Estimating the Ages of Yews – Challenging Constant Annual Increment as a suitable model

Article *in* Quarterly Journal of Forestry · July 2019

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Estimating the Ages of Yews

Challenging Constant Annual Increment as a suitable model

Toby Hindson, **Andy Moir** and **Peter Thomas** present evidence to suggest that we need to rethink how we assess the age of yews.

"Trees in this world would fit into the affairs of human society. They would grow close together in forests, each tree forming just one straight cylinder… Old fashioned foresters and scientists, and many who write books on trees, still live in that world." Oliver Rackham (2006).

Introduction

The ages of yew trees are notoriously difficult to estimate (Bevan-Jones, 2002; Hageneder, 2007), and indeed Tabbush and White (1996) concluded that the age of the trees at Kingley Vale "can not be determined accurately using current technology". Nevertheless, various approaches exist and our aim is to consider which give the most accurate results. This develops some of the data and the arguments started in Hageneder (2007).

White (1994) developed a method of aging trees from their girth based on three phases of growth. In phase 1 rings are relatively wide as the crown develops to produce the 'core' of the tree. In phase 2, after the tree reaches maturity, a fixed volume of wood is produced per year, which, being spread more thinly over the ever-increasing trunk, results in progressively narrowing rings leading to diameter growth slowing with age. This is a similar assumption to that made by D.L. Prothero in Evans (1988), but White's method provides scope for adjustment based on a faster or slower core development, as determined from empirical data, which allows the age of a tree of known species growing in known soil conditions to be estimated. A third phase of 'senescent growth' may see the ring-width becoming disproportionately smaller as the canopy deteriorates, which can lead to underestimation of age. However, yew can return to phase 2 growth at any stage in its life, leading White (1998) to state that the yew "is the most difficult of trees to date with any degree of confidence"

Late Saxon yew at Corhampton churchyard, Hampshire. (Photo: Toby Hindson)

Tabbush and White (1996) took this further in developing a formula for ageing the old yews at Kingley Vale on the basis of tree girth:

$$y = \frac{c^2}{4\pi g} - \frac{a}{g} + n$$

where y is the tree age in years; c is trunk girth (cm); a is the cross-sectional area of the core (cm^2); g is the cross-sectional area of the last ring formed in the core (cm^2), described as the constant annual increment (CAI) in White (1998); and n is the time taken for the core to grow (years).

Tabbush and White used ring width data from Kingley Vale in this formula to model the annual girth increments of the yews over time. They produced two graphs, (A and B in

Figure 1) each representing different assumptions on the speed of core development, and the likely age of the yews would fall between these two curves. These parabolic (Stewart, pers. comm.) girth/age curves are similar to the assumed exponential projections produced by Meredith (in Chetan and Brueton, 1994). Prothero (in Evans, 1988) uses a logarithmic (Stewart, pers. comm.) decline in bole girth increment, yielding lower ages for large girth yews.

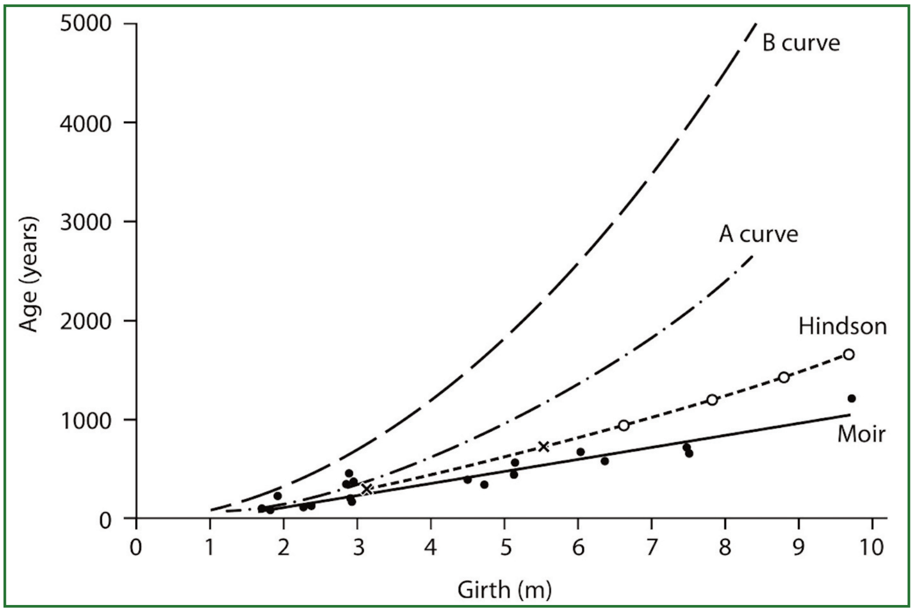

Figure 1. Age of yew trees estimated from girth. Moir's (2011) data (lowest line) are based on ring width measurements from 19 trees with a linear regression (y = 119.41x – 128.25, R^2 = 0.9344). Hindson's data (unpublished; taken from Table 1) are based on ring counts (x) and on repeat measurements of girth on the same trees (o). Tabbush and White's (1996) curve A assumes a core age of 40 years and core ring widths of 3.00mm, and curve B a core growth for 30 years and ring widths of 2.5mm.

New findings

The work most diametrically opposed to Tabbush and White's findings is found in Moir's 2011 report on Wakehurst Place, West Sussex, based on numerous core samples taken from living yews of varying girth (Figure. 1), giving mean ring widths of 1.23-3.02mm. The linearity of Moir's data is caused by ring width being almost constant without declining from smaller to larger girth, at least up to 7m in girth ('Moir's constant'). Both studies produce similar ages for small yews but differ by increasingly wide margins for larger trees. Moir's work would estimate a 9m girth yew to be approximately 950 years old, whereas Tabbush and White would give 3,000-6,000 years.

Moir's graph represents a substantial challenge to the idea that White's Constant Annual Increment (CAI) (1994) is the dominant consideration in calculating yew age. Growth rate from Moir's data matches the girth increase data of Hindson and Norton (2012) at Kingley Vale. It also agrees with published estimates of ring width growth by Newbould (1960), Williamson (1978) and many other studies (Thomas and Polwart, 2003).

Further evidence supporting this is provided by re-measurement of large yews in Ancient Yew Group (AYG) studies at a variety of other sites, as categorized by Moir et al. (2013) and presented in Table 1 overleaf. Increase in girth between known dates was used to calculate mean increase in radius, and hence estimated mean ring widths during that period for trees in different size categories (Table 1, Figure 2).

Data from Kingley Vale in particular show the disparity between Tabbush and White's method, which predicts a mean annual ring width of 0.4mm, and that of Hindson and Norton (2012), which predicts more than 1mm. Likewise, the empirically generated mean girth increments of old yews shown in Table 1 are more than twice the value of those of Tabbush and White even using their curve A, which yields lower age estimates (and therefore larger girth for a given age) than their curve B.

Interestingly, Moir's linear relationship between age and girth in Figure 1 does not exactly match the curved girth/age line in Figure 1 generated from Hindson and Norton's ring width data in Figure. 2. Moir's ring widths are directly measured and should match Hindson and Norton's calculated ring widths if the relationship between the diameter and circumference of the yew is mathematically perfect.

Moir and Hindson's findings (Figure 1) demonstrate the assumed relationship between girth and diameter would be distorted in the case of fragmented or convoluted yews. That is key to understanding a serious confusion in this particular method of data abstraction. Hindson and Norton's data in Figure 2 show a linear decline with increasing bole size, and indicates that CAI plays a part in the reduction of the bole expansion rate albeit not in the definitive manner envisaged by Tabbush and White. Part of this may be due to growth being concentrated in vertical runs of vigorous wood or 'functional units' on old boles (Larson, 1994; Lonsdale, 2013). Moir showed that typical ring widths on selected areas of vigorous bole (Moir, 1999) are unchanging up to 7m girth, and possibly beyond (Moir in Hageneder, 2007), but increasing areas of slow growth, dead wood or space between the functional units results in smaller measurements of girth and thus of estimated mean ring width. Discrepancies between the three conflicting methodologies are due to the variability of ring widths in different sections of the bole, and the increasing unevenness of yew boles as they age. When viewed in that context the supposed

Table 1. Yew girth at two dates of measurement at least 35 years apart (Hindson, unpublished). Categories are defined in Figure 2. Original records are available from the authors. Mean ring widths are calculated from the mean increase in girth per year. This is inevitably less accurate where the original height of measurement is unknown and where the trunk is fragmented or partly dead, as in a number of the Exceptional trees.

Site/Yew	Initial measure (m), height above ground (m); gr = ground level	Date	Latest measure (m), height above ground (m); gr = ground level	Date	Increase in girth per year (mm)	Time period years
Exceptional						
Tandridge, Sy	10.36 @ gr	1890	10.90 @ gr	2013	4.3	123
Farringdon, Hants	9.14	1781	9.70 @ 1.5	2008	2.5	227
Crowhurst, Sy	9.14 @ 1.5	1630	9.50 @ 1.5	2000	0.1	370
Crowhurst, Sx	8.23 @ 1.2	1680	9.19 @ root crown/1.2	2012	2.9	332
Herstmonceaux, Sx	9.14 @ 0.9	1896	9.57 @ gr	2013	3.6	117
Eastling, Kent	9.14 @ 1.2	1874	9.60 @ 1.5	1999	3.7	125
Data	**ring width 0.48 mm**				**2.9**	
Ancient						
Ankerwycke 1, Berks	8.43 @ 0.9	1813	9.55 @ 0.9/1.2	2010	5.2	197
Ankerwycke 1, Berks	7.62 @ base	1877	7.86 @ base	2013	1.8	136
Durley, Hants	6.83 @ 0.9/1.5	1963	7.37 @ 0.9/1.5	1999	15	36
Corhampton 1, Hants	7.62 @ 0.9	1896	7.70 @ 0.9	2008	0.7	112
Corhampton 1, Hants	6.71 @ gr	1896	7.32 @ gr	2010	5.3	114
Long Sutton, Hants	8.10 @ gr	1896	8.33 @ gr	2013	1.9	117
Priors Dean, Hants	7.54 @ 1.5	1961	7.82 @ 1.5	1999	7.4	38
Itchen Abbas, Hants	7.47 @ 1.5	1960	7.57 @ 1.5	1999	2.6	39
Bedhampton, Hants	6.10 @ 0.9	1896	6.39 @ 0.9	2011	2.5	115
Bedhampton, Hants	6.20 @ 0.9	1896	6.74 @ 0.9	2011	4.7	115
Boarhunt, Hants	7.70 @ 1.5	1915	7.80 @ 1.5	1999	1.2	84
Hawkley 1, Hants	6.93 @ 1.0	1958	7.37 @ 1.1	1999	11	41
Merdon Castle, Hants	6.93 @ 0/1.2	1915	7.39 @ gr/1.8	2005	5.1	90
Selborne, Hants	7.01 @ breast height	1778	8.03 @ 1.5	1963	5.5	185
Warblington, Hants	7.92 @ 0.9	1836	8.20 @ 0.9	1999	1.7	163
Cudham 2, Gt Lond	8.64 @ 0.9	1890	8.76 @ 0.9	2000	1.2	110
Data	**ring width 0.73 mm**				**4.6**	
Veteran						
Long Sutton 1, Hants	5.11 @ 1.0	1959	5.46@ 1.0	2013	6.6	54
Long Sutton 2, Hants	5.56 @ 1.0	1976	5.74 @ 1.0	2013	4.8	37
Warlingham 1, Sy	6.25 @ 1.52/0.3	1880	6.73 @ above roots	2001	3.4	121
Woldingham, Sy	4.27 @ 0.6/0	1880	5.08 @ gr	1999	6.8	119
Addington, Gt Lond	4.57 @ gr	1895	5.21 @ 0.2	2010	2.2	115
Cherkley Court, Sy	4.14 @ base	1890	4.85 @ base	1985	7.5	95
Alice Holt, Hants	4.47 @ min	1964	4.55 @ min	2011	1.6	47
Brockenhurst, Hants	4.57	1793	6.50 @ 0.9	2010	8.9	217
Farringdon 2, Hants	5.38 @ 0.9	1946	5.84 @ 0.9	1998	8.8	52
Hambledon, Hants	5.49 @ 0.9	1896	5.92 @ 0.9	1999	4.2	103
Hawkley 2, Hants	4.93 @ 1.0	1982	5.10 @ 0.3/1.0	2009	6.3	27
Hound, Hants	4.88 @ 0.5	1961	5.28 @ 0.46	2000	10	39
Hurstbourne Priors, Hants	4.88 @ 0.6	1965	5.11 @ 0.6	2006	5.6	41
Merdon Castle, Hants	4.80 @ 0.9	1915	5.26 @ 0.9	1999	5.4	84
Steep, Hants	5.99 @ 1.2	1895	7.06 @ 0.9/1.2	1998	10	103
West Tisted, Hants	6.32 @ 0.9	1915	7.04 @ 0.9	2013	7.3	98
Harlington, Gt Lond	5.21 @base	1895	5.97 @ base	2009	6.7	114
Data	**ring width 0.98 mm**				**6.2**	

discrepancy allows triangulation, and a case acknowledging all three methodologies can be built. This work is ongoing and has the working title 'Modular Theory'. This theory recognises the fragmentary nature of many old yews (Hindson in Hageneder, 2007).

Conclusion

The evidence presented here shows that radius is a key measure in ageing older yew specimens. The uneven growth habit of yew is so marked that estimation of tree age from girth alone is of little value where the yew girth deviates markedly from a complete circular cross-section. This conclusion is likely to be relevant to the ageing of fragmented and convoluted trees of other species as well. Moreover, although Tabbush and White's methodology has great value for trees that follow the three phases of growth, the ability of yew to return to formative rates of growth at almost any age, creates extra variability to the accuracy of this method.

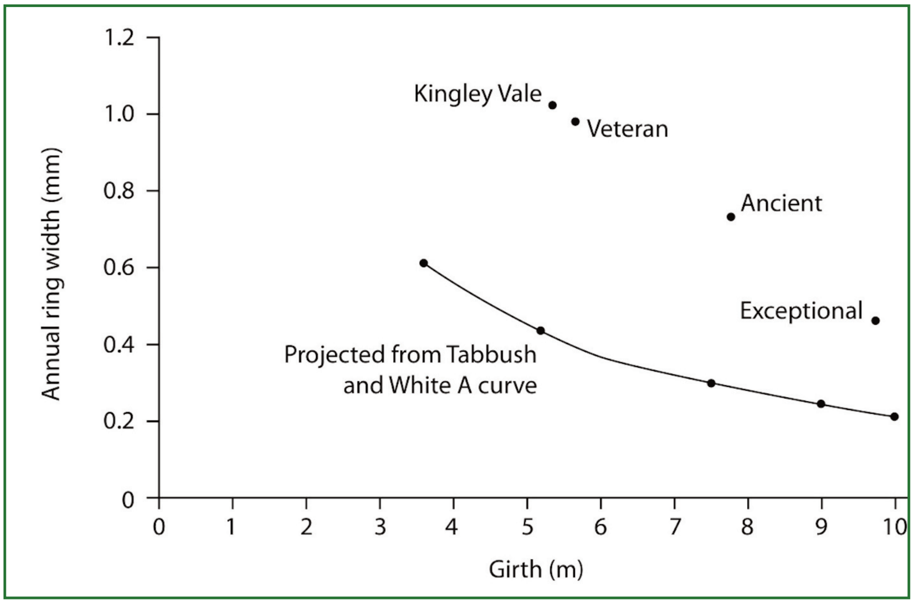

Figure 2. Estimated annual ring width of yew trees at different girth. Curve A is interpolated from Tabbush and White (1996) – Figure 1. Data for Kingley Vale is taken from Hindson and Norton (2012) and other data from Hindson (2011; Table 1) calculated from measurement and re-measurement of 49 yews for trees within different AYG classification classes (Moir et al. 2013): veteran, 5-6.99m girth; ancient, 7-8.99m and; exceptional >9m.

It is suggested that the measured girth of the yew usually increases according to the asymmetry of the most vigorous growth areas on its circumference instead of growing in a way that can be modelled as a smooth cylinder. Hence old yews show substantially greater overall girth increment than would be predicted using otherwise valid girth measurements such as that of Tabbush and White (1996). However, CAI is an imponderable and cannot be entirely neglected. The total quantity of new wood that can be laid down each year is simply determined by crown size and environmental factors, and this is laid down locally in functional units, which has not previously been considered an important factor.

It seems highly likely that measuring the highest diameter of a yew (as with a pair of callipers) and applying the 'constant' ring width found by Moir, suitably modified for the site, would provide a more realistic method of aging old yews. This is likely to yield a lower age estimate than that derived from the girth using Tabbush and White's method (1996). The re-measurement of trees given here supports this view.

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