

Techniques for measuring stand height

This guideline advises landholders and forest operators how stand height can be measured so basal area harvesting limits under the private native forestry (PNF) Code of Practice can be calculated. Stand height should be calculated by measuring the height of five dominant trees within the stand, and dividing the total by five to get the average height.

There are several ways of measuring tree height with the most accurate and efficient methods using costly instrumentation. However it is possible to obtain accurate tree heights using relatively inexpensive equipment. Five methodologies are presented below.

Method 1: Using a metric tape measure

This is the cheapest and simplest technique, and requires two people. One person stands well back from the tree at a point approximately equal to the height of the tree. The second person stands at the base of the tree.

Holding a 40-centimetre section of tape measure vertically out in front of them, the first person closes one eye and looks past the edge of the tape so the tree appears next to the tape. Moving the tape so the '0' point corresponds to the base of the tree, they can then 'measure' the apparent height to the top of the tree with the centimetre graduations on the tape.

The next step is to calculate 10% of this apparent height. Taking care not to move, the first person asks the second person to mark a point on the trunk of the tree that corresponds to 10% of the 'apparent' height. This mark corresponds to 10% of the actual tree height. The first person then measures the height from the base of the tree to the second person's mark, and multiplies this figure by 10 to obtain the actual tree height.

For short trees of less than 10 metres in height, operators should use a point that is 20% (one-fifth) of the tree height. For very tall trees over 25 metres in height, operators might consider using 5% (one-twentieth) of the total tree height.

For this very simple method, there is no need to know how far away the operator is from the tree or to worry about sloping land.

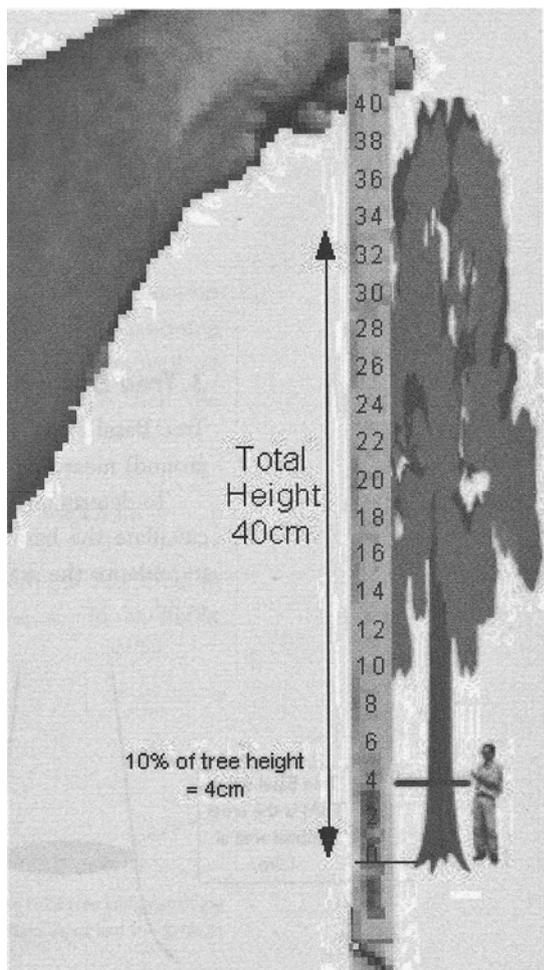


Figure 1: Measuring tree height using a tape measure

Precautions

For this method to be effective:

- the operator must hold the tape vertically, letting the tape hang momentarily before pulling it tight and sighting
- the operator should stand very still, being sure not to move their head when sighting
- the 'base' of the tree must be identified correctly.

Method 2: Using a clinometer (percent scale) and tape measure

This is an accurate and recommended method of measuring tree height, using a tape measure and an instrument called an *optical reading clinometer*. The latter is a hand-held precision instrument used for measuring angles and slopes and sells for between \$160 and \$200 (2007 prices, including GST), depending on the model.

The instrument is held in one hand and viewed through an optical lens fitted with a crosshair, a plus and minus degree scale and a percent scale (see Figure 3 on the next page). Both eyes need to be open with one eye reading the scale on the instrument while the other looks at the target. (A target may be a twig, a branch, a leaf or any other object as long as it is at eye level.) Both scales measure the angle or slope to the target, expressed in either degrees or percent, from the horizontal at eye level.

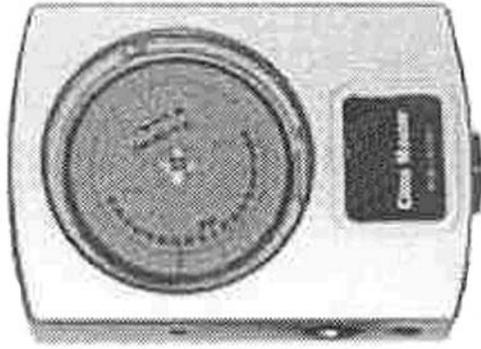


Figure 2: A clinometer

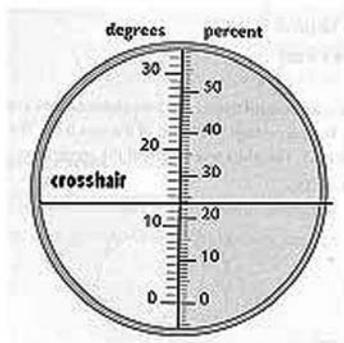


Figure 3: Looking through a clinometer's eyepiece

Measuring tree height on reasonably level ground

1. To measure the height of a tree, move back far enough so the tree-top can be comfortably be viewed through the crosshair of the clinometer, and read the percent scale.
2. Measure the distance to the tree from where the reading was taken, with a tape measure.
3. Calculate the height of the tree.

In the example below, the clinometer reading is 50% and distance to the tree is 38 metres (see Figure 4 on next page):

Tree height = $50/100 \times 38$ metres = 19 metres

To this must be added the eye's height from the ground, say 1.6 metres

So tree height would be approximately 20.6 metres.

Measuring tree height on sloping ground

On sloping ground, two readings will need to be taken with the clinometer. One reading is taken to the tree-top (apex) and a second reading is taken to the base of the trunk.

When the base of the trunk is below eye level, the percent values are added (see Figure 5 on next page). The distance to the tree is then measured with a tape measure. The height is then calculated as follows. For example, if the tree-top reading is 50%, the ground reading is 13% and the distance to the tree is 38 metres, the mathematical calculation is:

Tree height = $(50 + 13)/100 \times 38 = 23.9$ metres.

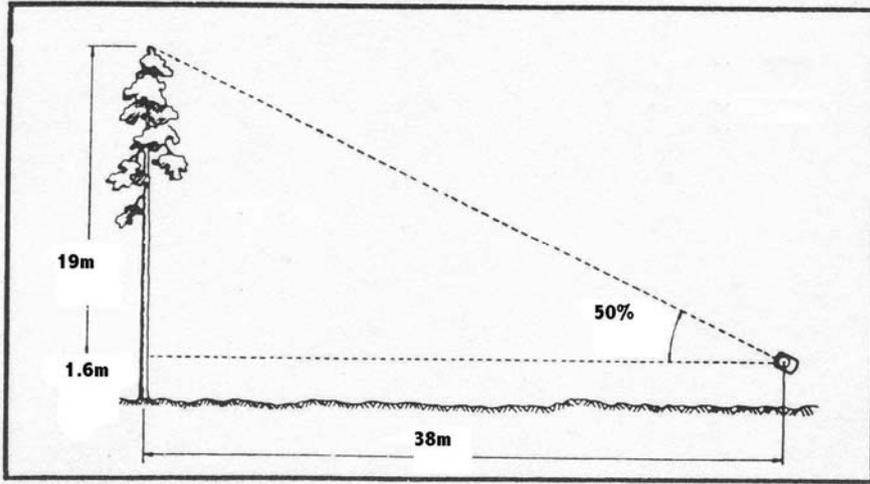


Figure 4: Using a clinometer on reasonably level ground

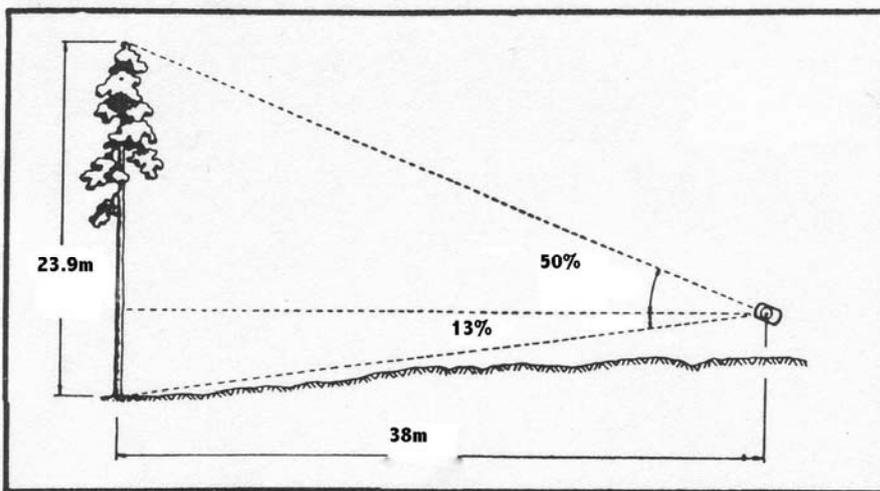


Figure 5: Using a clinometer on sloping ground when the base of the trunk is below eye level

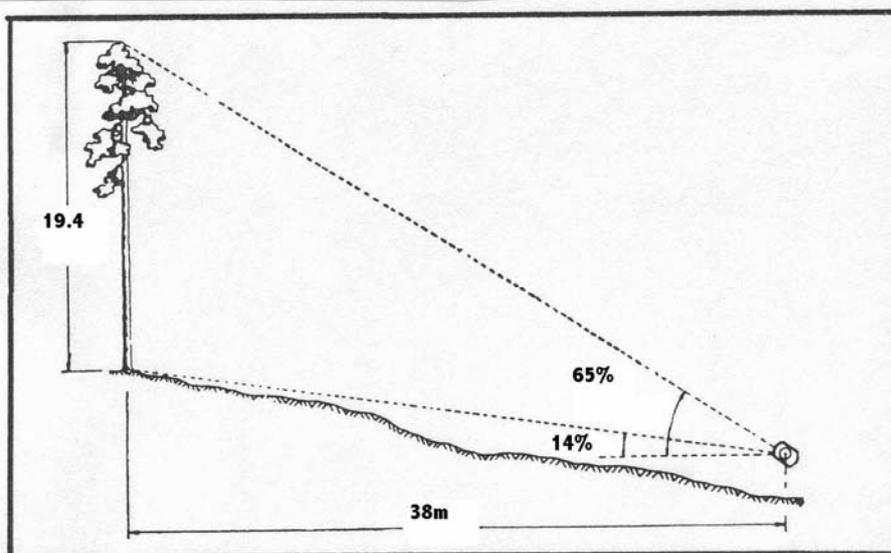


Figure 6: Using a clinometer on sloping ground when the trunk base is above eye level

Where the base of the trunk is above eye level, the trunk base percent is subtracted from the tree-top percent (see Figure 6). The distance to the tree is then measured with a tape measure. The height is then calculated as follows. For example, if the tree-top reading is 65%, the base reading is 14% and the distance to the tree is 38 metres, the calculation is:

$$\text{Tree height} = (65 - 14)/100 \times 38 = 19.4 \text{ metres}$$

Note: When measuring tree height on sloping ground, it may sometimes be possible to measure across the slope, thereby eliminating slope angle and the need for a base of tree reading. If using this technique, calculate the heights as you would on reasonably level ground.

As readings on the percent scale are based on the horizontal distance, if the distance is measured on sloping ground a distance error is introduced which must be corrected for accuracy purposes. For small gradients (less than 5 degrees) the error is insignificant, but it increases progressively as the gradient increases. As a result, if measuring distance on ground with a gradient steeper than 5 degrees, use method 3 below. See method 3 to find out how to calculate the steepness of the gradient.

Method 3: Using a clinometer (degree scale) and tape measure

To measure the slope of the ground, use the degree scale on the clinometer. Facing up or down the slope, select a target at eye level, that is, an object that would be at eye level if the person was standing next to it. Next, tilt the clinometer up or down until the crosshair intersects the target, and read the degree scale.

The trigonometrical correlation which can be used to correct tree height is:

H = h x cosine of a where:

- **H** is the true or corrected tree height
- **h** is the observed tree height
- **a** is the ground slope *in degrees*.

Most calculators will be able to calculate cosines.

Example 1

If the tree-top reading is 50%, the ground reading is 13%, the distance to the tree is 38 metres and the ground slope is 9 degrees (see Figure 7 on next page), the mathematical calculation is:

$$\text{Tree height} = (50 + 13)/100 \times 38 = 23.9 \text{ metres}$$

$$\text{Tree height} = 23.9 \text{ metres} \times \text{cosine of } 9$$

$$\text{Tree height} = 23.9 \times 0.987 = 23.6 \text{ metres}$$

23.6 metres is the true tree height.

Example 2

Alternatively, multiply the ground distance by the cosine of the slope angle and take the sum percentage of the corrected distance:

$$38 \times \text{cosine of } 9 (0.987) = 37.5$$

$$\text{Tree height} = (50 + 13)/100 \times 37.5 = 23.6 \text{ metres}$$

23.6 metres is the true tree height.

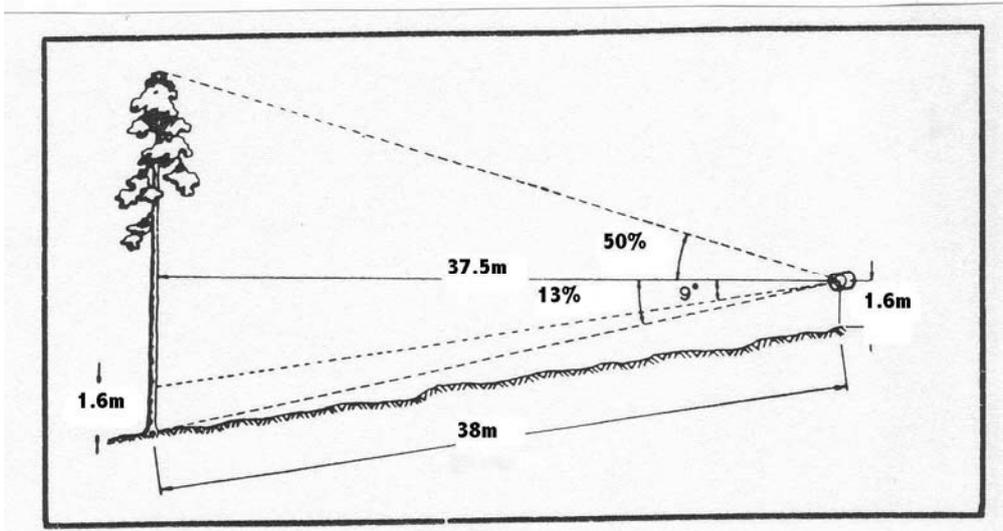


Figure 7: Correction for distance error on sloping ground

Method 4: Using a height meter

Measure a distance from the tree of 15 metres or 20 metres. In some cases, distances of 30 metres or 40 metres will have to be measured for taller stands. Some height meters come with a separate prism which when used with a special target mounted by the tree will establish the distance from that tree. However such targets incur extra cost and save little time in comparison to the use of a tape measure.

A large selection of height meters and combined height meters/clinometers are available. Purchased from an instrument provider, they sell for between \$170 and \$220 (2007 prices, including GST).

The instrument is held in one hand and viewed through an optical lens fitted with a crosshair, and a 20-metre scale on the left-hand side and a 15-metre scale on the right-hand side (see Figure 8 on next page). By sighting on the top of a tree from the distance the operator has measured, the tree height can be read straight off from the corresponding left or right scale of the instrument. As the scale is for distances of 15 and 20 metres, readings should be doubled when measuring from distances of 30 metres and 40 metres respectively.

Examples of measuring tree height using a height meter on reasonably level ground

On level ground the tree-top reading is usually sufficient. The height of the observer only has to be added. So in Figure 8 at a distance of 20 metres, the reading to the top of the tree is 12 metres. The height of the observer's eye above the ground is 1.6 metres so the tree height will be 13.6 metres.

Examples of measuring tree height using a height meter on sloping ground

Example 1

On sloping ground where the base of the tree is below the eye level of the observer, the height of the tree is obtained by adding the readings to the top of the tree and to the bottom of the tree together. In Figure 9, at a distance of 20 metres the reading to the top of the tree is 10.25 metres and the reading to the bottom of the tree is 3.25 metres, so the tree height will be 13.5 metres.

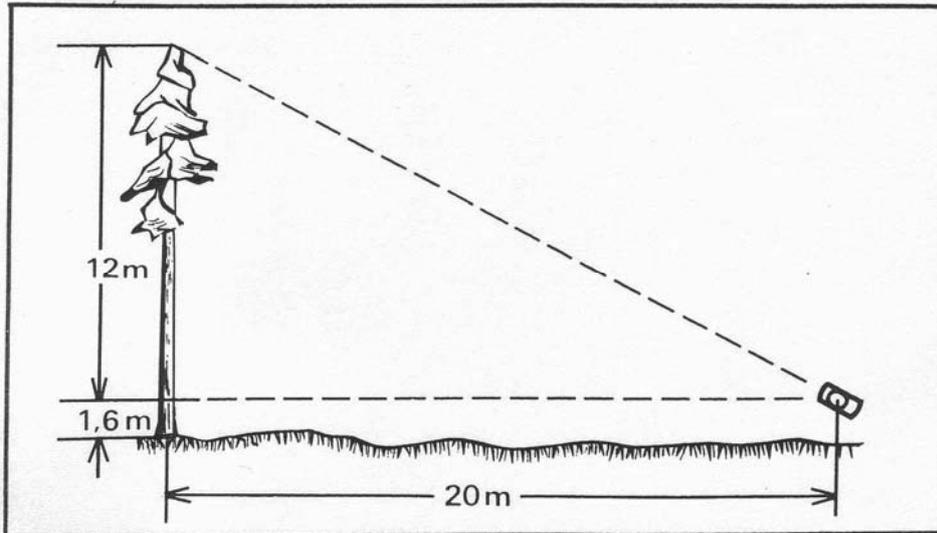


Figure 8: Using a height meter on level ground

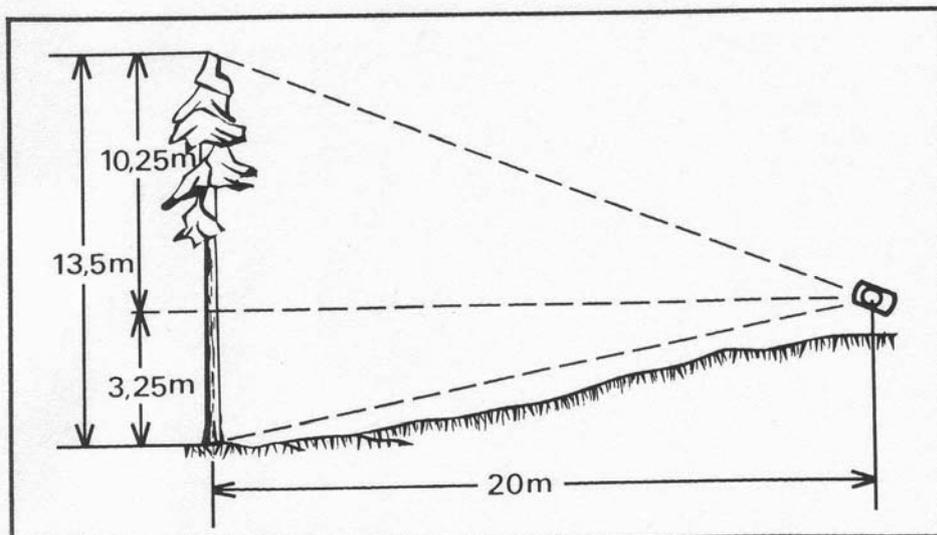


Figure 9: Using a height meter on sloping ground when the base of the tree is below eye level

Example 2

If the base of the tree is above the eye level of the observer, the reading to the bottom of the tree is subtracted from the reading to the top of the tree. In Figure 10 on the next page, at a distance of 20 metres, the reading to the top of the tree is 16 metres, the reading to the bottom of the tree is 3.5 metres, so the tree height will be 12.5 metres.

Method 5: Using a Haglof electronic clinometer

The Haglof electronic clinometer (HEC) is a simple to use device for measuring tree heights without the mathematical calculations required for a traditional optical reading clinometer. However, it still requires some practice to master and at around \$400 (2007 prices, including GST), it is almost twice the price of a traditional clinometer.

The tool is used in the same way as a traditional clinometer with the operator positioning themselves at a set distance from the tree with the distance still needing to be measured using a tape measure. The distance is set in the HEC, and tree height is assessed by focusing the line in the viewfinder on the base and then on the top of the tree.

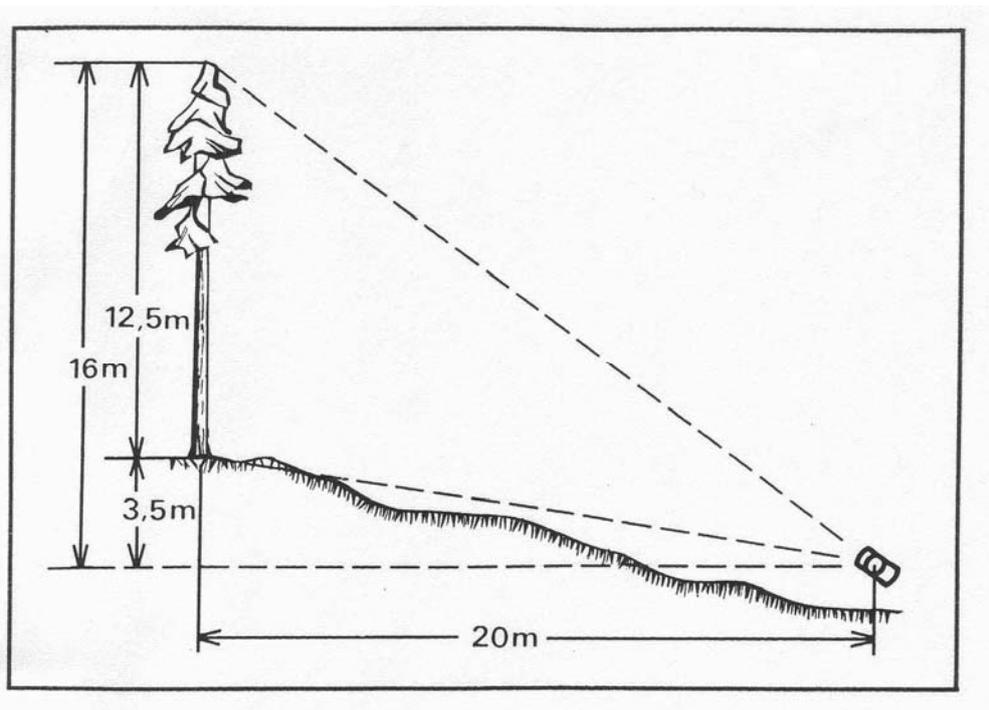


Figure 10: Using a height meter on sloping ground when the base of the tree is above eye level

The main advantage over the traditional clinometer is the ease of operation. One short click switches the device on and a second short click accepts the default distance. The HEC is now ready for height measurement. With a long click for the base of the tree and another for the top of the tree, the height is calculated by the HEC and displayed in its viewfinder.

The only disadvantages are the need to still use a tape measure and the difficulty of allowing for distance error when measuring on steep ground. As with the traditional clinometer, the simplest way to measure is across the slope, eliminating the need for additional calculations, although this is not always possible. For accuracy with the HEC, the gradient needs to be determined, and then the distance from the tree adjusted accordingly before the down and up angles can be recorded. See Method 3 for details on calculating the angle of the slope and adjusting the distance from the tree.

Further reading

Australian Forest Growers, *Australian Forest Grower Magazine*, Spring 2004

Australian Master Tree Grower 1999, *The farmers log*

Australian National University, School of Forestry mensuration notes

Coombell Farm Forestry Centre 2001, *Coombell Farm forestry training course manual*

Department of Agriculture, Fisheries and Forestry, *National farm forest inventory manual*, available from Nick Stephens, phone: (02) 6272 4034, email: nickstephens@brs.gov.au or visit www.daff.gov.au

Prospectors Earth Sciences, *Prospectors Earth Sciences catalogue and instrument notes*

State Forests of NSW 1995, *Technical paper no. 59: Field methods manual*, Research Division, Sydney.

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