Forestry Commission
231 Corstorphine Road
Edinburgh
EH12 7AT

http://www.forestry.gov.uk

Estimating the Age of Large and Veteran Trees in Britain

INFORMATION NOTE

ISSUED BY FORESTRY PRACTICE NOVEMBER 1998

BY JOHN WHITE*

SUMMARY

A method of age estimation is proposed that avoids any damage to vulnerable specimen trees. It relies upon comparison with lists of measurements of known date. From these the likely performance of various species in different locations on particular site types can be evaluated. Cross-referencing between individual specimens is credible because trees develop predictably through well-defined patterns of growth. Age can be calculated largely from annual ring areas within the stem, as determined by a simple girth measurement.

INTRODUCTION

1. Large trees of historical or conservation significance cannot be cut down or weakened in any way by boring holes in them to count the annual rings. Age can only be estimated by external measurement and then by direct comparison with other trees of similar species, size, and known planting date on comparable sites elsewhere. Accurate comparisons of this kind can only be made after a considerable amount of data from a wide range of situations has been accumulated. A lot of detective work must then be carried out on the trees to be dated. Detailed site notes are essential. Some knowledge of landscape archaeology (Rackham, 1990a) will provide useful information about how a location in which trees now stand has changed over time. Only through very detailed observation can we interpret much of what ancient trees are telling us.

2. Direct comparison with other trees is practical in Britain because there is a wealth of recorded data and historical information to draw on. The Forestry Commission's National Tree Register (Mitchell and White, unpublished) contains numerous measurements and ages of trees gathered over a period of 40 years from 1952. It also incorporates earlier published measurements. New records of tree size continue to be accumulated on TROBI, the Tree Register of the British Isles (Alderman, database manager, TROBI unpublished). English Nature, through its Veteran Tree Initiative, is at present in the process of listing ancient trees on a huge scale. Patterns of growth and ultimate sizes of trees, particularly very large specimens, have emerged from all these databases. Hundreds of ring counts relative to stem diameter measurements have also been made on cut or broken stumps. From all of this evidence, tables of expected growth relative to stem size have been formulated for a number of commonly planted species.

THE PATTERN OF GROWTH

3. Trees progress through three phases of growth: a formative period, middle age or the 'mature state', and senescence. Planted trees and young natural seedlings may take a few seasons to become established, but soon growth picks up as crown size and consequently leaf area increases year by year. The increment of new wood, nourished by ever more foliage, will inevitably increase each season until the canopy is fully developed. This may or may not be hindered by adjacent trees or other physical obstructions. The growth of new wood in the stem generally produces more or less constant ring widths during this period. However, annual rings of equal width progressively increase in area as the stem diameter expands.

4. Once optimum crown size is reached, usually after 40 to 100 years, annual production of plant food from the foliage is likely to stabilise and remain uniform except for the occasional effects of weather and defoliators such as caterpillars (Rackham, 1990b). The current annual increment of new wood (CAI) will also remain more or less constant in terms of volume. This is laid down each year as a fresh layer over the entire under-bark surface of the tree. As the size of the tree increases it is spread ever more thinly over a

* Forest Research Dendrologist (retired)
Current address: 8 St Andrew's Drift, Langham, Holt, Norfolk NR25 7AG

larger area. This produces annual rings in the stem which are of the same cross-sectional area but they progressively decline in width (Figure 1). In old age the crown of a tree may sustain damage, branches begin to fall off or die back. The leaf area that can be supported decreases and annual production of new wood is reduced. Ring width, often thinly distributed anyway, declines further. Most species can barely survive when rings are reduced to 0.5 mm (20 rings to one centimetre).

5. Some species groups such as oak and chestnut keep faithfully to the three phases of growth format outlined above. However other trees do not. Pioneers such as poplar, willow and alder frequently have a productive but short formative period and then go straight into senescence. Birch, which is relatively short-lived, tends to have an extremely brief middle age period. Yew, on the other hand, lives a charmed existence. It can return to formative rates of growth at almost any stage in its very long life. It may be stimulated by a boost of plant food from branch layering, or by vigorous regeneration after catastrophic damage. For this reason it is the most difficult of trees to date with any degree of confidence.

MEASUREMENTS

6. There are several features of a tree that can be measured. Height and crown spread are perhaps the most apparent. Unfortunately, after middle age these dimensions are an unrealistic guide to age. Thickness of the stem is a constant non-reversible feature of tree growth in so far as it has to increase each year that the tree lives. By good fortune stem girth is easy to measure and consequently it can be recorded with great precision.

7. Provided there are no branches, swellings, buttresses or abnormal lumps, girth should be measured with a tape at breast height (1.3 m or 4 ft 3 in above ground level). Girth is the single parameter which sums the infinite number of diameters in an irregular cross-section (Mitchell *et al.*, 1994). Diameter at breast height (dbh) is the measurement on which the estimation of age suggested here depends. Conversion of girth measured in centimetres to diameter is achieved by dividing girth by π. Some recorders still prefer to measure in feet and inches. This can be converted to diameter centimetres as follows:

(feet x 12 + additional inches) x 0.80857.

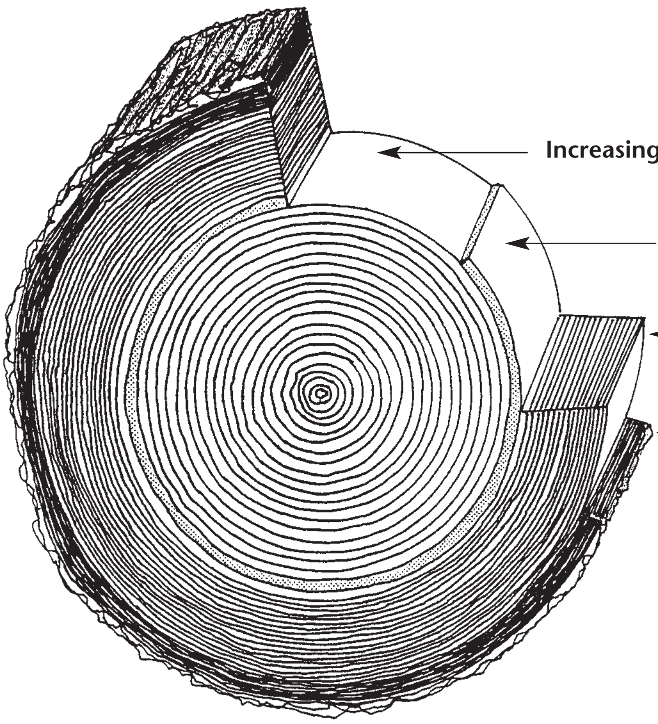
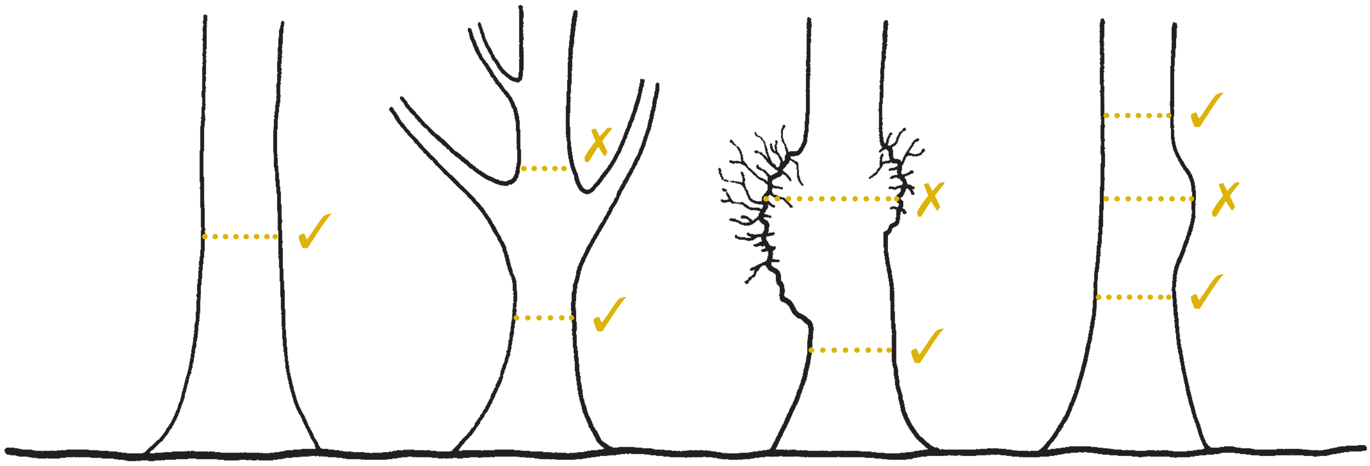


Figure 1. Diagrammatic cross-section of a tree

Figure 2. The correct positions at which to take measurements



Traditionally timber merchants measured standing trees five feet above ground level rather than at breast height. For the purposes of age calculation for very large trees this makes little difference. Where deformities, branch swellings and other irregularities occur the narrowest part of the trunk should be measured and its height above ground noted (Figure 2). If a grove of similar sized trees exists, a mean diameter measurement ultimately gives a more realistic estimate of age.

HOW AGE IS CALCULATED FROM DBH

8. The process is split into either two or three parts depending upon the phase of the tree (paragraph 3) and each requires a different approach. First there is the rapid formative expansion period up to optimum crown development (core development). Second there is the more constant middle age period (the mature state). Finally, there is the period after crown decline (senescence).

Core development

9. Core size and the speed of early growth is fairly predictable within a given species group on a particular site type. The information in Table 1a has been compiled from numerous annual ring and stump measurements. Such information is not usually available directly from large or old trees of the sort for which age is being estimated. They are likely to be hollow or completely rotten in the centre. Hard data from younger trees on comparable sites have to be used. There are indications that in spite of climatic changes, core growth in some species of old trees has not varied much for many hundreds of years. Ancient bog oak at Wicken Fen in Cambridgeshire, for example, has ring widths similar to young oaks growing nearby in East Anglia today.

10. There is obviously some gradation of ring width from core development to the next more stable growth phase. Trees do not suddenly stop expanding their crowns and annual wood production at a given age. However, most species do appear to change from evenly spaced core rings to diminishing 'middle age' rings within a relatively short period. Table 1a is compiled from average maximum core ages. If it is feasible to do so, it is better to compile a local site table to replace Table 1a if enough evidence from broken or cut stumps or half-rotten wood from stem cavities is available (see Table 1b).

11. Great care is needed when deciding which site category to use in order to determine core size (Table 1a). This is critical because all the subsequent calculations of age depend on the core age and ring width indicated. Observed conditions at the site of the tree must be thorough but treated with caution. These probably did not prevail many years ago when the tree in question was young. Much will have changed since then. Determination of site history is often a matter of some speculation. Evidence of big low branches or old branch scars may indicate open isolated early growth.

Table 1a. Tree age and ring width when mature state is reached (based on dendrological records)

Core development category	Age (years)/ring width mm (first 'mature state' ring)																			
	Common/sessile oak	Turkey oak	Red oak	Beech	Sweet chestnut	Walnut	Black mulberry	Ash	Common lime	Horse chestnut	Plane	Yew (see para 5)	Robinia	*Araucaria araucana*	*Pinus nigra*	Tulip tree	*Cedrus deodara*	*Cedrus libani*	Holly	Sycamore
Champion tree potential (ideal site conditions)	70/5	30/10	60/6	80/6					100/5		100/6			60/5	60/6	70/7	40/8			
Good site, open grown, sheltered	80/4	40/6	70/5	70/5	70/5	55/4	40/3	50/5	80/5	50/5	60/6		70/5	45/5	70/5	50/6	50/7	60/6		80/6
Average site, garden, parkland	100/35	50/5	80/4	70/4	60/5	50/4	30/3	70/4	70/5	40/5	70/5	60/4	80/4	60/4	70/5		50/6			60/6
Churchyard		40/6		60/4		50/4			80/5	50/5	70/5	55/3	80/4							60/6
Poor ground and/or some exposure	120/3			60/4	40/5	50/3						40/3	50/3	60/3	60/5	50/4		80/4	80/3	60/5
Woodland boundary pollard, or open woodland	100/3.5							20/5												
Inside woodland	70/2.5			120/3	100/3			100/3				30/3							60/4	

Notes: This table has been compiled from variable amounts of information presently available. It is incomplete and will be subject to revision as further trees of known date are measured. Individual local category additions can be compiled in the light of special investigations (see Table 1b).

The absence of any low branches might indicate dense woodland in the formative years. Ancient woodland ground flora may or may not be present, even if woodland as such has now gone. Artefacts such as tiles, bricks or pottery might give clues about sites and the age of extant trees. Ground disturbance, ridge and furrow cultivation for example, can be dated accurately. This will usually indicate a maximum time that trees could have been present. A building or a ruin of known age may serve a similar purpose for all but ancient wildwood species that might predate it. Designed period landscapes are also good indicators of maximum tree age. Old stumps, of oak usually, may remain in place for up to 200 years after cutting. They give helpful clues to the minimum length of time a site has been under woodland.

Development to maturity

12. At the nominal completion of the core development phase the area of a single annual ring is measured. This ring area (mature state CAI) is then assumed to remain constant until senescence sets in. The ring areas suggested in Table 2 are based on Table 1a averages of many assessments. This to some extent irons out possible anomalies due to periods of good or bad growth but it also detracts from precision. The possibility of more permanent fluctuations of growth due to local environmental changes has not been taken into account. Only adjacent stump ring counts and designated CAI calculations can indicate such changes.

13. It has been found that very old trees which retain a reasonable head of branches do actually maintain their mature state CAI very well. A senescent growth amendment to the calculation is not usually needed until dead wood mounts up or serious crown damage has occurred.

Senescent growth

14. If serious crown disintegration occurs through pest predation or disease, environmental extremes, or simply old age, the CAI might be reduced to almost nothing. Ring widths of less than 0.5 mm are likely. Stem diameter may not reflect this small annual increase if parts of the trunk have died or fallen away. On a very large stem it is likely that the ordinary

mature state CAI basal area formula will be producing outer rings of the expected absolute minimum sustainable width (20 rings per cm), in which case no action to change the calculation procedure need be taken. On smaller diameter trees it may be necessary to estimate how long the crown has been in decline, calculate how many centimetres of diameter it would account for (say 20 years per cm) and exclude this from the basal area calculation. Then add the number of years since decline set in to the calculation. For dead trees follow the same procedure without reducing the perceived basal area.

15. To calculate the number of rings in the outermost centimetre of a stem subtract 2 cm from the dbh and calculate a new basal area (BA) (see paragraph 16, calculation 3a). Then subtract this from the total BA and divide by the indicated mature state CAI (see paragraph 16, calculation 2d).

Table 1b. (Example) Staverton Estate

Core development category	Age/mm (fist 'mature state' ring)
Common oak Staverton 'Thicks' Mean of best stems	80/2
Common oak Staverton deer park Mean of best stems	100/2
Holly Staverton Park	60/2
Beech Staverton Estate Butley Road	70/4
Moccas Knoll Oak	80/5
Moccas Woolhope Oak	90/6

Additional Table 2 data for the above core development categories:

60/2 = 12 cm radius = 452 cm basal area = 15.0 cm CAI
80/2 = 16 cm radius = 804 cm basal area = 20.0 cm CAI
100/2 = 20 cm radius = 1257 cm basal area = 25.0 cm CAI

Notes: Tables such as this can be compiled from stem analysis. Even tiny fragments of semi-rotten wood can provide vital information if their position (radius) in the stump or stem is measurable.

Table 2. Core development, age and ring width when optimum crown size is reached, and the associated mature state CAI

Age/ring mm (from Table 1a)	Core radius cm	Basal area cm^2	CAI cm^2
70/2.5	17.5	962	27.3
30.3	9	254	16.7
40/3	12	452	22.3
50/3	15	707	28.0
55/3	16.5	855	30.8
60/3	18	1018	33.6
80/3	24	1810	45.0
100/3	30	2827	56.3
120/3	36	4072	67.6
100/3.5	35	3848	76.6
40/4	16	804	39.7
50/4	20	1257	49.8
55/4	22	1521	54.8
60/4	24	1810	59.8
70/4	28	2463	69.9
80/4	32	3217	79.9
40/5	20	1257	62.0
45/5	22.5	1590	69.9
50/5	25	1963	77.8
60/5	30	2827	93.5
70/5	35	3848	109.2
80/5	40	5027	124.9
100/5	50	7854	156.3
40/6	24	1810	89.3
50/6	30	1827	112.0
60/6	36	4072	134.6
76/6	42	5542	157.2
80/6	48	7238	179.8
90/6	54	9161	202.4
100/6	60	11310	225.1
50/7	35	3848	152.4
60/7	42	5542	183.2
70/7	49	7543	214.0
40/8	32	3217	158.8
30/10	30	2827	185.4

Notes: This table circumvents the need to calculate BA and CAI for the categories listed in Table 1a. CAI has been calculated by subtracting one ring width from the radius, to give a new basal area, and subtracting this from the full core basal area indicated.

MEASUREMENT AND CALCULATIONS

16. The sequence of data capture and calculation is as follows. See also Appendix 1.

1. On the site:
   a. Identify the tree.
   b. Take situation notes (with reference to the core development category in Table 1a).
   c. Measure girth (paragraph 7).
   d. If several trees occur together, measure all of them.
   e. If crown decline or damage is found, estimate how long ago (paragraph 14).
   f. Enquire about the history of the location.

2. Using a calculator and Tables 1a and 2:
   a. Determine the age when optimum crown development occurred and possible average annual ring width up to that point (Table 1a or 1b).
   b. Calculate core radius (age x ring width) or refer to Table 2.
   c. Calculate basal area of this central core of wood:

   $$\left[\frac{\text{dbh}}{2}\right]^2 \times 3.14159 \text{ (or refer to Table 2)}$$

   d. Calculate CAI of the outer annual ring on the core (mature state CAI). Subtract one ring width from the core radius (2b), calculate a new basal area (as in 2c). Subtract this from basal area 2b (or refer to Table 2).

3. Using a calculator and following the assessment sequence (Appendix 1) determine the age of the tree as follows:
   a. Calculate basal area of the whole tree:

   $$\left[\frac{\text{dbh}}{2}\right]^2 \times 3.14159 \text{ (or refer to Table 2)}$$

   b. Subtract basal area of core (2c from 3a).
   c. Divide remaining basal area by the mature state CAI (2d), to give the age of this outer section.
   d. Add 2a (age of core) to 3c to obtain total age of tree (subject to 4 below).

4. After crown decline, annual rings on most species can be presumed to be in the region of 0.05 cm (20 rings per cm). For the estimated duration of decline a separate calculation is required (see paragraph 14) and diameter at 3a reduced accordingly. If a tree is dead the time since death has to be estimated (or determined) and simply added to the calculated age.

ACKNOWLEDGEMENTS

Thanks are due to the Forestry Commission for allowing this revision to be made, especially to Dr Peter Freer-Smith (Chief Research Officer) and Paul Tabbush (Head of Silviculture) at Alice Holt Lodge. Great appreciation also goes to The Trustees of TROBI for access to data.

REFERENCES

MITCHELL, A. F., SCHILLING, V. E. AND WHITE, J.E.J. (1994).
Champion trees of the British Isles.
Forestry Commission Technical Paper 7.
Forestry Commission, Edinburgh.

RACKHAM, O. (1990a).
Trees and woodland in the British landscape.
J. M. Dent and Sons Ltd, London.

RACKHAM, O. (1990b).
The history of the countryside.
J. M. Dent and Sons Ltd, London.

First published as Research Information Note 250 in July 1994; revised November 1998.

Research Information Notes are available free on request and can be ordered via the Publications catalogue on the Forestry Commission's web site at **www.forestry.gov.uk** or from the Research Communications Officer, address below.

Enquiries relating to this publication should be addressed to:

The Research Communications Officer
Forest Research
Alice Holt Lodge
Wrecclesham
Farnham
Surrey
GU10 4LH

Tel: 01420 22255
Fax: 01420 23653

E-mail: j.parker@forestry.gov.uk

APPENDIX 1 - ASSESSMENT SHEET (worked example)

Tree age estimation from stem diameter measurement

Tree name:	*Shaden Tuft Oak*
Scientific name:	*Quercus sp.*
Location:	*Forest of Dean*
Grid reference:	*SO 630 092*
Stem girth/cm:	*575*
Stem diameter/cm:	*183*
Stem radius (r)/cm:	*91.5*
Total basal area (BA)/cm²:	*26302.176* (r x r x 3.14159)
Core category (Table 1a):	*Woodland boundary pollard*
Core age/years:	*100*
Core ring width/mm:	*3.5*
Core basal area (Table 2 or paragraph 16, 2c)/cm²:	*3848*
Area (CAI) of outer core ring (Table 2 or paragraph 16, 2d)/cm²:	*76.6*
BA excluding the core (total BA minus core BA)/cm²:	*22454.176 (26302.176 – 3848)*
Age of outer section of the stem/years:	*293* (above divided by CAI of outer core ring)
Add core age/years:	*100*
Add years of decline (see paragraph 16.4)/years:	*Nil*
Total of last 3 entries (= estimated age of tree/years):	*393*
Planting year (date measured minus estimated age):	*1599*

Additional notes:

Tree now in plantation. Immediate area recently cleared of conifers.

Date measured: *1992*

APPENDIX 1 - ASSESSMENT SHEET*

Tree age estimation from stem diameter measurement

Tree name:

Scientific name:

Location:

Grid reference:

Stem girth/cm:

Stem diameter/cm:

Stem radius (r)/cm:

Total basal area (BA)/cm:

(r x r x 3.14159)

Core category (Table 1a):

Core age/years:

Core ring width/mm:

Core basal area (Table 2 or paragraph 16, 2c)/cm:

Area (CAI) of outer core ring (Table 2 or paragraph 16, 2d)/cm:

BA excluding the core (total BA minus core BA)/cm:

Age of outer section of the stem/years:

(above divided by CAI of outer core ring)

Add core age/years:

Add years of decline (see paragraph 16, 4)/years:

Total of last 3 entries (= estimated age of tree/years):

Planting year (date measured minus estimated age):

Additional notes:

Date measured:

**Appendix I can be copied freely for use in the field.*

ISSN 1460-3802
ISBN 0-85538-383-6

FPD9/30-IH(ECD)-NVSPT/12K-NOV98