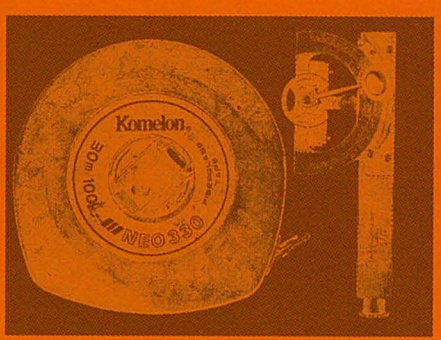
SECTION 6
STANDARD RECORDING PROCEDURES

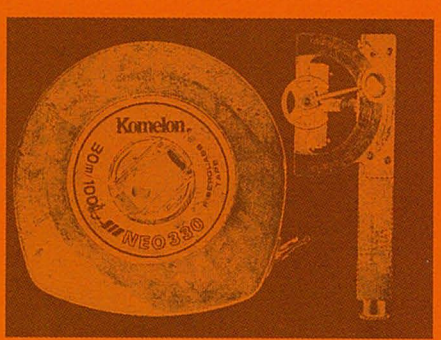












SECTION 6 - STANDARD RECORDING PROCEDURES

Plot locations and plot measurements should be recorded in a consistent way. Each plot record should have a unique identification, plot description, and stand history, and a set of data with measurement dates.

6.1 STANDARD CODING

The Forest Research Institute ***Permanent Sample Plot*** (***PSP***) System (Dunlop, 1995) is a database which uses a series of abbreviations, codes, and measurement descriptors. These are shown below. Standard data recording forms are available and they provide the format of the field measurements.

6.2 PSP PLOT COVER SHEET

A copy of the standard form is shown in Appendix C. The following details are required:

6.2.1 Plot Identification - a 13 character field (e.g., *RO 3278 00 001 00)* consisting of:

Code	2 alphabetic characters signifying region in New Zealand
Experiment	4;2 numeric characters signifying experiment number and sub-number
Plot	3;2 numeric characters signifying plot and sub-plot number

6.2.2 Plot Index

Field	Field Size (N, A, AN)[a]	Example
Forest	4 A	KANG
Compartment	4 N	892
Stand number	4 N	02
Latitude	4 N	38.5
Longitude	5 N	176.5
Altitude	4 N	550
Crop type	4 AN	22YH
Spacing	8 N	2.4 1.8
Plot type	4 A	GROW
Controller	4 A	FRIM
Species	5 A	P.RAD
Year planted	4 N	1985
Volume table [b]	1:3 A:N	T010
Height model [c]	1:2 A:N	H34
Seedlot	20 A	9/0/83/95

[a] N =Numeric, A =Alphabetic, AN =Alphanumeric
[b] Volume table is the number of a tree volume formula based on ***dbh*** and total height.
[c] Height model is one of a number of formulae that relate height growth to age.

6.2.3 Measurement Description

This part of the form is re-used, so that there is provision for six measurement entries.

Field	Field size	Example
Measurement date	2;2 N;N	8;95
Thinning date	2;2 N;N	3;95
Plot area	6 N	0.0400 ha

6.3 PSP DIAMETER / HEIGHT FORM

A copy of the standard form is shown in Appendix C.

Note that this form has provision for printing the previous measurement date and associated measurements so that they can be compared with the current ones. Asterisks denote a field to be entered into the database for the current measurement date. The following details are required:

6.3.1 Plot Identification - see Section 6.2

6.3.2 Measurement Date - see Section 6.2

6.3.3 Tree Characteristics

Field	Field Size	Example
Unique tree number	2;4 N;N	2/10
Species key [d]	1 N	1
Diameter at ***breast height***	5 N	59.6 cm
Tree status [e]	2 A	UF
Total height	4 N	25.3 m
Height purpose code [f]	2 A	PS
Green crown height	4 N	13.5 m
Stem quality - user defined	1 AN	3
Descriptive code [g]	2 A	DT

[d] Species key is derived from the Cover Sheet

[e] Tree status includes the following codes:

Normal, living	(leave blank)
Thinned or felled	F
Dead	X
Dead from windthrow	W

[f] Height purpose

Predominant height tree	P
Sample height tree, representative of the stand	S
Predominant and sample height tree	PS
Not suitable as a sample height tree, but height measured	N
Predominant height tree of bad form	PN

g Descriptive code

Code may be from a standard FRI list or user defined. Examples are:

Dead or defective top	DT
Forked	FK
Growing with excessive lean	LN
Swept	SW
Toppled by wind or snow but still alive	TP

6.4 THE PSP PLOT HISTORY SHEET

Site description and details of silvicultural treatment are required for each plot. A copy of the standard Plot History Sheet is shown in Appendix C.

BACKGROUND READING

Beers, J.E.; Sutton, G.J.; Penman, J. 1983: An evaluation of three stem-plotting methods. *New Zealand Forest Service, FRI Bulletin No. 28.*

Chaturvedi, M.D. 1926: Measurements of the Cubical Contents of Forest Crops. Oxford Forestry Memoirs, OUP, London.

Duff, G. 1960: Methods of measurement and volume calculation for exotic conifers. *New Zealand Forest Service, Forest Research Institute Technical Paper No. 29.*

Dunlop, J.D. 1995: Permanent sample plot system - User Manual. *New Zealand Forest Research Institute, FRI Bulletin No. 187.*

Van Dijk, W.A.J. 1982: A new rangefinder staff for hypsometers. *New Zealand Forest Service, FRI Bulletin No. 14.*

Vincent, T.G.; Dunstan, J.S. 1989: Register of commercial seedlots issued by the New Zealand Forest Service. *New Zealand Ministry of Forestry, FRI Bulletin No. 144.*

APPENDIX A

A.1 EQUIPMENT NEEDED

A.1.1 Plot Establishment and Maintenance

- Centre pegs 1.5 m x 50 mm x 50 mm ground durable
- Corner pegs 1.5 m x 75 mm x 50 mm ground durable
- Axe and slasher
- Chainsaw with fuel, oil, tools, and safety gear
- 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 numbers on aluminium strips
- 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
- PSP Manual and height tables
- 30 m and 50 m fibreglass length tapes
- Height pole (telescopic)
- Hypsometer (Suunto and Vertex, or Impulse) and Compass
- Sighting board (diamond plots only)
- Rangefinder staff, target staff, transponder or reflector
- Diameter tapes (steel and fibreglass)
- Diameter callipers (steel or plastic)

A.2 CALIBRATION CHECKS

All measuring equipment must be checked before the start of a measuring season and at monthly intervals.

A.2.1 Length Tapes

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

A.2.2 Diameter Tapes

The numbers on diameter tapes generally wear out before the tapes become inaccurate. Fibreglass tapes can be checked against a steel tape. The total length of the tape should be within 0.5 mm of the true length.

A.2.3 Hypsometers and Compasses

Height-measuring equipment (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 m in height. Estimated height should be within 2% of true height and individual height readings should agree with a theodolite standard.

Optical rangefinders on new instruments must be checked against a measured horizontal distance to the top plate of the target staff.

Angle measuring instruments can also be checked for their accuracy in measuring elevation and depression from the horizontal. The instrument, when held rigid in a vice-like apparatus, should measure angles correct to 0.25° over 8 m.

A.3 FORMULAE

A.3.1 Plot Area

Circular

$$A = \pi r^2$$

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

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

where A = *area of plot* (m^2)
$\pi = 3.14159$
r = *horizontal radius* (m)
s = *slope in degrees*
R = *radius on slope s*
$\cos s$ = cos*ine of s*

Diamond

$$A = 2\, d_o\, d_s$$

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

where d_o = *half diagonal on ground level (m)*
d_s = *half diagonal on line of maximum slope (m)*

A.3.2 Tree Girth

$$\pi\, d$$

A.3.3 Stem Basal Area

$$\frac{\pi\, D^2}{40000} \qquad (m^2)$$

A.3.4 Plot Basal Area

$$\frac{\pi}{40000} * \sum D^2 \qquad (m^2)$$

where *d, D are diameters in cm*

A.3.5 Sample Tree Volume

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

where V = *tree volume (under bark) in* m^3
D = *dbh over bark in cm*
H = *total height in m*
ln = *natural logarithm*
exp = *antilog*
a, b, c are constants dependent on species and locality

A.3.6 Tree Height

Method 1. Degree scale - Length tape

$$H = d * CosB(TanA - TanB) + c$$

Method 2. Percentage scale - Length tape

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

Method 5. Degree scale - Adjustable rangefinder

$$H = d * Cos^2 B(TanA - TanB) * (1 + 0.03 * TanB) + c$$

Method 6. Percentage scale - Adjustable rangefinder

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

where H = *total height* (m)

d = *range finder or tape distance* (m)

$A; P$ = *angle in degrees; angle in percentage to top of tree*

$B; Q$ = *angle in degrees; angle in percentage to top of tree*

c = *datum or height* (m) *above ground level*

Cos, Tan = *Cosine and tangent of angle in degrees*

A.3.7 Mean Dbh

$$\sqrt{\frac{1}{n} * \sum D^2} \qquad \text{or} \qquad c * \sqrt{\frac{\sum BA}{n}}$$

where n = *number of stems*

D = *dbh over bark in cm*

BA = *basal area of each tree in* m^2

$$c = \sqrt{\frac{40000}{\pi}}$$

Note: *n* and plot basal area may be divided by plot area to give stocking in stems/ha and basal area (BA) in m^2/ha.

A.4 MEASUREMENT ERRORS

It is difficult to make accurate measurements in forests. The terrain is often steep, and access and sightlines are often impeded by undergrowth. Some possible effects of observation errors on recorded data are shown below.

A.4.1 Errors in Plot Area Measurement

Circular plot - radius length error

True radius	Error in plot area (%) through change in true radius length			
(m)	5 cm	10 cm	20 cm	30 cm
11.28	± 0.9	± 1.7	± 3.4	± 5.1
15.96	± 0.6	± 1.2	± 2.5	± 3.7
17.84	± 0.6	± 1.1	± 2.2	± 3.3
25.23	± 0.4	± 0.8	± 1.6	± 2.3

Note: above errors apply over the whole plot.

Diamond plot - half diagonal length error

True ½ diagonal	Error in plot area (%) through change in true diagonal length			
(m)	5 cm	10 cm	20 cm	30 cm
14.14	± 0.4	± 0.7	± 1.4	± 2.1
20.00	± 0.2	± 0.5	± 1.0	± 1.5
22.36	± 0.2	± 0.4	± 0.9	± 1.3
31.62	± 0.2	± 0.3	± 0.6	± 0.9

Note: above errors apply to ½ plot.

Diamond plot - errors in determining right angle for diagonals

Angle errors (°)	Area error (%)
0.5	-0.0
1.0	-0.1
2.0	-0.2
3.0	-0.6
4.0	-1.0
5.0	-1.5

Note: above errors apply to ½ plot.

A.4.2 Errors in Height Measurement

When measuring distance to a tree, a 0.5% error in tree height is incurred for every 0.1 m (10 cm) moved.

Change in angle due to error in length of baseline.

Tree height (m)	Change in angle from vertical for errors in baseline of:			
	10 cm	20 cm	30 cm	40 cm
10	0.5°	0.9°	1.0°	1.2°
	(0.9%)	(1.6%)	(1.7%)	(2.1%)
15	0.4°	0.7°	0.9°	1.0°
	(0.7%)	(1.2%)	(1.7%)	(1.7%)
20	0.3°	0.5°	0.7°	0.8°
	(0.5%)	(0.9%)	(1.2%)	(1.4%)
25	0.2°	0.4°	0.6°	0.7°
	(0.3%)	(0.7%)	(1.0%)	(1.2%)
30	0.2°	0.4°	0.5°	0.7°
	(0.3%)	(0.7%)	(0.9%)	(1.2%)

Note: percentage error in height shown in parentheses is for 45° elevation

Measuring to the front of the tree, rather than to the centre of the tree stem under the tip, incurs approximately a 1.0% height error in a tree with a dbh of 40 cm.

A tree height error of 1% is associated with every 0.5° error in reading an upper angle with a hypsometer. The error is at a minimum when the upper angle is 45°.

Undetected tree lean causes the greatest errors in height measurement. For a given degree of lean the size of the error depends solely on the size of the upper angle to the tip of the tree.

Lean from vertical (°)	Percentage errors in height for elevations to tree tip			
	45°	50°	55°	60°
1	1.7	2.1	2.5	3.0
2	3.5	4.2	5.0	6.0
3	5.2	6.2	7.5	9.1
4	7.0	8.3	10.0	12.1
5	8.7	10.4	12.5	15.2
6	10.5	12.5	15.0	18.2
7	12.3	14.6	17.5	21.3
8	14.1	16.7	20.1	24.3
9	15.8	18.9	22.6	27.4
10	17.6	21.0	25.2	30.5

Note: Errors are positive for tree lean towards observer and negative for lean away from the observer.

A.4.3 Errors in Diameter Measurement

If the diameter tape is not held at right angles to the tree stem axis, a small but positive error will be incurred. A 10° shift from horizontal results in an error of approximately +0.8% in diameter (1.6% in basal area).

Due to stem taper, measurement of dbh at a level other than 1.4 m above ground level results in an error. For each 15 cm deviation there is a 2 mm error (1% for a dbh of 25 cm).

A.5 SUGGESTED STANDARDS OF PRECISION

The following precision standards are considered to be realistic, given the probable magnitude of unavoidable errors in forest plot measurement.

Source	Precision (+ or -)
Plot area	1%
Plot radius, 1/2 diagonal and slope distance	1% (10 cm)
Bearings (angle of 90°) and hypsometer angles	0.5°
Tree girth and diameter using girth tape	1%
Height (hypsometer)	5%
Height (using pole)	2% (10 cm)
Crown depth (hypsometer)	5%

APPENDIX B: TABLES

TABLE 1 : Slope Corrections for Plot Radii and Diagonals

TABLE 2 : Height Method 1 - Tape distance with angles in degrees

TABLE 3 : Height Method 2 - Tape distance with angles in percentages

TABLE 4 : Height Method 5 - Rangefinder distance with angles in degrees

TABLE 5 : Height Method 6 - Rangefinder distance with angles in percentages

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 ha				Plot size in ha			
	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

$$radius = \sqrt{\left(\frac{10000 * a}{\pi \cos s}\right)}$$

where a = *plot area in ha*

s = *slope in °*

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

where d_s = *½ diagonal on slope*

d = *horizontal ½ diagonal*

TABLE 2: HEIGHT METHOD 1

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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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
-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	0.58	0.60	0.62	0.65	0.67	0.70	0.73	0.75	0.78	0.81	0.84	0.87
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
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
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
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
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
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
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
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
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
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
11	0.38	0.40	0.42	0.45	0.47	0.50	0.52	0.55	0.58	0.60	0.63	0.66
12	0.36	0.38	0.40	0.43	0.45	0.48	0.50	0.53	0.56	0.58	0.61	0.64
13	0.34	0.36	0.38	0.41	0.43	0.46	0.48	0.51	0.54	0.56	0.59	0.62
14	0.32	0.34	0.36	0.39	0.41	0.44	0.46	0.49	0.52	0.54	0.57	0.60
15	0.30	0.32	0.34	0.37	0.39	0.42	0.44	0.47	0.50	0.52	0.55	0.58

Note: Multiply tape distance by table value and add ***datum*** to obtain total height.

TABLE 2 CONT. : HEIGHT METHOD 1

Height in metres for 1 m TAPE DISTANCE with upper and lower angles in DEGREES

Lower Angle	Upper Angle											
	42	43	44	45	46	47	48	49	50	51	52	53
-30	1.28	1.31	1.34	1.37	1.40	1.43	1.46	1.50	1.53	1.57	1.61	1.65
-29	1.27	1.30	1.33	1.36	1.39	1.42	1.46	1.49	1.53	1.56	1.60	1.65
-28	1.26	1.29	1.32	1.35	1.38	1.42	1.45	1.49	1.52	1.56	1.60	1.64
-27	1.26	1.28	1.31	1.34	1.38	1.41	1.44	1.48	1.52	1.55	1.59	1.64
-26	1.25	1.28	1.31	1.34	1.37	1.40	1.44	1.47	1.51	1.55	1.59	1.63
-25	1.24	1.27	1.30	1.33	1.36	1.39	1.43	1.47	1.50	1.54	1.58	1.63
-24	1.23	1.26	1.29	1.32	1.35	1.39	1.42	1.46	1.50	1.53	1.58	1.62
-23	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45	1.49	1.53	1.57	1.61
-22	1.21	1.24	1.27	1.30	1.33	1.37	1.40	1.44	1.48	1.52	1.56	1.61
-21	1.20	1.23	1.26	1.29	1.33	1.36	1.40	1.43	1.47	1.51	1.55	1.60
-20	1.19	1.22	1.25	1.28	1.32	1.35	1.39	1.42	1.46	1.50	1.54	1.59
-19	1.18	1.21	1.24	1.27	1.30	1.34	1.38	1.41	1.45	1.49	1.54	1.58
-18	1.17	1.20	1.23	1.26	1.29	1.33	1.37	1.40	1.44	1.48	1.53	1.57
-17	1.15	1.18	1.22	1.25	1.28	1.32	1.35	1.39	1.43	1.47	1.52	1.56
-16	1.14	1.17	1.20	1.24	1.27	1.31	1.34	1.38	1.42	1.46	1.51	1.55
-15	1.13	1.16	1.19	1.22	1.26	1.29	1.33	1.37	1.41	1.45	1.50	1.54
-14	1.12	1.15	1.18	1.21	1.25	1.28	1.32	1.36	1.40	1.44	1.48	1.53
-13	1.10	1.13	1.17	1.20	1.23	1.27	1.31	1.35	1.39	1.43	1.47	1.52
-12	1.09	1.12	1.15	1.19	1.22	1.26	1.29	1.33	1.37	1.42	1.46	1.51
-11	1.07	1.11	1.14	1.17	1.21	1.24	1.28	1.32	1.36	1.40	1.45	1.49
-10	1.06	1.09	1.12	1.16	1.19	1.23	1.27	1.31	1.35	1.39	1.43	1.48
-9	1.05	1.08	1.11	1.14	1.18	1.22	1.25	1.29	1.33	1.38	1.42	1.47
-8	1.03	1.06	1.10	1.13	1.16	1.20	1.24	1.28	1.32	1.36	1.41	1.45
-7	1.02	1.05	1.08	1.11	1.15	1.19	1.22	1.26	1.30	1.35	1.39	1.44
-6	1.00	1.03	1.06	1.10	1.13	1.17	1.21	1.25	1.29	1.33	1.38	1.42
-5	0.98	1.02	1.05	1.08	1.12	1.16	1.19	1.23	1.27	1.32	1.36	1.41
-4	0.97	1.00	1.03	1.07	1.10	1.14	1.18	1.22	1.26	1.30	1.35	1.39
-3	0.95	0.98	1.02	1.05	1.09	1.12	1.16	1.20	1.24	1.29	1.33	1.38
-2	0.93	0.97	1.00	1.03	1.07	1.11	1.14	1.18	1.23	1.27	1.31	1.36
-1	0.92	0.95	0.98	1.02	1.05	1.09	1.13	1.17	1.21	1.25	1.30	1.34
0	0.90	0.93	0.97	1.00	1.04	1.07	1.11	1.15	1.19	1.23	1.28	1.33
1	0.88	0.91	0.95	0.98	1.02	1.05	1.09	1.13	1.17	1.22	1.26	1.31
2	0.86	0.90	0.93	0.96	1.00	1.04	1.08	1.11	1.16	1.20	1.24	1.29
3	0.85	0.88	0.91	0.95	0.98	1.02	1.06	1.10	1.14	1.18	1.23	1.27
4	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.08	1.12	1.16	1.21	1.25
5	0.81	0.84	0.87	0.91	0.94	0.98	1.02	1.06	1.10	1.14	1.19	1.23
6	0.79	0.82	0.86	0.89	0.93	0.96	1.00	1.04	1.08	1.12	1.17	1.22
7	0.77	0.80	0.84	0.87	0.91	0.94	0.98	1.02	1.06	1.10	1.15	1.20
8	0.75	0.78	0.82	0.85	0.89	0.92	0.96	1.00	1.04	1.08	1.13	1.17
9	0.73	0.76	0.80	0.83	0.87	0.90	0.94	0.98	1.02	1.06	1.11	1.15
10	0.71	0.74	0.78	0.81	0.85	0.88	0.92	0.96	1.00	1.04	1.09	1.13
11	0.69	0.72	0.76	0.79	0.83	0.86	0.90	0.94	0.98	1.02	1.07	1.11
12	0.67	0.70	0.74	0.77	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.09
13	0.65	0.68	0.72	0.75	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.07
14	0.63	0.66	0.70	0.73	0.76	0.80	0.84	0.87	0.91	0.96	1.00	1.05
15	0.61	0.64	0.67	0.71	0.74	0.78	0.81	0.85	0.89	0.93	0.98	1.02

Note: Multiply tape distance by table value and add ***datum*** to obtain total height.

TABLE 3: HEIGHT METHOD 2

Height in metres for 1 m TAPE DISTANCE with upper and lower angles in PERCENTAGES

Lower	Upper Angle											
Angle	50	52	54	56	58	60	62	64	66	68	70	72
-50	0.89	0.91	0.93	0.95	0.97	0.98	1.00	1.02	1.04	1.06	1.07	1.09
-48	0.88	0.90	0.92	0.94	0.96	0.97	0.99	1.01	1.03	1.05	1.06	1.08
-46	0.87	0.89	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04	1.05	1.07
-44	0.86	0.88	0.90	0.92	0.93	0.95	0.97	0.99	1.01	1.03	1.04	1.06
-42	0.85	0.87	0.89	0.90	0.92	0.94	0.96	0.98	1.00	1.01	1.03	1.05
-40	0.84	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.98	1.00	1.02	1.04
-38	0.82	0.84	0.86	0.88	0.90	0.92	0.93	0.95	0.97	0.99	1.01	1.03
-36	0.81	0.83	0.85	0.87	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02
-34	0.80	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.98	1.00
-32	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.91	0.93	0.95	0.97	0.99
-30	0.77	0.79	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98
-28	0.75	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.92	0.94	0.96
-26	0.74	0.75	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95
-24	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.89	0.91	0.93
-22	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92
-20	0.69	0.71	0.73	0.75	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90
-18	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.85	0.87	0.89
-16	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.85	0.87
-14	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.85
-12	0.62	0.64	0.66	0.68	0.70	0.71	0.73	0.75	0.77	0.79	0.81	0.83
-10	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82
-8	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80
-6	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78
-4	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76
-2	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74
0	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72
2	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70
4	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68
6	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66
8	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64
10	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62
12	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60
14	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.51	0.53	0.55	0.57
16	0.34	0.36	0.38	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55
18	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53
20	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51
22	0.27	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49
24	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.47
26	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45
28	0.21	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0.39	0.40	0.42
30	0.19	0.21	0.23	0.25	0.27	0.29	0.31	0.33	0.34	0.36	0.38	0.40
32	0.17	0.19	0.21	0.23	0.25	0.27	0.29	0.30	0.32	0.34	0.36	0.38
34	0.15	0.17	0.19	0.21	0.23	0.25	0.27	0.28	0.30	0.32	0.34	0.36
36	0.13	0.15	0.17	0.19	0.21	0.23	0.24	0.26	0.28	0.30	0.32	0.34
38	0.11	0.13	0.15	0.17	0.19	0.21	0.22	0.24	0.26	0.28	0.30	0.32
40	0.09	0.11	0.13	0.15	0.17	0.19	0.20	0.22	0.24	0.26	0.28	0.30

Note: Multiply tape distance by table value and add ***datum*** to obtain total height.

TABLE 3 CONT. : HEIGHT METHOD 2

Height in metres for 1 m TAPE DISTANCE with upper and lower angles in PERCENTAGES

Lower Angle	Upper Angle											
	74	76	78	80	82	84	86	88	90	92	94	96
-50	1.11	1.13	1.14	1.16	1.18	1.20	1.22	1.23	1.25	1.27	1.29	1.31
-48	1.10	1.12	1.14	1.15	1.17	1.19	1.21	1.23	1.24	1.26	1.28	1.30
-46	1.09	1.11	1.13	1.14	1.16	1.18	1.20	1.22	1.24	1.25	1.27	1.29
-44	1.08	1.10	1.12	1.13	1.15	1.17	1.19	1.21	1.23	1.24	1.26	1.28
-42	1.07	1.09	1.11	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.25	1.27
-40	1.06	1.08	1.10	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.24	1.26
-38	1.05	1.07	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.23	1.25
-36	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.20	1.22	1.24
-34	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.17	1.19	1.21	1.23
-32	1.01	1.03	1.05	1.07	1.09	1.10	1.12	1.14	1.16	1.18	1.20	1.22
-30	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21
-28	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.17	1.19
-26	0.97	0.99	1.01	1.03	1.05	1.06	1.08	1.10	1.12	1.14	1.16	1.18
-24	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17
-22	0.94	0.96	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.11	1.13	1.15
-20	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14
-18	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12
-16	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.09	1.11
-14	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.09
-12	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07
-10	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.01	1.03	1.05
-8	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04
-6	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02
-4	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00
-2	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98
0	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96
2	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94
4	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92
6	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90
8	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88
10	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86
12	0.62	0.64	0.66	0.68	0.70	0.71	0.73	0.75	0.77	0.79	0.81	0.83
14	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81
16	0.57	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79
18	0.55	0.57	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77
20	0.53	0.55	0.57	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75
22	0.51	0.53	0.55	0.57	0.59	0.61	0.63	0.64	0.66	0.68	0.70	0.72
24	0.49	0.51	0.53	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70
26	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68
28	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.65
30	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.57	0.59	0.61	0.63
32	0.40	0.42	0.44	0.46	0.48	0.50	0.51	0.53	0.55	0.57	0.59	0.61
34	0.38	0.40	0.42	0.44	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.59
36	0.36	0.38	0.40	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.56
38	0.34	0.36	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.50	0.52	0.54
40	0.32	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.46	0.48	0.50	0.52

Note: Multiply tape distance by table value and add ***datum*** to obtain total height.

TABLE 3 CONT. : HEIGHT METHOD 2

Height in metres for 1 m TAPE DISTANCE with upper and lower angles in PERCENTAGES

Lower Angle	Upper Angle											
	98	100	102	104	106	108	110	112	114	116	118	120
-50	1.32	1.34	1.36	1.38	1.40	1.41	1.43	1.45	1.47	1.48	1.50	1.52
-48	1.32	1.33	1.35	1.37	1.39	1.41	1.42	1.44	1.46	1.48	1.50	1.51
-46	1.31	1.33	1.34	1.36	1.38	1.40	1.42	1.44	1.45	1.47	1.49	1.51
-44	1.30	1.32	1.34	1.35	1.37	1.39	1.41	1.43	1.45	1.46	1.48	1.50
-42	1.29	1.31	1.33	1.35	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.49
-40	1.28	1.30	1.32	1.34	1.36	1.37	1.39	1.41	1.43	1.45	1.47	1.49
-38	1.27	1.29	1.31	1.33	1.35	1.36	1.38	1.40	1.42	1.44	1.46	1.48
-36	1.26	1.28	1.30	1.32	1.34	1.35	1.37	1.39	1.41	1.43	1.45	1.47
-34	1.25	1.27	1.29	1.31	1.33	1.34	1.36	1.38	1.40	1.42	1.44	1.46
-32	1.24	1.26	1.28	1.30	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.45
-30	1.23	1.25	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44
-28	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.35	1.37	1.39	1.41	1.43
-26	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.35	1.37	1.39	1.41
-24	1.19	1.21	1.23	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40
-22	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.35	1.37	1.39
-20	1.16	1.18	1.20	1.22	1.24	1.26	1.27	1.29	1.31	1.33	1.35	1.37
-18	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36
-16	1.13	1.15	1.17	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34
-14	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31	1.33
-12	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31
-10	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29
-8	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28
-6	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26
-4	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24
-2	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22
0	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20
2	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18
4	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16
6	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14
8	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12
10	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.01	1.03	1.05	1.07	1.09
12	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07
14	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05
16	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03
18	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.94	0.96	0.98	1.00
20	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98
22	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96
24	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.89	0.91	0.93
26	0.70	0.72	0.74	0.75	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91
28	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.85	0.87	0.89
30	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.80	0.82	0.84	0.86
32	0.63	0.65	0.67	0.69	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84
34	0.61	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.81
36	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.73	0.75	0.77	0.79
38	0.56	0.58	0.60	0.62	0.64	0.65	0.67	0.69	0.71	0.73	0.75	0.77
40	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.72	0.74

Note: Multiply tape distance by table value and add ***datum*** to obtain total height.

TABLE 3 CONT. : HEIGHT METHOD 2

Height in metres for 1 m TAPE DISTANCE with upper and lower angles in PERCENTAGES

Lower Angle	Upper Angle											
	122	124	126	128	130	132	134	136	138	140	142	144
-50	1.54	1.56	1.57	1.59	1.61	1.63	1.65	1.66	1.68	1.70	1.72	1.74
-48	1.53	1.55	1.57	1.59	1.60	1.62	1.64	1.66	1.68	1.69	1.71	1.73
-46	1.53	1.54	1.56	1.58	1.60	1.62	1.64	1.65	1.67	1.69	1.71	1.73
-44	1.52	1.54	1.56	1.57	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.72
-42	1.51	1.53	1.55	1.57	1.59	1.60	1.62	1.64	1.66	1.68	1.70	1.71
-40	1.50	1.52	1.54	1.56	1.58	1.60	1.62	1.63	1.65	1.67	1.69	1.71
-38	1.50	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.66	1.68	1.70
-36	1.49	1.51	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.67	1.69
-34	1.48	1.50	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69
-32	1.47	1.49	1.50	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.68
-30	1.46	1.48	1.49	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67
-28	1.44	1.46	1.48	1.50	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66
-26	1.43	1.45	1.47	1.49	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65
-24	1.42	1.44	1.46	1.48	1.50	1.52	1.54	1.56	1.58	1.59	1.61	1.63
-22	1.41	1.43	1.45	1.46	1.48	1.50	1.52	1.54	1.56	1.58	1.60	1.62
-20	1.39	1.41	1.43	1.45	1.47	1.49	1.51	1.53	1.55	1.57	1.59	1.61
-18	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52	1.54	1.56	1.57	1.59
-16	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52	1.54	1.56	1.58
-14	1.35	1.37	1.39	1.41	1.43	1.45	1.47	1.49	1.51	1.53	1.54	1.56
-12	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.47	1.49	1.51	1.53	1.55
-10	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.47	1.49	1.51	1.53
-8	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52
-6	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50
-4	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48
-2	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46
0	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44
2	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42
4	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40
6	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38
8	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36
10	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31	1.33
12	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31
14	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29
16	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.18	1.20	1.22	1.24	1.26
18	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24
20	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22
22	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19
24	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17
26	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.06	1.08	1.10	1.12	1.14
28	0.91	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12
30	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.03	1.05	1.07	1.09
32	0.86	0.88	0.90	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07
34	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.98	1.00	1.02	1.04
36	0.81	0.83	0.85	0.87	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02
38	0.79	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.93	0.95	0.97	0.99
40	0.76	0.78	0.80	0.82	0.84	0.85	0.87	0.89	0.91	0.93	0.95	0.97

Note: Multiply tape distance by table value and add ***datum*** to obtain total height.

TABLE 4 : HEIGHT METHOD 5

Height in metres for 1 m RANGEFINDER DISTANCE with upper and lower angles in DEGREES

Lower	Upper Angle											
Angle	30	31	32	33	34	35	36	37	38	39	40	41
-30	0.85	0.87	0.89	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.07
-29	0.85	0.87	0.89	0.91	0.92	0.94	0.96	0.98	1.00	1.03	1.05	1.07
-28	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07
-27	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.08
-26	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.06	1.08
-25	0.85	0.86	0.88	0.90	0.92	0.94	0.97	0.99	1.01	1.03	1.06	1.08
-24	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.99	1.01	1.03	1.06	1.08
-23	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.99	1.01	1.03	1.06	1.08
-22	0.83	0.85	0.87	0.89	0.92	0.94	0.96	0.98	1.01	1.03	1.06	1.08
-21	0.83	0.85	0.87	0.89	0.91	0.93	0.96	0.98	1.00	1.03	1.05	1.08
-20	0.82	0.84	0.86	0.89	0.91	0.93	0.95	0.98	1.00	1.03	1.05	1.08
-19	0.82	0.84	0.86	0.88	0.90	0.92	0.95	0.97	1.00	1.02	1.05	1.07
-18	0.81	0.83	0.85	0.87	0.90	0.92	0.94	0.97	0.99	1.02	1.04	1.07
-17	0.80	0.82	0.84	0.87	0.89	0.91	0.94	0.96	0.98	1.01	1.04	1.06
-16	0.79	0.81	0.84	0.86	0.88	0.90	0.93	0.95	0.98	1.00	1.03	1.06
-15	0.78	0.80	0.83	0.85	0.87	0.90	0.92	0.95	0.97	1.00	1.02	1.05
-14	0.77	0.79	0.82	0.84	0.86	0.89	0.91	0.94	0.96	0.99	1.02	1.05
-13	0.76	0.78	0.81	0.83	0.85	0.88	0.90	0.93	0.95	0.98	1.01	1.04
-12	0.75	0.77	0.80	0.82	0.84	0.87	0.89	0.92	0.94	0.97	1.00	1.03
-11	0.74	0.76	0.78	0.81	0.83	0.86	0.88	0.91	0.93	0.96	0.99	1.02
-10	0.73	0.75	0.77	0.80	0.82	0.85	0.87	0.90	0.92	0.95	0.98	1.01
-9	0.71	0.74	0.76	0.78	0.81	0.83	0.86	0.89	0.91	0.94	0.97	1.00
-8	0.70	0.72	0.75	0.77	0.80	0.82	0.85	0.87	0.90	0.93	0.96	0.99
-7	0.69	0.71	0.73	0.76	0.78	0.81	0.83	0.86	0.89	0.92	0.94	0.97
-6	0.67	0.70	0.72	0.74	0.77	0.79	0.82	0.85	0.87	0.90	0.93	0.96
-5	0.66	0.68	0.71	0.73	0.75	0.78	0.81	0.83	0.86	0.89	0.92	0.95
-4	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.82	0.85	0.87	0.90	0.93
-3	0.63	0.65	0.67	0.70	0.72	0.75	0.78	0.80	0.83	0.86	0.89	0.92
-2	0.61	0.63	0.66	0.68	0.71	0.73	0.76	0.79	0.81	0.84	0.87	0.90
-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	0.58	0.60	0.62	0.65	0.67	0.70	0.73	0.75	0.78	0.81	0.84	0.87
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
2	0.54	0.57	0.59	0.61	0.64	0.67	0.69	0.72	0.75	0.77	0.80	0.83
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
4	0.51	0.53	0.55	0.58	0.60	0.63	0.65	0.68	0.71	0.74	0.77	0.80
5	0.49	0.51	0.53	0.56	0.58	0.61	0.64	0.66	0.69	0.72	0.75	0.78
6	0.47	0.49	0.52	0.54	0.56	0.59	0.62	0.64	0.67	0.70	0.73	0.76
7	0.45	0.47	0.50	0.52	0.55	0.57	0.60	0.62	0.65	0.68	0.71	0.74
8	0.43	0.45	0.48	0.50	0.53	0.55	0.58	0.60	0.63	0.66	0.69	0.72
9	0.41	0.43	0.46	0.48	0.51	0.53	0.56	0.58	0.61	0.64	0.67	0.70
10	0.39	0.41	0.44	0.46	0.49	0.51	0.54	0.56	0.59	0.62	0.65	0.68
11	0.37	0.39	0.42	0.44	0.47	0.49	0.52	0.54	0.57	0.60	0.62	0.65
12	0.35	0.37	0.40	0.42	0.44	0.47	0.49	0.52	0.55	0.58	0.60	0.63
13	0.33	0.35	0.38	0.40	0.42	0.45	0.47	0.50	0.53	0.55	0.58	0.61
14	0.31	0.33	0.36	0.38	0.40	0.43	0.45	0.48	0.50	0.53	0.56	0.59
15	0.29	0.31	0.34	0.36	0.38	0.41	0.43	0.46	0.48	0.51	0.54	0.57

Note: Multiply rangefinder distance by table value and add ***datum*** to obtain total height.

TABLE 4 CONT. : HEIGHT METHOD 5

Height in metres for 1 m RANGEFINDER DISTANCE with upper and lower angles in DEGREES

Lower Angle	Upper Angle											
	42	43	44	45	46	47	48	49	50	51	52	53
-30	1.09	1.11	1.14	1.16	1.19	1.22	1.24	1.27	1.30	1.34	1.37	1.40
-29	1.09	1.12	1.14	1.17	1.20	1.22	1.25	1.28	1.31	1.35	1.38	1.42
-28	1.10	1.12	1.15	1.18	1.20	1.23	1.26	1.29	1.32	1.36	1.39	1.43
-27	1.10	1.13	1.15	1.18	1.21	1.24	1.27	1.30	1.33	1.36	1.40	1.44
-26	1.10	1.13	1.16	1.18	1.21	1.24	1.27	1.30	1.34	1.37	1.41	1.44
-25	1.11	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45
-24	1.11	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.35	1.38	1.42	1.46
-23	1.11	1.14	1.16	1.19	1.22	1.25	1.28	1.32	1.35	1.39	1.43	1.47
-22	1.11	1.14	1.16	1.19	1.22	1.25	1.29	1.32	1.36	1.39	1.43	1.47
-21	1.11	1.13	1.16	1.19	1.22	1.25	1.29	1.32	1.36	1.39	1.43	1.47
-20	1.10	1.13	1.16	1.19	1.22	1.25	1.29	1.32	1.36	1.40	1.44	1.48
-19	1.10	1.13	1.16	1.19	1.22	1.25	1.29	1.32	1.36	1.40	1.44	1.48
-18	1.10	1.13	1.16	1.19	1.22	1.25	1.29	1.32	1.36	1.40	1.44	1.48
-17	1.09	1.12	1.15	1.18	1.22	1.25	1.28	1.32	1.36	1.40	1.44	1.48
-16	1.09	1.12	1.15	1.18	1.21	1.25	1.28	1.32	1.35	1.39	1.44	1.48
-15	1.08	1.11	1.14	1.17	1.21	1.24	1.28	1.31	1.35	1.39	1.43	1.48
-14	1.07	1.10	1.14	1.17	1.20	1.24	1.27	1.31	1.35	1.39	1.43	1.47
-13	1.07	1.10	1.13	1.16	1.19	1.23	1.26	1.30	1.34	1.38	1.42	1.47
-12	1.06	1.09	1.12	1.15	1.19	1.22	1.26	1.30	1.34	1.38	1.42	1.46
-11	1.05	1.08	1.11	1.14	1.18	1.21	1.25	1.29	1.33	1.37	1.41	1.46
-10	1.04	1.07	1.10	1.13	1.17	1.20	1.24	1.28	1.32	1.36	1.40	1.45
-9	1.03	1.06	1.09	1.12	1.16	1.19	1.23	1.27	1.31	1.35	1.40	1.44
-8	1.02	1.05	1.08	1.11	1.15	1.18	1.22	1.26	1.30	1.34	1.39	1.43
-7	1.00	1.04	1.07	1.10	1.14	1.17	1.21	1.25	1.29	1.33	1.38	1.42
-6	0.99	1.02	1.06	1.09	1.12	1.16	1.20	1.24	1.28	1.32	1.37	1.41
-5	0.98	1.01	1.04	1.08	1.11	1.15	1.19	1.23	1.27	1.31	1.35	1.40
-4	0.96	1.00	1.03	1.06	1.10	1.13	1.17	1.21	1.25	1.30	1.34	1.39
-3	0.95	0.98	1.01	1.05	1.08	1.12	1.16	1.20	1.24	1.28	1.33	1.37
-2	0.93	0.97	1.00	1.03	1.07	1.10	1.14	1.18	1.22	1.27	1.31	1.36
-1	0.92	0.95	0.98	1.02	1.05	1.09	1.13	1.17	1.21	1.25	1.30	1.34
0	0.90	0.93	0.97	1.00	1.04	1.07	1.11	1.15	1.19	1.23	1.28	1.33
1	0.88	0.92	0.95	0.98	1.02	1.06	1.09	1.13	1.17	1.22	1.26	1.31
2	0.87	0.90	0.93	0.96	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.29
3	0.85	0.88	0.91	0.95	0.98	1.02	1.06	1.10	1.14	1.18	1.23	1.27
4	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.08	1.12	1.16	1.21	1.25
5	0.81	0.84	0.87	0.91	0.94	0.98	1.02	1.06	1.10	1.14	1.19	1.23
6	0.79	0.82	0.85	0.89	0.92	0.96	1.00	1.04	1.08	1.12	1.17	1.21
7	0.77	0.80	0.83	0.87	0.90	0.94	0.98	1.02	1.06	1.10	1.14	1.19
8	0.75	0.78	0.81	0.85	0.88	0.92	0.96	0.99	1.04	1.08	1.12	1.17
9	0.73	0.76	0.79	0.82	0.86	0.90	0.93	0.97	1.01	1.06	1.10	1.15
10	0.71	0.74	0.77	0.80	0.84	0.87	0.91	0.95	0.99	1.03	1.08	1.12
11	0.68	0.72	0.75	0.78	0.82	0.85	0.89	0.93	0.97	1.01	1.05	1.10
12	0.66	0.69	0.73	0.76	0.79	0.83	0.86	0.90	0.94	0.98	1.03	1.07
13	0.64	0.67	0.70	0.74	0.77	0.80	0.84	0.88	0.92	0.96	1.00	1.05
14	0.62	0.65	0.68	0.71	0.75	0.78	0.82	0.85	0.89	0.93	0.98	1.02
15	0.59	0.63	0.66	0.69	0.72	0.76	0.79	0.83	0.87	0.91	0.95	1.00

Note: Multiply rangefinder distance by table value and add ***datum*** to obtain total height.

TABLE 5: HEIGHT METHOD 6

Height in metres for 1 m RANGEFINDER DISTANCE with upper and lower angles in PERCENTAGES

Lower Angle	Upper Angle											
	50	52	54	56	58	60	62	64	66	68	70	72
-50	0.79	0.80	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.95	0.96
-48	0.79	0.80	0.82	0.83	0.85	0.87	0.88	0.90	0.91	0.93	0.95	0.96
-46	0.78	0.80	0.81	0.83	0.85	0.86	0.88	0.90	0.91	0.93	0.94	0.96
-44	0.78	0.79	0.81	0.83	0.84	0.86	0.88	0.89	0.91	0.93	0.94	0.96
-42	0.77	0.79	0.81	0.82	0.84	0.86	0.87	0.89	0.91	0.92	0.94	0.96
-40	0.77	0.78	0.80	0.82	0.83	0.85	0.87	0.89	0.90	0.92	0.94	0.95
-38	0.76	0.78	0.79	0.81	0.83	0.85	0.86	0.88	0.90	0.92	0.93	0.95
-36	0.75	0.77	0.79	0.81	0.82	0.84	0.86	0.88	0.89	0.91	0.93	0.95
-34	0.75	0.76	0.78	0.80	0.82	0.83	0.85	0.87	0.89	0.90	0.92	0.94
-32	0.74	0.75	0.77	0.79	0.81	0.83	0.84	0.86	0.88	0.90	0.92	0.93
-30	0.73	0.75	0.76	0.78	0.80	0.82	0.84	0.85	0.87	0.89	0.91	0.93
-28	0.72	0.74	0.75	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.90	0.92
-26	0.71	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.87	0.89	0.91
-24	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.84	0.86	0.88	0.90
-22	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.81	0.83	0.85	0.87	0.89
-20	0.67	0.69	0.71	0.73	0.75	0.76	0.78	0.80	0.82	0.84	0.86	0.88
-18	0.66	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.85	0.87
-16	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.83	0.85
-14	0.63	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84
-12	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83
-10	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81
-8	0.57	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79
-6	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78
-4	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76
-2	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74
0	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72
2	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70
4	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68
6	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66
8	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64
10	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62
12	0.38	0.40	0.42	0.44	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.59
14	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.57
16	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55
18	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53
20	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.44	0.46	0.48	0.50
22	0.27	0.29	0.31	0.33	0.35	0.36	0.38	0.40	0.42	0.44	0.46	0.48
24	0.25	0.27	0.29	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46
26	0.23	0.25	0.26	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.43
28	0.21	0.22	0.24	0.26	0.28	0.30	0.32	0.34	0.36	0.37	0.39	0.41
30	0.19	0.20	0.22	0.24	0.26	0.28	0.30	0.31	0.33	0.35	0.37	0.39
32	0.16	0.18	0.20	0.22	0.24	0.26	0.27	0.29	0.31	0.33	0.35	0.37
34	0.14	0.16	0.18	0.20	0.22	0.24	0.25	0.27	0.29	0.31	0.33	0.34
36	0.13	0.14	0.16	0.18	0.20	0.21	0.23	0.25	0.27	0.29	0.30	0.32
38	0.11	0.12	0.14	0.16	0.18	0.19	0.21	0.23	0.25	0.27	0.28	0.30
40	0.09	0.10	0.12	0.14	0.16	0.17	0.19	0.21	0.23	0.24	0.26	0.28

Note: Multiply rangefinder distance by table value and add ***datum*** to obtain total height.

TABLE 5 CONT. : HEIGHT METHOD 6

Height in metres for 1 m RANGEFINDER DISTANCE with upper and lower angles in PERCENTAGES

Lower Angle	Upper Angle											
	74	76	78	80	82	84	86	88	90	92	94	96
-50	0.98	0.99	1.01	1.02	1.04	1.06	1.07	1.09	1.10	1.12	1.13	1.15
-48	0.98	0.99	1.01	1.03	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.15
-46	0.98	0.99	1.01	1.03	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.16
-44	0.98	0.99	1.01	1.03	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.16
-42	0.97	0.99	1.01	1.02	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.16
-40	0.97	0.99	1.01	1.02	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.16
-38	0.97	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.11	1.12	1.14	1.16
-36	0.96	0.98	1.00	1.02	1.03	1.05	1.07	1.09	1.10	1.12	1.14	1.16
-34	0.96	0.98	0.99	1.01	1.03	1.05	1.06	1.08	1.10	1.12	1.14	1.15
-32	0.95	0.97	0.99	1.01	1.02	1.04	1.06	1.08	1.10	1.11	1.13	1.15
-30	0.95	0.96	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.11	1.13	1.15
-28	0.94	0.96	0.97	0.99	1.01	1.03	1.05	1.07	1.09	1.10	1.12	1.14
-26	0.93	0.95	0.97	0.99	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.13
-24	0.92	0.94	0.96	0.98	1.00	1.01	1.03	1.05	1.07	1.09	1.11	1.13
-22	0.91	0.93	0.95	0.97	0.99	1.00	1.02	1.04	1.06	1.08	1.10	1.12
-20	0.90	0.92	0.94	0.96	0.97	0.99	1.01	1.03	1.05	1.07	1.09	1.11
-18	0.89	0.91	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10
-16	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.09
-14	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.05	1.07
-12	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06
-10	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05
-8	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03
-6	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.93	0.95	0.97	0.99	1.01
-4	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00
-2	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98
0	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96
2	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94
4	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92
6	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90
8	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88
10	0.64	0.66	0.68	0.70	0.72	0.73	0.75	0.77	0.79	0.81	0.83	0.85
12	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81	0.83
14	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81
16	0.57	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.72	0.74	0.76	0.78
18	0.55	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76
20	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74
22	0.50	0.52	0.54	0.56	0.58	0.60	0.61	0.63	0.65	0.67	0.69	0.71
24	0.48	0.50	0.51	0.53	0.55	0.57	0.59	0.61	0.63	0.65	0.67	0.69
26	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.59	0.60	0.62	0.64	0.66
28	0.43	0.45	0.47	0.49	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64
30	0.41	0.43	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.57	0.59	0.61
32	0.38	0.40	0.42	0.44	0.46	0.48	0.49	0.51	0.53	0.55	0.57	0.59
34	0.36	0.38	0.40	0.42	0.43	0.45	0.47	0.49	0.51	0.53	0.54	0.56
36	0.34	0.36	0.38	0.39	0.41	0.43	0.45	0.47	0.48	0.50	0.52	0.54
38	0.32	0.34	0.35	0.37	0.39	0.41	0.42	0.44	0.46	0.48	0.49	0.51
40	0.30	0.31	0.33	0.35	0.37	0.38	0.40	0.42	0.44	0.45	0.47	0.49

Note: Multiply rangefinder distance by table value and add ***datum*** to obtain total height.

TABLE 5 CONT. : HEIGHT METHOD 6

Height in metres for 1 m RANGEFINDER DISTANCE with upper and lower angles in PERCENTAGES

Lower Angle	Upper Angle											
	98	100	102	104	106	108	110	112	114	116	118	120
-50	1.17	1.18	1.20	1.21	1.23	1.25	1.26	1.28	1.29	1.31	1.32	1.34
-48	1.17	1.19	1.20	1.22	1.23	1.25	1.27	1.28	1.30	1.31	1.33	1.35
-46	1.17	1.19	1.20	1.22	1.24	1.25	1.27	1.29	1.30	1.32	1.33	1.35
-44	1.17	1.19	1.21	1.22	1.24	1.26	1.27	1.29	1.31	1.32	1.34	1.36
-42	1.18	1.19	1.21	1.23	1.24	1.26	1.28	1.29	1.31	1.33	1.34	1.36
-40	1.18	1.19	1.21	1.23	1.24	1.26	1.28	1.29	1.31	1.33	1.35	1.36
-38	1.17	1.19	1.21	1.23	1.24	1.26	1.28	1.30	1.31	1.33	1.35	1.36
-36	1.17	1.19	1.21	1.23	1.24	1.26	1.28	1.30	1.31	1.33	1.35	1.37
-34	1.17	1.19	1.21	1.22	1.24	1.26	1.28	1.30	1.31	1.33	1.35	1.37
-32	1.17	1.19	1.20	1.22	1.24	1.26	1.28	1.29	1.31	1.33	1.35	1.37
-30	1.16	1.18	1.20	1.22	1.24	1.25	1.27	1.29	1.31	1.33	1.35	1.36
-28	1.16	1.18	1.20	1.21	1.23	1.25	1.27	1.29	1.31	1.32	1.34	1.36
-26	1.15	1.17	1.19	1.21	1.23	1.25	1.26	1.28	1.30	1.32	1.34	1.36
-24	1.15	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.31	1.33	1.35
-22	1.14	1.16	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.35
-20	1.13	1.15	1.17	1.19	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34
-18	1.12	1.14	1.16	1.18	1.19	1.21	1.23	1.25	1.27	1.29	1.31	1.33
-16	1.11	1.13	1.15	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32
-14	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31
-12	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30
-10	1.07	1.09	1.11	1.13	1.15	1.16	1.18	1.20	1.22	1.24	1.26	1.28
-8	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27
-6	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25
-4	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24
-2	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22
0	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20
2	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18
4	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16
6	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14
8	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12
10	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.09
12	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07
14	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.98	1.00	1.02	1.04
16	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02
18	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.93	0.95	0.97	0.99
20	0.75	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97
22	0.73	0.75	0.77	0.79	0.81	0.83	0.84	0.86	0.88	0.90	0.92	0.94
24	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.91
26	0.68	0.70	0.72	0.74	0.76	0.77	0.79	0.81	0.83	0.85	0.87	0.89
28	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.80	0.82	0.84	0.86
30	0.63	0.65	0.67	0.69	0.70	0.72	0.74	0.76	0.78	0.80	0.81	0.83
32	0.60	0.62	0.64	0.66	0.68	0.70	0.71	0.73	0.75	0.77	0.79	0.81
34	0.58	0.60	0.62	0.63	0.65	0.67	0.69	0.71	0.72	0.74	0.76	0.78
36	0.55	0.57	0.59	0.61	0.63	0.64	0.66	0.68	0.70	0.72	0.73	0.75
38	0.53	0.55	0.57	0.58	0.60	0.62	0.64	0.65	0.67	0.69	0.71	0.72
40	0.51	0.52	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.66	0.68	0.70

Note: Multiply rangefinder distance by table value and add ***datum*** to obtain total height.

TABLE 5 CONT. : HEIGHT METHOD 6

Height in metres for 1 m RANGEFINDER DISTANCE with upper and lower angles in PERCENTAGES

Lower Angle	Upper Angle											
	122	124	126	128	130	132	134	136	138	140	142	144
-50	1.36	1.37	1.39	1.40	1.42	1.43	1.45	1.47	1.48	1.50	1.51	1.53
-48	1.36	1.38	1.39	1.41	1.43	1.44	1.46	1.47	1.49	1.51	1.52	1.54
-46	1.37	1.38	1.40	1.42	1.43	1.45	1.47	1.48	1.50	1.51	1.53	1.55
-44	1.37	1.39	1.41	1.42	1.44	1.46	1.47	1.49	1.50	1.52	1.54	1.55
-42	1.38	1.39	1.41	1.43	1.44	1.46	1.48	1.49	1.51	1.53	1.54	1.56
-40	1.38	1.40	1.41	1.43	1.45	1.46	1.48	1.50	1.52	1.53	1.55	1.57
-38	1.38	1.40	1.42	1.43	1.45	1.47	1.49	1.50	1.52	1.54	1.55	1.57
-36	1.38	1.40	1.42	1.44	1.45	1.47	1.49	1.51	1.52	1.54	1.56	1.58
-34	1.38	1.40	1.42	1.44	1.46	1.47	1.49	1.51	1.53	1.54	1.56	1.58
-32	1.38	1.40	1.42	1.44	1.46	1.47	1.49	1.51	1.53	1.55	1.56	1.58
-30	1.38	1.40	1.42	1.44	1.45	1.47	1.49	1.51	1.53	1.55	1.56	1.58
-28	1.38	1.40	1.42	1.43	1.45	1.47	1.49	1.51	1.53	1.54	1.56	1.58
-26	1.38	1.39	1.41	1.43	1.45	1.47	1.49	1.51	1.52	1.54	1.56	1.58
-24	1.37	1.39	1.41	1.43	1.45	1.46	1.48	1.50	1.52	1.54	1.56	1.58
-22	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52	1.54	1.55	1.57
-20	1.36	1.38	1.40	1.41	1.43	1.45	1.47	1.49	1.51	1.53	1.55	1.57
-18	1.35	1.37	1.39	1.41	1.43	1.45	1.46	1.48	1.50	1.52	1.54	1.56
-16	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.47	1.49	1.51	1.53	1.55
-14	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.46	1.48	1.50	1.52	1.54
-12	1.32	1.34	1.36	1.38	1.39	1.41	1.43	1.45	1.47	1.49	1.51	1.53
-10	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52
-8	1.29	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.47	1.49	1.51
-6	1.27	1.29	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.47	1.49
-4	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48
-2	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46
0	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44
2	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42
4	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40
6	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38
8	1.14	1.16	1.18	1.20	1.22	1.24	1.25	1.27	1.29	1.31	1.33	1.35
10	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31	1.33
12	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31
14	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28
16	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.21	1.23	1.25
18	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23
20	0.99	1.01	1.03	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20
22	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.09	1.11	1.13	1.15	1.17
24	0.93	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.09	1.10	1.12	1.14
26	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.11
28	0.88	0.90	0.92	0.94	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.08
30	0.85	0.87	0.89	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04	1.06
32	0.82	0.84	0.86	0.88	0.90	0.92	0.93	0.95	0.97	0.99	1.01	1.03
34	0.80	0.81	0.83	0.85	0.87	0.89	0.91	0.92	0.94	0.96	0.98	1.00
36	0.77	0.79	0.81	0.82	0.84	0.86	0.88	0.89	0.91	0.93	0.95	0.97
38	0.74	0.76	0.78	0.80	0.81	0.83	0.85	0.87	0.88	0.90	0.92	0.94
40	0.72	0.73	0.75	0.77	0.79	0.80	0.82	0.84	0.85	0.87	0.89	0.91

Note: Multiply rangefinder distance by table value and add ***datum*** to obtain total height.

APPENDIX C: STANDARD FORMS

PLOT COVER SHEET

PSP DIAMETER / HEIGHT FORM

PLOT HISTORY SHEET

PSP PLOT COVER SHEET

	CODE	EXPERIMENT	PLOT
A		;	;

NEW, REM or INS

I or M

FOREST	COMPT	STAND
		. .

NEW PLOTS ONLY

LAT	LONG	ALT (m)	CROP TYPE	SPACING	PLOT TYPE	CONTROLLER
				;		

KEY	SPECIES	YEAR PLANTED	VOL TABLE	HEIGHT TABLE	SEEDLOT NUMBER
1			T	H	
2			T	H	
3			T	H	

MEAS (mth;yr)	;	;	;	;	;	;
THIN (mth;yr)	;	;	;	;	;	;
PLOT AREA (ha)	.	.	.	.	.	.

NOT FOR PUNCHING

Tree nos of DBH checked trees						
Tree nos of Height checked trees						
Measured by						
REMARKS						

NEW = new plot, REM = re-measurement, INS = inserted measurement

I or M = Imperial or Metric

PSP DIAMETER / HEIGHT FORM

CODE	EXPERIMENT	PLOT
E	;	;

MONTH/YEAR ;

QUAD TREE NUMBERS		SK	DBH (cm)		St	TOTAL HEIGHT (m)		HP	CROWN HEIGHT (m)		SQ	DESC CODE
**	**			**	**		**	**		**	**	**
			-	.		-	.		-	.		
			-	.		-	.		-	.		
			-	.		-	.		-	.		
			-	.		-	.		-	.		
			-	.		-	.		-	.		
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			-	.		-	.		-	.		
			-	.		-	.		-	.		
			-	.		-	.		-	.		
			-	.		-	.		-	.		

SK : Species Key
St : Tree Status F, W or X (preceded by U if DBH is unrepresentative)
HP : P, S or N (Height purpose code)
SQ : Stem Quality (User defined)
DESC CODE : Descriptive Code

PSP PLOT HISTORY SHEET

CODE	EXPERIMENT	PLOT
	;	;

		CODE
FOREST		
LOCATION		
OWNER		

OBJECTIVES

THINNING		
PRUNING		
FERTILISATION		
GROWTH		
OTHER		

RELATED PLOTS

PRESCRIBED TREATMENT

SLOPE	ASPECT	TOPOGRAPHY

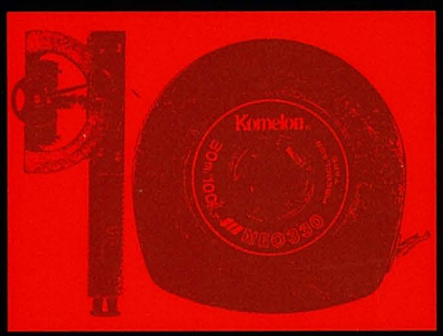
CLIMATE

GEOLOGY

PREVIOUS CROP

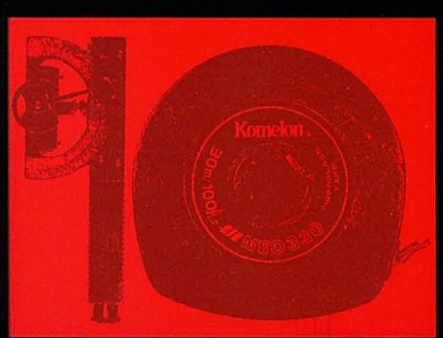
	MTH ; YEAR	AREA (ha)	SURROUND (m)	SHAPE	ROTATION
PLOT ESTABLISHMENT	;				

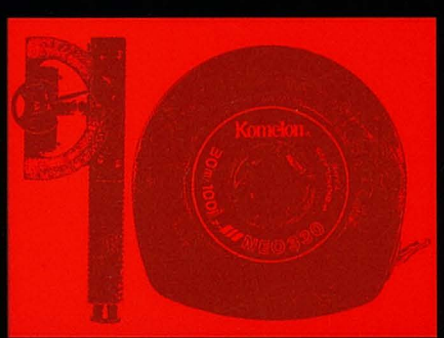
COMMENTS

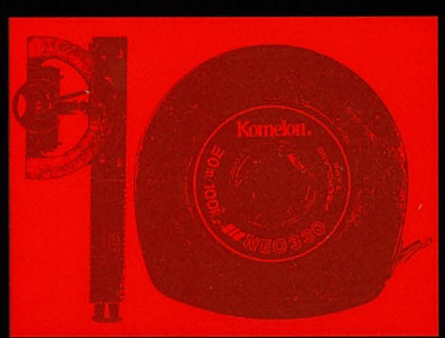

Komelon
30m 100ft
NEO 220


Komelon
30m 100ft
NEO 220


Komelon
30m 100ft
NEO 220


Komelon
30m 100ft
NEO 220


Komelon
30m 100ft
NEO 220


Komelon
30m 100ft
NEO 220