Chiltern Woodlands Project

The Why and How of Tree Measurement

By Liz Hamilton, project volunteer

Why Measure Trees?

Perhaps, for the same reason as we climb mountains, because they are there. Trees which are large, old, commemorate an event or have a special connection with a locality deserve our particular attention, but it is worth measuring any tree, regardless of how ordinary it may seem today. By recording its size we may be augmenting existing information about a tree or creating a new record: in both cases future tree enthusiasts may value our work.

Man must have been measuring trees for hundreds of years. We know that coppice was cut when the stems were the correct size for the desired use, and timber trees were felled for particular uses, for example in ships or buildings. Much of this early measurement was probably done by experienced eyes without specific equipment. John Evelyn (1620-1706) measured trees and his ‘Sylva, or a Discourse of Forest Trees’, first published in 1664, is a classic early forestry book, written to encourage landowners to plant trees to supply the navy.

Edward Hoppus, Surveyor to the Corporation of the London Assurance, first drew up his timber-measuring tables in 1736, based on the quarter-girth measure. Timber measured in Hoppus feet was the standard method used to measure timber volume in this country until very recently and is still in use in some countries. If you are researching old documents and come across references to Hoppus feet, bear in mind that this is a measure of volume, being approximately 21.5% less than the true volume of a tree or log.

Foresters now mainly use metric measurements and a vast array of tables allow calculations of usable timber volume from measurements of standing individual trees and whole stands (where these comprise relatively uniformly-sized trees), as well as felled timber.

Interest in tree heights grew steadily throughout the 19th century, helped by the discovery in parts of the world, such as western North America, of conifers suitable for cultivation in Britain which were capable of reaching a great size and outstripping our native species.

In modern times the late Alan Mitchell is best known for measuring thousands of trees throughout the British Isles. His ‘Field Guide to the Trees of Britain and Northern Europe’, first published by Collins in 1974, contains a huge wealth of information and references to tree sizes. The excellent introduction to this book covers a number of topics including methods for measuring tree height.

What Do We Measure?

Mitchell concentrates on two measurements to describe the size of a tree: the **girth** and the **height.** He defines ‘a tree’ for his book as ‘a woody plant that commonly achieves a height of 6m (20 ft) on a single stem’ and thus excludes shrubs, although he includes Hazel (*Corylus* spp.) ‘an abundant countryside species which might be thought to be a tree’. He dismisses the measurement of the spread of a tree ‘beloved of gardening books…It is greatly dependent on surroundings and is nearly meaningless’.

Mitchell says that the height and spread of a tree reach a maximum size then stop increasing and after a variable time start to decrease as senility sets in. Thus neither gives an accurate estimate of age except in young trees.

Girth
On the other hand, the girth goes on increasing throughout a tree's life and so can be used to estimate age. Although trees vary enormously, Mitchell found that most trees conform to a simple rule:

- **mean growth in girth in most trees with a full crown is one inch (2.5 cm) a year. Thus a tree in open ground with an 8 ft (2.44m) girth is about 100 years old**
- **a tree of similar size in a wood might be 200 years old**
- **growing in an avenue (or slightly hemmed in) it will be around 150 years old**

Needless to say, Mitchell states some exceptions:

- most young trees grow much faster
- growth slows with age, so in very old trees the growth rate over the life of the tree will be less

Young oaks on a good site may grow 1.5-2 inches (3.75-5 cm) a year for their first 60-80 years, then at the standard rate until they attain a girth of 20-22 ft (6-6.6m), then they slow further as a function of the loss of leafing crown.

In certain species normal growth is 2-3 inches (5-7.5 cm) per year. This includes: Wellingtonia (may attain 6 in/15cm) per year), Coast Redwood, Low's Fir, Grand Fir, Cedar of Lebanon, Monterey Cypress, Sitka Spruce, Douglas Fir, Western Red Cedar, Western Hemlock, Cricket-bat Willow, Black Italian and other hybrid poplars, Wingnuts, Nothofagus spp., Red and Chestnut-leafed Oaks, Hungarian and Turkey Oaks, Tulip Tree, London Plane and most Eucalyptus spp.

In the following normal growth soon falls below 1 inch (2.5 cm) per year: most small-growing trees, Scots Pine, Norway Spruce, Horse Chestnut and Common Lime.

Yew is a very special case. For the first 100 years a Yew should attain 1 inch per year, but after that the rate of increase in girth slows, even when the crown retains full vigour and increases its spread annually. For this reason it is difficult to estimate the age of a Yew from its girth, but as a rough guide: 8 ft (2.44 m) = 100-150 years old, 16 ft (4.88 m) = 300-400 years, 20 ft (6.1 m) = 500-600 years and 30 ft (9.5 m) = 850-1,000 years.

Tree Rings
If the opportunity arises to inspect tree stumps, this should yield valuable information about the ages of the trees in a wood and their growth rates. Ideally the stumps should be freshly cut when the rings still show clearly. The structure of a tree stem is quite complex, but annual rings arise because in the spring large, thin-walled cells form close to the bark (these form the spring wood). Through the growing season new cells are progressively smaller and darker, with thicker walls. In the following season the new spring cells form next to the smallest and darkest cells from the previous year. This forms the annual ring. In some species such as birch and holly the rings may not be very clear.

For anyone able to inspect felled trees in other parts of the world, bear in mind that the differentiation of cells to produce annual rings only happens when there is a break in the growing season caused by cold or drought.

Counting annual rings helps to reveal information about varying growth rates in different places due to site factors such as soil fertility and moisture availability. In a single tree there may also be marked variations in the width of the spring wood. These can be linked to variations in the weather: if the tree growth was slowed by drought or cold the spring wood will be narrower. Trees in a stand should put on a growth spurt after nearby trees have been felled (a thinning) and this will show in wider spring wood: this can useful when piecing together the management history of a wood.

Height
Trees may be damaged in a variety of ways which shorten their height or they may be deliberately coppiced, pollarded or lopped. Nonetheless information about tree heights is valuable even if it is not a good predictor of age. The potential height of a species is of interest to gardeners, foresters and others, and the variation in heights attained by species on different sites is also of interest. Mitchell included a wealth of tree height information in his 'Field Guide' and was clearly keen to identify both the tallest specimen in Britain of every species and the tallest tree of all. He notes that in 1970 the tallest tree was a Douglas Fir at Powis Castle (then 55 m), although by 1973 this tree had been equalled or overtaken by two Grand Firs (in its native range in western North America this species has been known to reach 100m).

As Mitchell points out, some of the taller-growing species only introduced relatively recently have yet to show their full height potential in Britain. It was reported in February 2009 that Douglas Fir has once again taken the lead in Britain's tallest tree race. The Stonardon Douglas Fir at Dunans Castle in Perthshire was measured at 63.79 m (209 ft), 12 m (40 ft) taller than Nelson's Column. Scotland is renowned for its excellent growing conditions for conifers and this measurement was taken on behalf of the Tree Register (founded by Alan Mitchell himself) by someone climbing to the top (please don't try this at home!).

What To Record
To be of most value tree measurements should use standard methods and provide a minimum of information as follows:

- The name and contact details of the person collecting the information.
- Date when the measurements were taken
- Specific location of the tree: 8 figure Ordnance Survey Grid Reference; GPS co-ordinates (if available)
- Nearest village/town, with details of nearby features if this helps to locate the tree (this might be accompanied by a sketch map or photographs)
- Setting eg woodland, parkland, street, garden, farmland, churchyard
- Directions to the tree
- Name and contact details of the site owner and whether there is public access
- Species of the tree
- Special name of the tree, if any
- Height in metres
- Girth in metres measured 1.5 metres above the ground
- Any special or additional information about the tree

The Chilterns Special Trees and Woods Project has a Special Tree Recording Form which can be downloaded from the website.

Measuring A Tree's Girth (diagrams are from www.tree-register.org)
The girth is the circumference of the tree around its trunk (or bole or stem). This is measured 1.5 metres (5 feet) above the highest point of the surrounding ground. You may find it useful to carry a stick of this length with you. Make a note if the adjacent ground appears disturbed in some way. Make sure that the tape is level all round the trunk. Check your first result once or twice and record the smallest figure. This should be in metres (to two decimal places).

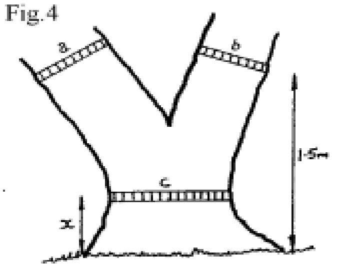
N.B. Modern foresters and forestry books use a different measurement: diameter at breast height or dbh. You should be aware that this measurement is taken 1.3 metres above ground level. However, tree databases such as the Ancient Tree Hunt and The Tree Register, as well as the Chilterns Project, have kept the more traditional 1.5 metre (5 ft) point above the ground.

Use a proper metric measuring tape if possible, rather than improvising with rope or string which may be stretchy or elastic. Steel tapes may not be very flexible and can behave erratically! You may need help if the tree is very large. Check that the tape is undamaged. Special dbh tapes are available from forestry suppliers: these give the diameter of a tree when the girth is measured.

If there are burrs or swellings at 1.5 m, measure the trunk at various points below 1.5 m to obtain the smallest measurement. Note the height at which this measurement was taken. If in doubt record several measurements at various heights such as at 0.3 m, 1 m and 1.5 m. A tree which is completely burred on its main stem, exaggerating any measurement, should be noted as such. Measure under ivy or other creepers if possible (but don't pull ivy etc away from the trunk to do so – the owner may like it there).

If a tree forks at or below 1.5 m the measurement is recorded at the narrowest part of the main stem below the fork and the height of the forking noted. e.g. 1.24 m girth @ 0.3 m (forks @ 1 m). The two or more stems should be recorded at 1.5 m. e.g. 0.45 m + 0.34 m girth (see below).

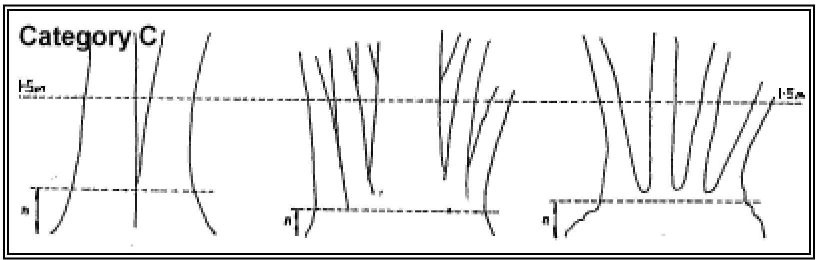
Fig.4



A tree may break into two or more stems at or near ground level (see below), for example where it has been coppiced. Where possible measure the largest individual stem at 1.5 m for comparison with an individual tree. Measure as many of the other stems as practical at 1.5 m and show these as:

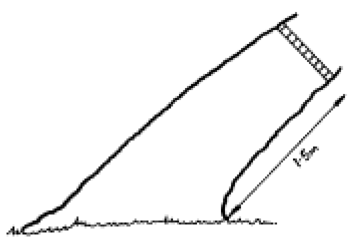
biggest stem + other stem + other stem etc (all in metres) @1.5m.

Also measure the height at which the stems separate from the base of the tree or stool, and the girth of the base or stool at this point.



A **leaning tree** should always be recorded on the lower or underneath side. Collapsed trees still growing can also be recorded in this fashion. Ensure that the tape position is correct and follow all the above points as if measuring a vertical trunk (see below).

Fig.6



Measuring Tree Height

There are many ways of measuring tree height from the ground. Some use expensive devices such as an hypsometer, or require the measurement of angles with the use of trigonometry and accompanying tables or calculators.

Measuring tree height from the ground is relatively accurate when the surrounding ground is flat, when the proper top of the tree is visible, and when there is clear ground between the tree and the observer. Clearly in many situations some or none of these apply!

Try to apply the following rules:

- measure to the true top of the tree if possible
- measure distance on the ground to the point below the highest part of the tree (this will often be to the centre of the trunk, but if the tree is leaning this may be away from the trunk)
- stand level with the tree, not above or below it on sloping ground
- check the height with a second measurement on a different baseline

If vision is obstructed, the true top is not visible or the baseline is impeded you may have to estimate the height and this should be recorded as such.

Trees with crown dieback should be measured to the highest live branch, with a separate measurement to the top of the original crown as this is also of interest.

Where a tree has clearly been cut or damaged in some way which affects its height this should be noted.

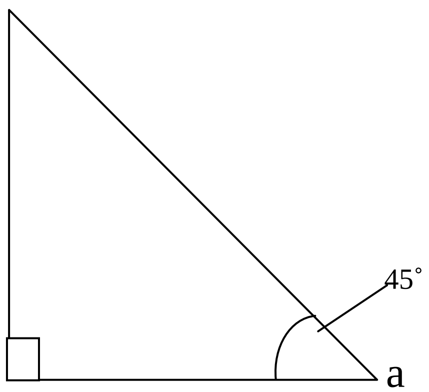
At a Special Trees and Woods Project training day held at Ashridge in the spring of 2009, several methods of measuring tree height without the use of expensive equipment were tried. One method, described by Alan Mitchell, needs only one person and a stick, rapidly christened the 'Mitch Stick'. Mitchell claims that this method is 'quite accurate if used with care' but at Ashridge the testers found the method tricky and produced a large range of results when attempting to measure the height of the same tree.

A number of other methods, essentially one- and two-person variants of the 'Mitch Stick' method, were also tried and also produced very variable results.

45˚ Clinometer

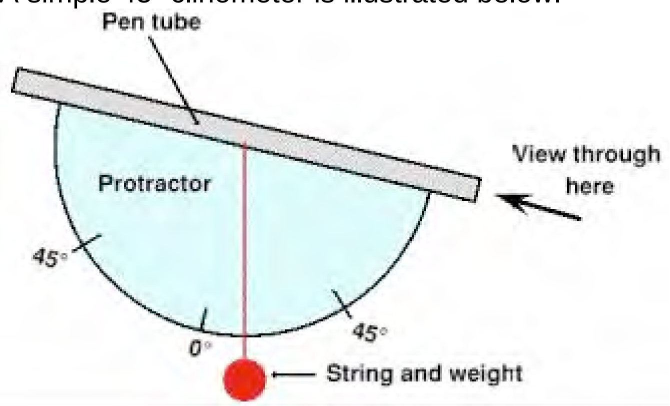
At the Ashridge training day a home-made version of a '45˚ clinometer' was easy to use and produced consistent results.

This device is based on the fact that in an isosceles right-angled triangle where the two sides adjacent to the right angle are of equal length, the other two angles will be 45˚.



In the triangle above, the vertical side (equivalent to the tree) is equal in length to the horizontal side. The observer stands at point “**a”**.

A simple 45˚ clinometer is illustrated below.



Source: www.saps.plantsci.cam.ac.uk/worksheets/activ/treehttn.pdf

In place of the protractor you could use a paper plate cut in half, or any semicircular piece of firm card or thin wood. You also need an empty pen tube or a piece of straight tube, some string and a weight.

Attach the tube to the straight edge of the semicircle: this is the sighting guide. Exactly half way along the straight edge make a hole to attach the piece of string: the whole needs to be big enough for the string to move freely. Hang the weight on the other end of the string so that it dangles beyond the edge of the semicircle.

Mark the line that is at 45˚ to the tube (clearly there are two such lines but mark the one nearest to the end of the tube you will hold to your eye). Even if you have used a protractor it would be useful to highlight this line.

Ideally you need a second person to work with you to check the position of the string.

Look through the tube so that the tree top is visible. Walk backwards away from the tree keeping the top visible through the tube. Your partner will need to follow you and note when the weighted string lines up with the 45˚ line. Stop and measure the distance that you are from the tree. This distance is equal to the height of the tree less your height. So add your height (strictly the height of your eyes) to the distance from the tree to give you an estimate of the tree's height.

Try to follow the rules for measuring tree height set out above. A disadvantage of this method is that the observing position is fixed and with some crown shapes to obtain the 45˚ angle you may have to stand too close to see the true top of the tree.

With thanks to Joyce and Malcolm Wiles who, after the Ashridge training day in April 2009, produced a paper on 'The Maths of Measuring Tree Heights' from which some of the above has been obtained.

Some Useful Links

www.tree-register.org

www.ancient-tree-hunt.org.uk

www.rfs.org.uk The Royal Forestry Society's comprehensive website. The Society is based in Tring with a specialist forestry library.

www.forestry.gov.uk The Forestry Commission's website. Includes publications on trees and forestry.