Increased growth rate of oaks in Brasenose Wood in 1950s
Presented by James Rainey, Shotover Conference, 17th May 2014
Brief overview of results for comment.

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Updated July 2015

Preparation

Of 33 tree-ring core samples from oaks in Brasenose Wood, 29 were found to have data spanning 1900-1999, and in addition, had sufficient depth into the trunk to reach the rings of maximum width that indicate the onset of constant annual trunk area increase.

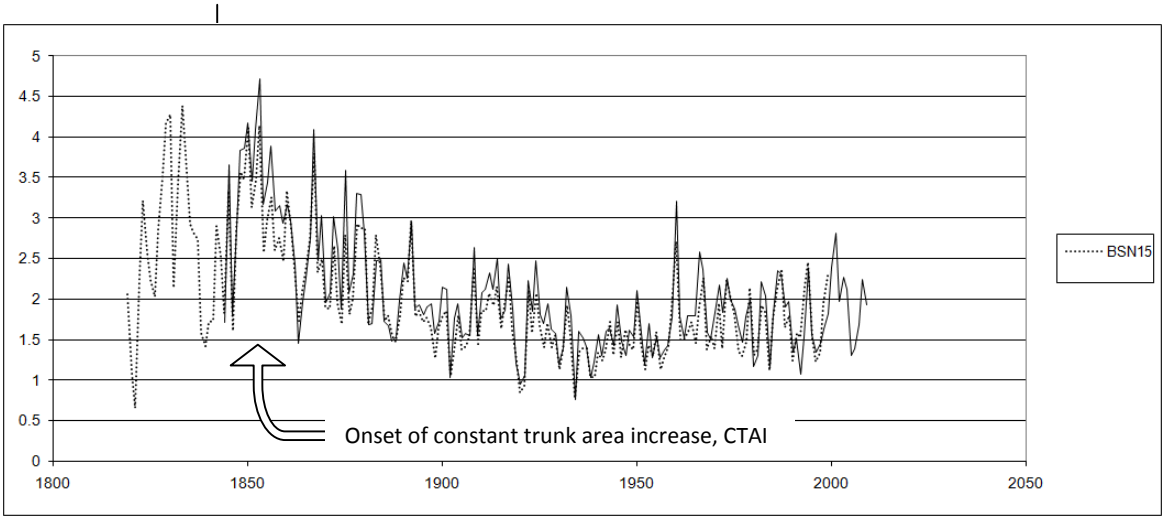


Figure 1: Example ring width sequence showing data from 2 cores from tree 'BSN15'.

Analytical stages

1 For each core, the ring marking the onset of constant trunk area increase (CTAI) was identified - most often indicated by the ring of maximum width (Fig. 1).

2 Regardless of the tree age, all of the core sequences were synchronised so that the year of onset of CTAI was coincident – allowing the calculation of a mean ring sequence (Fig. 2). This does not indicate the age at which maximum ring width is reach, but in fact eliminates the fact that this age differs widely between trees.

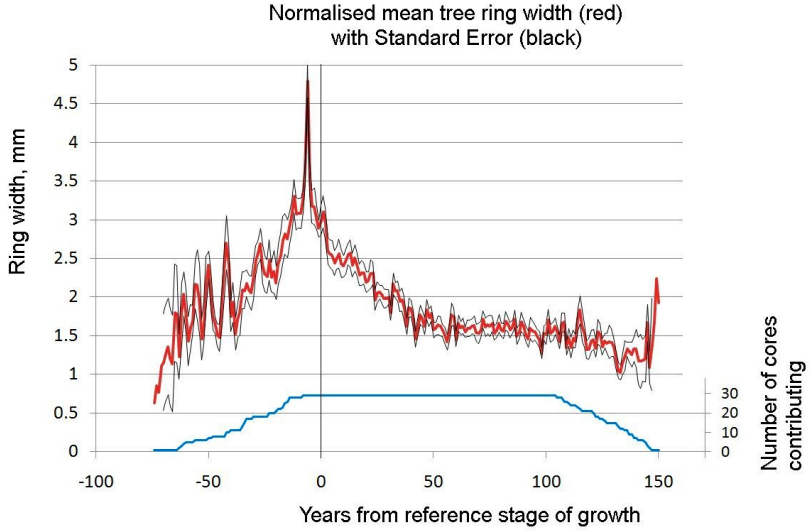


Figure 2: Mean ring width sequence, and standard error, from the 29 core samples, normalised for coincident climax year.

Note: Noise in the line at the extremities is due to the decreasing number of cores contributing to the average.

Main Assumptions. From the above mean ring sequence (Fig. 2) a point in the stage of growth has been chosen to represent a common reference size for all trees. This is defined here as 6 years after the onset of CTAI, and is chosen to avoid the greater variation in ring width around the year of maximum ring width. It is then assumed that, regardless of age, all trunks reach a similar diameter (represented by the mean) and is the stage at which they have become established in the canopy, produce the same leaf area each year and henceforth grow with constantly increasing trunk area. This reference point and associated assumption stabilises the problems associated with the uncertain rates of growth before reaching this stage.

Figure 3:

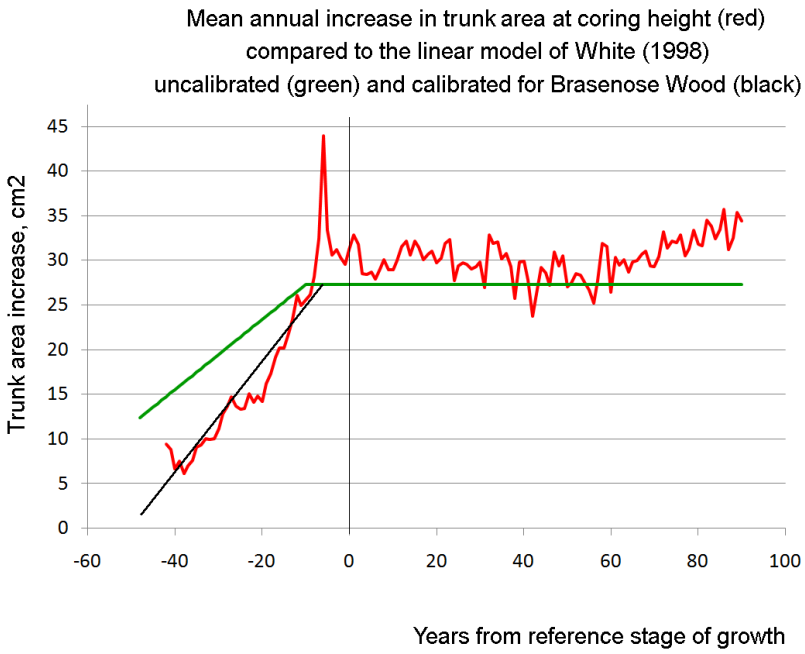


Figure 3 shows the mean annual increase in trunk area together with the bi-linear model by White (1989) for oaks 'inside woodland': that is 2.5mm constant ring width until age 70 followed by constant area increase. Although White's model is good in parts, it emphasises the difficulty in applying such calculations for tree age – at least at Brasenose Wood.

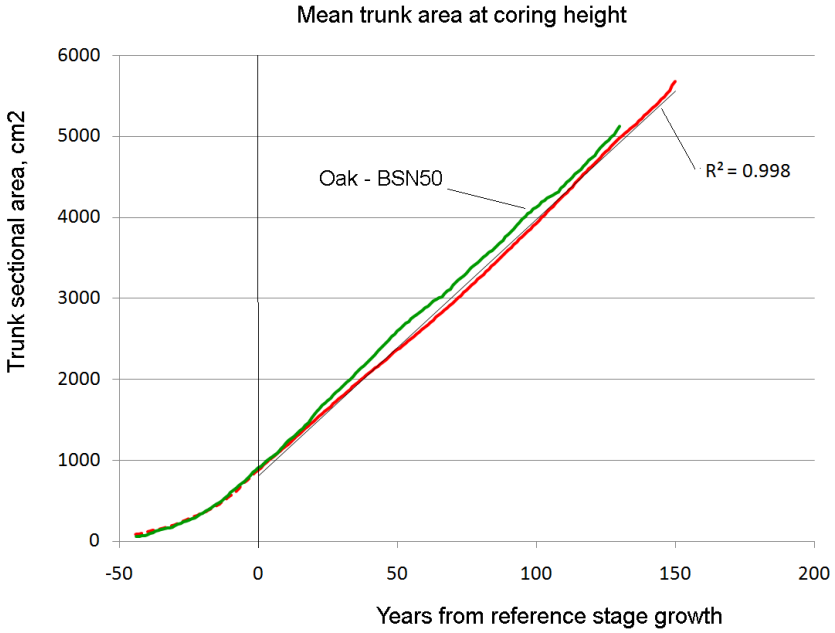


Figure 4: Mean increase in trunk area (red), using the standardised trunk radius shown in Figs 2 & 3 (six years following peak ring width). Also a plot from tree BSN50 showing typical linear growth (green).

The reference point derived here fixes all trees to have a trunk radius of 16.7cm, and therefore a normalised trunk area of 878cm^2 at six years following the onset of CTAI. Then starting from this reference point, the growth rate, radii and trunk area for each tree are calculated separately from the ring width data for each core. Without this reference point the linearity of the calculated increases in trunk area would not be properly expressed. The following calculations of the rates of growth for selected periods are not particularly sensitive to the above assumption, however, an extrapolation backward in time to an estimate of tree age would be very inaccurate and is not attempted here.

Results

For Brasenose Wood it was found that before reaching the onset of CTAI the growth curve of individual trees was not at all consistent, and generally showed rapid rates of establishment such that standard linear age/growth assumptions (e.g. White 1989) would be a poor representation for Brasenose Wood. However once the stage of CTAI was reached the trunk area increases were markedly linear in most trees.

Expressed as trunk area by calendar year (re-synchronised in time rather stage of growth as hitherto) the 29 core sequences were placed into three groups as follows:

Fig. 5 **15 cores** in which the computed area increase was remarkably linear (r^2>0.997) during each of the periods 1900 - 1950 and 1965 - 1999, but for each of these periods two significantly different gradients could be calculated.

Fig. 6 **8 cores** in which linear growth appeared to be at a constant rate throughout 1900-1999.

Fig. 7 **6 cores** in which the increase in area during 1900-1950 was curved or distorted such that linearity could not be assigned.

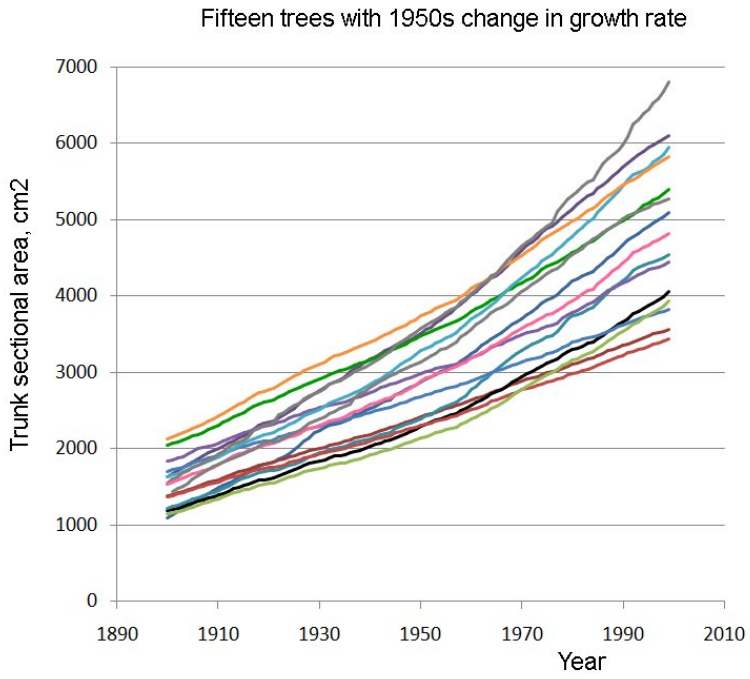


Figure 5

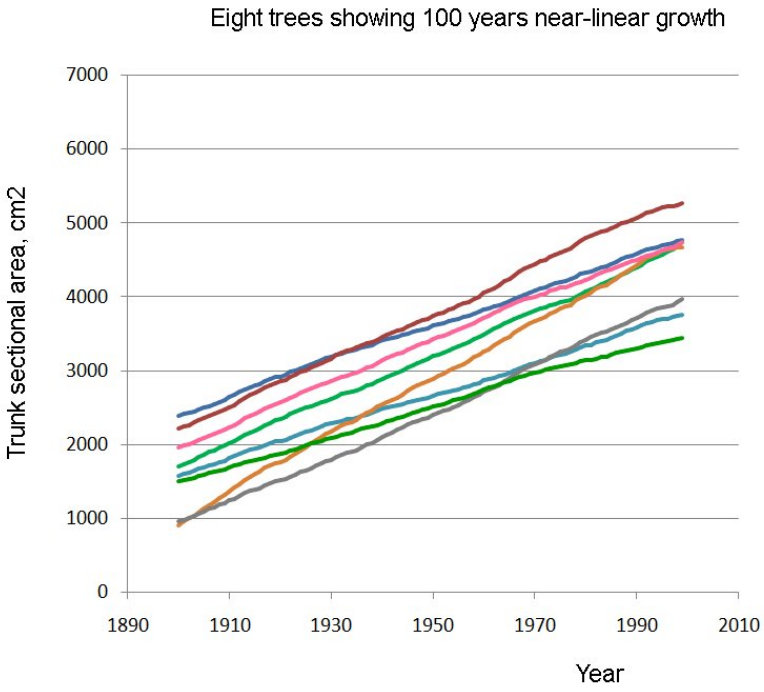


Figure 6

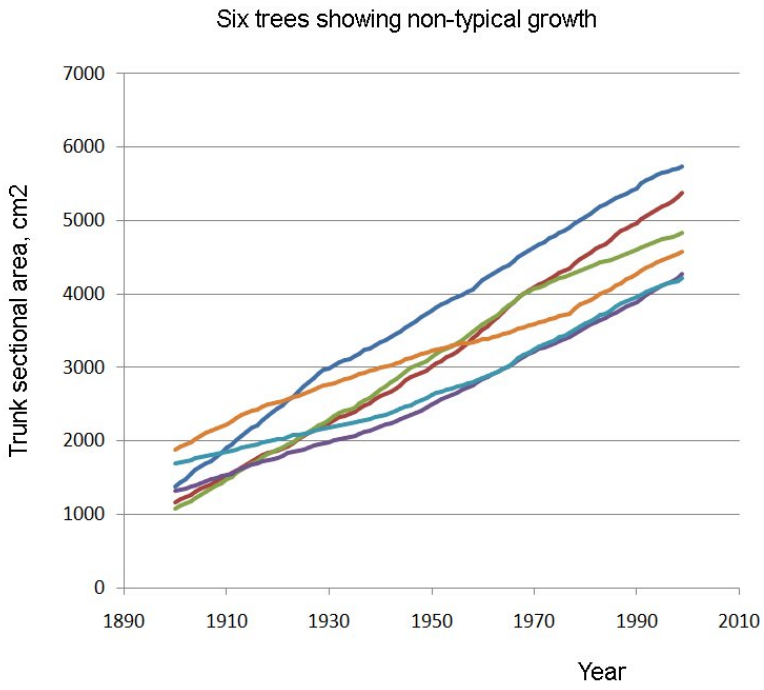


Figure 7

For the 15 bi-linear plots (Fig. 5) the estimated year of inflection between the periods of lower and higher growth rate was derived for each core by calculating the linear regression for both the earlier and later period of growth - either side of a variable threshold date. For each, the threshold date was increased in steps from 1920 to 1980 and the paired regression coefficients noted. The optimum threshold date was then taken as that with the highest combined regression coefficient.

When applied to all cores, this method of calculation confirmed that there was no logically sensible inflection point in either the 8 constantly linear cores or the 6 distorted cores. For the 15 bi-linear cores inflection dates ranged from 1952.3 to 1963.4 with a mean of 1956.46 +/- 0.85.

To illustrate and emphasise the change in liner growth rate, Figure 5 is redrawn below, but showing the additional area increase over that which would result from a continuation of the pre-threshold rate.

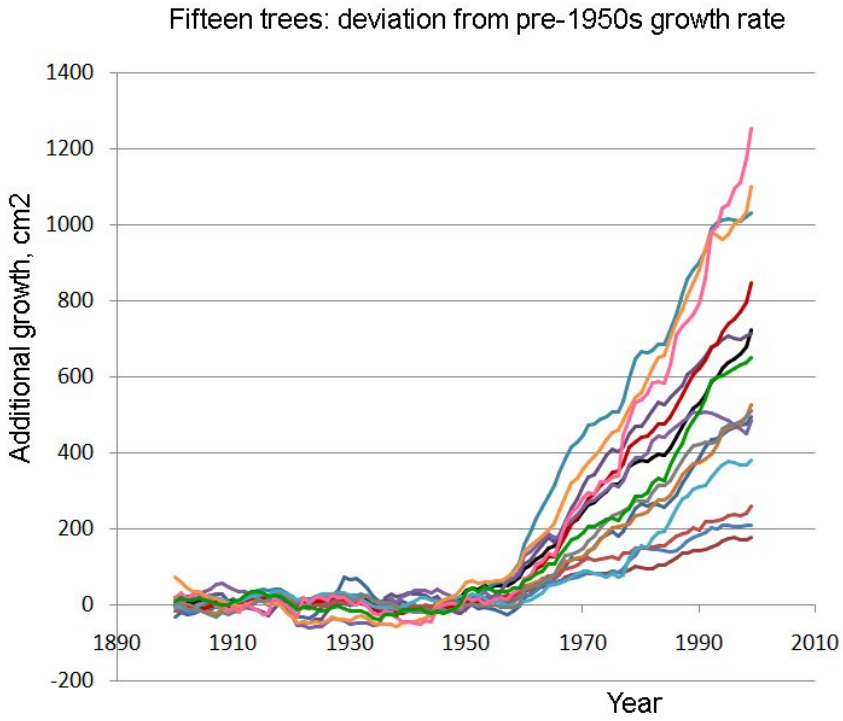


Figure 8

The additional increase in trunk area, in cm2, above that if the early period growth rate had continued.

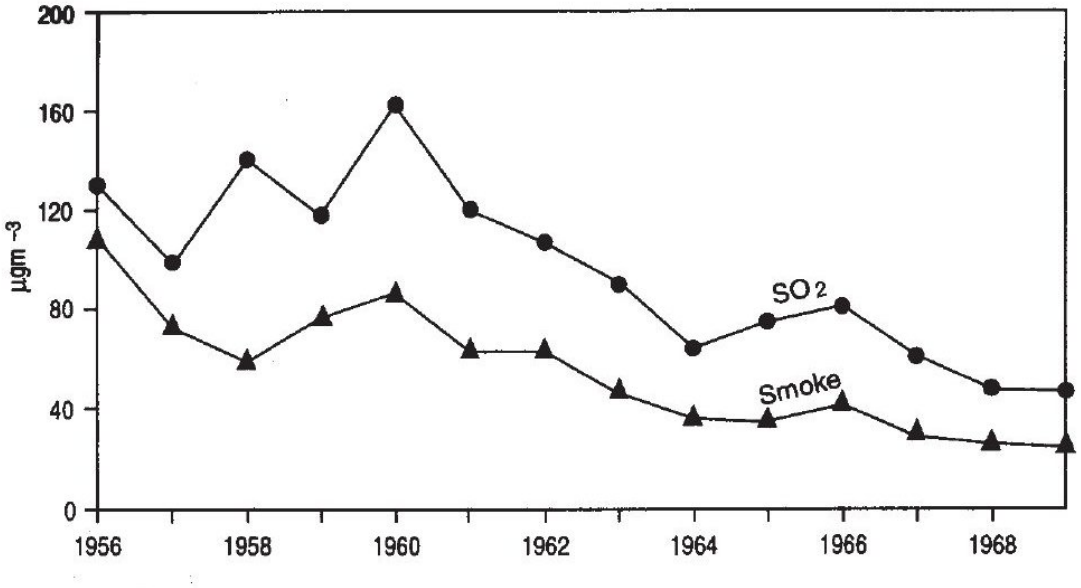
Figure 5 would suggest a coherent change towards stronger growth in the second half of the century. Figure 8 emphasises the linearity of the two growth periods.

Six of the cores in Figures 5 and 8 were from three trees – two from each. Some indication of the error in estimating the inflection date is given by comparing the dates from the pairs of cores from the same trees. The three differences in the dates were 0.3, 1.0 and 2.6 years. Three of the six non-linear cores shown in Figure 7 are each paired with cores with more conventional profiles shown in the other Figures.

Discussion

It would seem that some phenomenon occurred in the 1950s that appears to have changed the rate of growth of at least half of the oaks in Brasenose Wood. Fifteen cores (52%) show the effect either strongly or mildly, 8 cores (28%) appear to be only slightly affected or not at all with a near-constant growth rate, and 6 cores (20%) showing a contorted or curved growth habit.

The mean date of change of growth rate, 1956, very nearly coincides with the implementation of the Clean Air Act (1956) in the Oxford area in 1958. Viles (1996) gives 5-year concentrations of atmospheric sulphur-dioxide at Oxford (Fig. 9) and clearly shows the reduction in this toxic gas after 1960. With the exception of 1956 there is a similar trend for smoke.



Mean annual smoke and sulphur dioxide concentration (in µgm^{-3}) in central Oxford, 1956-1969

Figure 9
With permission - reproduced from Viles, H. (1996

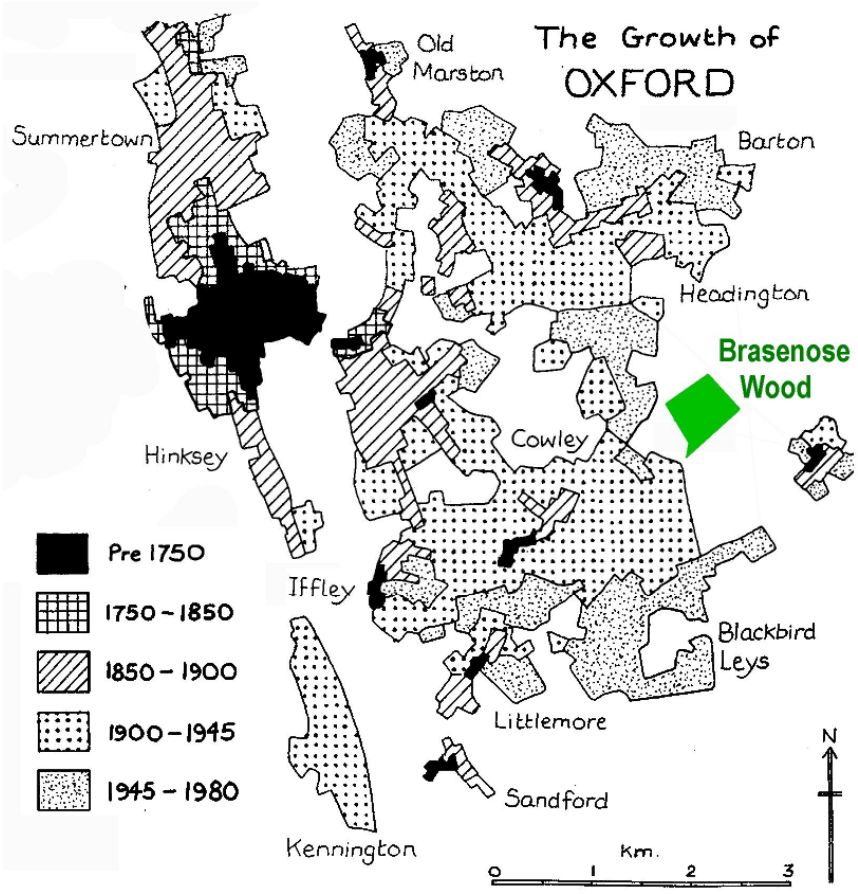


Figure 10
Modified with permission from Scargill and Crosby (1982)

The urban development around Oxford in the period 1850-1945 (Fig. 10, after Scargill and Crosby 1982) occupies a 180° westerly arc around Brasenose Wood, all of which would have been built with coal burning fires. On average the wind comes from this arc for about 70% of the year. The switch to cleaner domestic fuels would undoubtedly have produced a step change in atmospheric pollution over Brasenose Wood.

[It is probable that the influence of pollution from the car factory (to the southwest) was not as significant as the domestic coal burning; partly because of the height of the works' chimneys and also through having an impact from much smaller arc of wind directions.

It can also be noted that 9 pollution-sensitive bryophytes on Shotover have increased in abundance and/or vigour in the past 15 years.

The questions are:
Is there sufficient evidence to declare a link between the growth of Brasenose Wood oaks and the Clean Air Act?
Is there other similar evidence from anywhere else?

References

Scargill and Crosby (1982) *Oxfordshire and its countryside*

Viles, H. (1996) 'Unswept stone, besmeer'd by sluttish time': Air Pollution and. Building Stone Decay in Oxford, 1790- 1960. *Environment and History*, Vol. 2, No. 3 pp. 359-372.White Horse Press.

White, J. ()1998) Estimating the age of large and veteran trees in Britain. Forestry Commission. Edinburgh