



Sycamore Gap

Recovery and initial analysis of a wood slice from the Sycamore Gap Tree

Zoë Hazell and Cathy Tyers



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Between Peel Crag and Highshield Crag
Near Mile Castle 39
Hadrian's Wall
Henshaw
Northumberland, NE47 7AL

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Summary

Preliminary counting of the sequence of tree-rings from multiple radii on a cross-sectional slice of wood from the Sycamore Gap Tree, has established that the slice contains c. 100–120 rings, thus indicating the approximate minimum age of the tree at the height, c. 1m, where the cross-sectional slice was located. This minimum age provides a *terminus ante quem* for the appearance of this tree in the landscape, suggesting that this event probably occurred in the late 19th century or earlier. The actual age of the tree, and therefore the potential date of planting, could not be precisely determined, however, because of the limited preparation of the cross-sectional surface of the slice possible at this time, the challenges of resolving the tree-ring boundaries, the complex development of the tree's growth, and the height of the cross-sectional slice in the tree.

Acknowledgements

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For the images taken using the Keyence microscope, thanks to the AHRC for funding its purchase through the CapCo (Capability for Collections) Fund (Award AH/V011758/1).

Front cover image: Looking northwards at the Sycamore Gap tree, Northumberland, August 2018 (image: © Zoë Hazell).

Archive location

The slice and the additional small branches and twigs are currently at Fort Cumberland awaiting discussion with the landowner.

Date of research

The slice and other pieces have been seasoning since October 2023, and this process is ongoing. Initial analysis of the tree-rings took place in July 2024.

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Introduction

Overnight, between 27–28th September 2023, the Sycamore Gap tree near Mile Castle 39 on Hadrian's Wall, was felled. Before the tree was removed from the site, a complete cross-sectional slice was taken from the lowest end of the felled trunk. At the time of sampling, the primary purpose was to ensure that a segment of the tree was recovered, and used to inform research on the age of the tree.

The work presented in this report was undertaken at the request of the Historic England regional office, who wished to establish a minimum age of the tree based on a tree-ring count. The work that could be undertaken at this time has been limited as the cross-sectional slice had not seasoned sufficiently to allow the preparation of the surface to the standards required for an accurate ring count.

As well as obtaining estimated ring counts with the aim of establishing a minimum age for the tree, some high magnification images were obtained to highlight the anatomical characteristics of the wood at microscopic level.

1. The Sycamore Gap Tree



Figure 1. The Sycamore Gap tree, Northumberland, August 2018 looking northwest. Note that the wide lower trunk splits at around/just above head height (image © Zoë Hazell).

The tree at Sycamore Gap (Figure 1) was a well-known feature of the landscape along Hadrian's Wall. Multiple theories have been proposed about when the tree was, or might have been, planted. These include The National Trust (2024) who state that "...it was planted in the late 1800s by the previous landowner, John Clayton, to be a feature of the landscape", and Crow (2024) who suggests an earlier planting date. These differing hypotheses in relation to the planting date highlight the need for more detailed investigation to better understand the history of the tree.

1.1 Maples and their wood characteristics

The only *Acer* sp. (maple; Sapindaceae family) native to the British Isles is *Acer campestre* (field maple) (Stace 2010, 371–2). *Acer pseudoplatanus* (sycamore) is itself Introduced-Naturalised¹. Sycamores normally live for up to 400 years, with a likely maximum age of 600 years (Jones 1945a, 229). Financially, the timber of sycamore can fetch more than that of oak or ash. It needs to reach an age of 80 years or more to reach its full timber potential (Edlin 1956, 190).

Jones (1945b, 215) describes the wood of maples as pale, with that of *Acer pseudoplatanus* being “very pale brown to yellowish white”. *Acer* spp. are diffuse porous, with very little difference in vessel patterning between the early wood and the late wood, and with the growth rings “bounded by a pale line” (ibid). Gale and Cutler (2000, 27) describe sycamore as “creamy-yellow; [with] little or no differentiation between sapwood and heartwood”. These characteristics are shown in Figure 2.

¹ Introduced = “a plant that owes its existence in this country to importation (deliberate or not) by man” (Stace 2010: 1082). Naturalised = “an alien plant that has become established and self-perpetuating” (ibid: 1083).

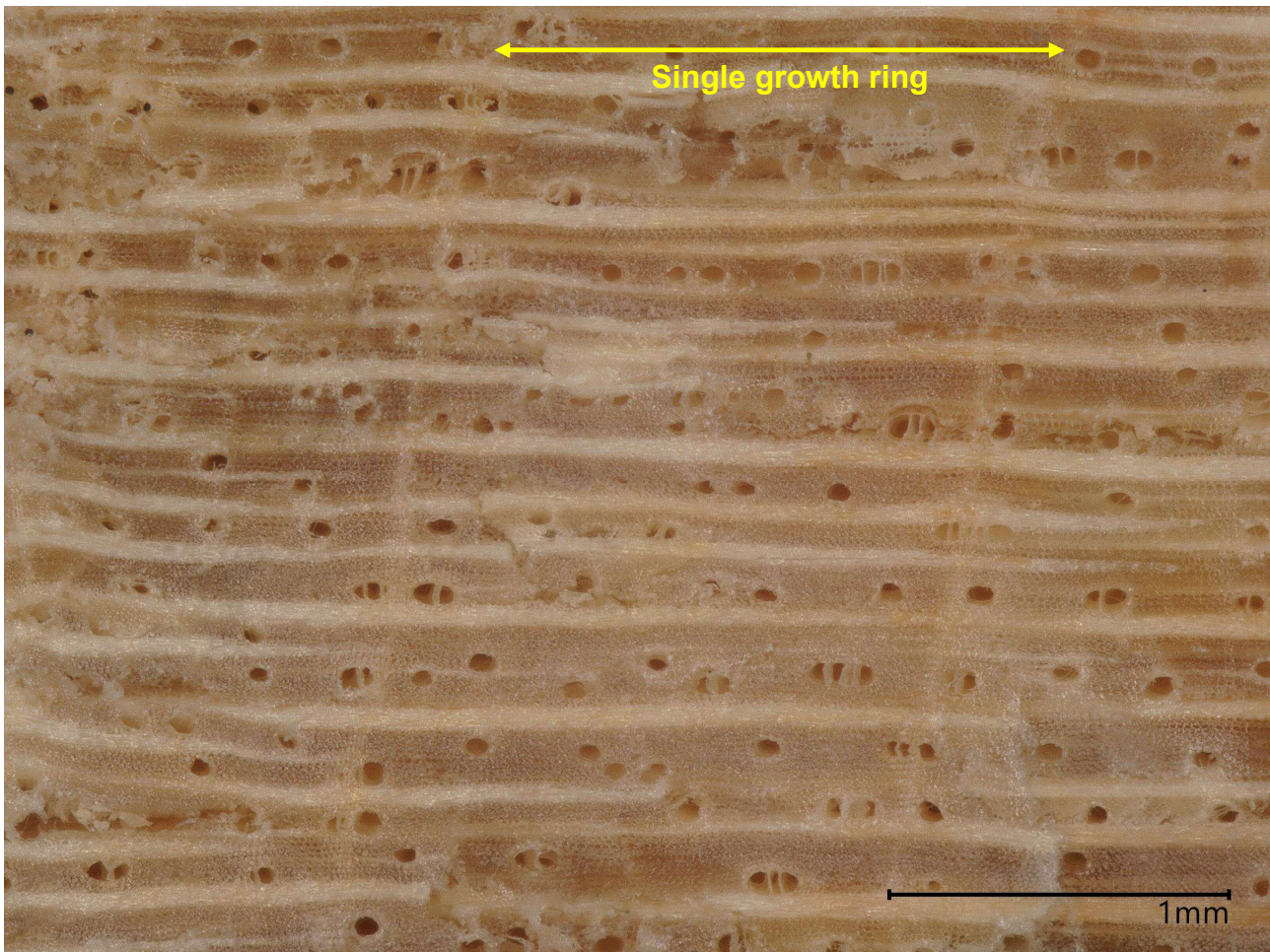


Figure 2. Close up image of the transverse section ('cross section') of the Sycamore Gap Tree's wood.

This image was taken of the freshly-cut face of a small subsample of the slice, produced with a double-edged razor blade. Note the wood's very pale colour, its diffuse porous character (i.e. that the vessels are distributed evenly throughout the growth ring), and that the ring boundaries (running approximately vertically) are relatively indistinct. This image was taken using Historic England's digital Keyence microscope². Image: Zoë Hazell, © Historic England.

1.2 Establishing age

Dendrochronology – in its broadest sense, the study of growth rings in trees in relation to time – identifies the age of a tree and the period over which that tree was growing. In temperate regions most species of tree put a discrete layer of new wood under the bark each growing season (i.e. annually). This means that by counting the growth-rings (layers) present in a tree, it is possible to establish how old the tree was when it was felled and, where the date of felling is known, calculate the year when growth was initiated.

Dendrochronology as standardly applied to our cultural heritage (dendroarchaeology /

² VHX-7000 main unit, VHX-7100 head, and VHX-S750E stand system.

tree-ring dating) takes this 'counting' a stage further by measuring the ring-widths in order to establish known-age time series (see English Heritage 1998 for a basic introduction).

In ring-porous species, such as oak (*Quercus* spp.), elm (*Ulmus* spp.) and ash (*Fraxinus excelsior* L.), large vessels (pores) are present in the early wood (spring wood), thus each individual ring is clearly defined. In contrast, the ring boundaries of diffuse porous species, such as sycamore, may be less obviously defined (see Figure 2), particularly where there are growth anomalies. This makes counting rings more difficult, and especially problematic for sycamore, birches and sometimes willows according to Thomas (2022, 325). Gale and Cutler (2000, 27–8) state that the wood growth of this genus (*Acer*) is prone to disruptions and, in addition, that the growth of epicormic shoots is characteristic of the genus. This means that multiple stems may combine within the trunk, each with its own pith, growth-rings, and history. Anatomical anomalies will feature at such points in a trunk where stems are growing together. In consequence, multiple radii may need to be counted and compared, ideally from cross-sectional slices at different heights within the trunk, to establish the number of annual growth-rings present in the tree and hence ascertain the age of the tree.

The width of a growth-ring reflects both general and local natural environmental conditions, as well as direct human influences on the environment. Conditions favourable to growth will result in a wide ring, whilst unfavourable ones will produce a narrow ring. The strongest influence on ring width is ultimately climatic, so trees of the same species growing at the same time in the same geographical region/environmental conditions will show a similar common pattern in growth ring-width variability. It is this sequence of growth ring variability through time, combined with the annual nature of the growth rings, that has allowed dendrochronology to be applied as a dating technique on (pre)historic sites and artefacts. In order to use dendrochronology as a dating technique, it has been necessary to develop a network of interlinked reference chronologies, a network which is constantly being added to through the study of new sites or artefacts.

In the British Isles dendroarchaeology primarily focuses on oak due to its widespread use and survival in (pre)historic contexts, although pine (*Pinus sylvestris* L.) is of importance where it is native and/or found in the historic environment. Dendroarchaeology is applied sporadically to other species such as elm, ash, beech (*Fagus sylvatica* L.), and spruce (*Picea abies* Karsten) and even more sporadically on diffuse porous species such as native alder (*Alnus glutinosa* Gaertn) (Crone 2014). The growth characteristics of sycamore, combined with its scarcity in historic assets, means that there is, as yet, no species-specific network of reference data with which to compare a newly acquired dataset, thus inter-species comparison would be necessary. However, living sycamores are increasingly forming the focus of ecological studies in relation to changing climate (e.g. Vaz Monteir et al. 2017) and in such studies the simple comparison of ring-width

measurements from multiple radii of a cross-sectional slice can be of great value in not only establishing an accurate count of the rings present on problematic samples (e.g. where anatomical anomalies are present on some parts of the sample), as statistical cross-matching of the individual radii can highlight false or missing rings, but thereby enhancing understanding of growth responses to changing environmental conditions. This has enabled the use of dendrochronology to help elucidate landscape or woodland histories where living or recently felled trees have been analysed (e.g. Bridge 2010; Moir 2014; Bridge and Tyers 2020).

2. Sampling, and movement of the wood slice

2.1 On-site sampling

2.1.1 Main slice

The main cross-sectional slice was cut from the bottom end of the fallen trunk using a chainsaw, and so is the section of wood that would have been sitting directly above the original cut. Although the height at which the tree was originally cut was not recorded, Tony Wilmott returned to the site to measure the height of the stump retrospectively. It was measured in June 2024 as c. 0.72 m above the ground surface, having had some shaping to smooth the initial uneven chopped surface. It is estimated that no more than 0.20 m has been removed, thereby putting its initial height above the ground surface at c. 0.92 m (Wilmott pers. comm. June 2024).

It has been confirmed (Wilmott pers. comm. July 2024) that the upward-facing side of the slice is the actual uppermost face, as it would have been growing in the tree. In terms of determining how the cross-sectional slice relates to the tree's original orientation, this was done by comparing the current outline shape with photographs of the tree stump taken on site shortly after the felling. Based on these comparisons, an orientation has been inferred, and is shown on Figure 3(a).

The cross-sectional slice was stored on a wooden pallet and wrapped for transportation.

2.1.2 Additional samples

Additional smaller pieces of small diameter branch and twigs, some with leaves, were also collected and retained, and kept with the slice in the same storage conditions.

3. Storage and treatment of the wood slice

3.1 Transport and storage of the wood slice

The cross-sectional slice was first transported locally for temporary storage in an outbuilding, until it could be shipped for longer term storage at Historic England's Fort Cumberland, Portsmouth. On arrival at Fort Cumberland the slice was first stored indoors in secure storage in the Garage building, until a suitable cool, damp place that was undercover but with air flow, was allocated. A small casemate was selected that fitted these criteria, where it was placed still on the pallet to keep it off the ground and allow airflow all around. It was lightly covered with a sheet of black Terram and regularly monitored.

3.2 Preparation

The first step was to level the face of the slice where the initial chainsaw cut had left an uneven surface (shown in Figure 3(a)). The surface was then sanded in stages using an orbital sander to 240 grit (shown in Figure 3(b)). It is standard practice on dry samples of commonly used species (e.g. oak) to sand down to 400 grit, and on problematic samples down to 1000 grit. However, the cross-sectional slice under analysis has yet to fully season and at 240 grit it was clear that the surface fibres were tearing and hence further surface preparation by sanding was not deemed appropriate at this time. During the very early stages of seasoning, numerous small radial cracks formed. The bark seemed intact and secure, apart from a small area that was glued in place using a cyanoacrylate ('superglue') adhesive to ensure it would not become lost. The sanded surface was then treated with a thin coat of Danish oil to both improve the visibility of the growth rings and seal the wood surface to help slow the rate of moisture loss (in order to minimise radial cracking). A test area was done first to check that the depth it absorbed into was minimal. It was established through visual observation that once the test area had dried, the oil has only penetrated a matter of millimetres (see Figure 4).

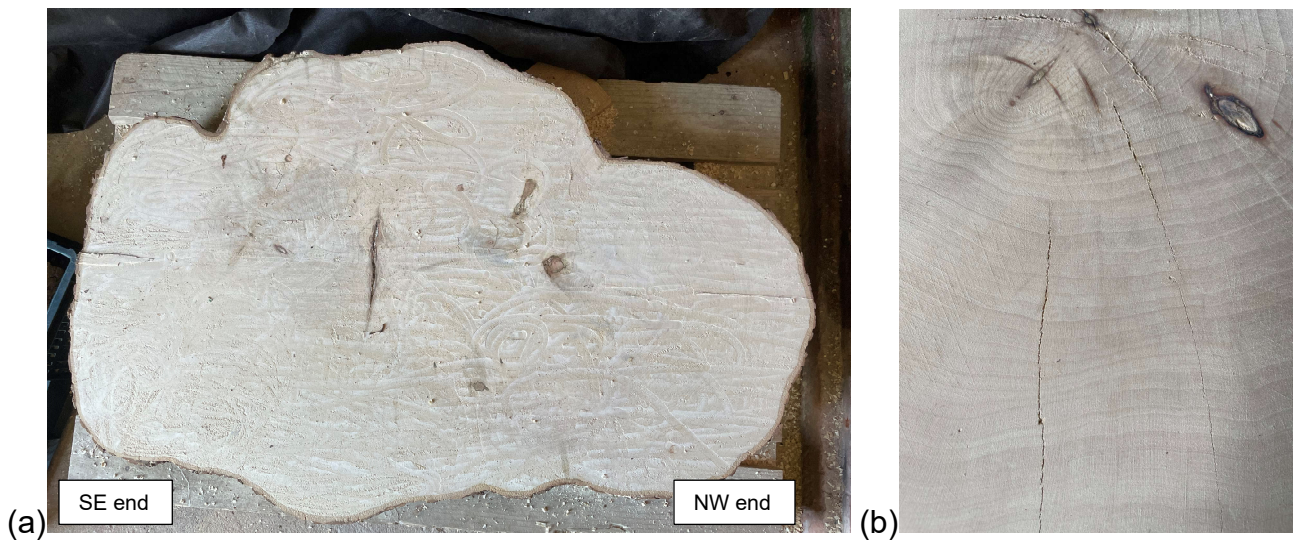


Figure 3. Photos of the wood slice during seasoning. The images show the slice (a) after preliminary levelling of the surface (before sanding) (30 April 2024), and (b) after the final sanding but before any staining (18 June 2024). Images: Zoë Hazell, © Historic England.



Figure 4. Photo of the complete wood slice after treatment with Danish oil (18 June 2024). Image: Zoë Hazell, © Historic England.

4. Analysis

Before the Danish oil was applied, the wood was examined with a hand lens (x12) to see if it would be possible to reliably distinguish and count the growth rings bearing in mind the limited surface preparation possible at this time. Unfortunately, the very pale colour of the original wood combined with the diffuse porous nature of the rings and the growth anomalies, precluded this. The application of the Danish oil meant that the ring boundaries showed up more clearly, but would still need to be examined under higher magnification to obtain an estimated ring count.

4.1 Description of the wood slice

The prepared face of the slice was recorded as follows:

- Size: maximum length and breadth 112.5 cm x 77.0 cm, height/thickness 13.0 cm
- Weight: 50.5 kg (as of 20th July 2024)
- Very pale white/cream coloured wood
- Good condition wood
- Two main pith (stem centre) areas (with additional secondary ones on each side).
The left side had a primary pith area with two piths (1a and 1b), plus secondary piths 2, 3 and 4. The right side had the primary pith, with secondary ones 2, 3 and 4, and with a possible 5th one close to 4. These are shown on Figure 5.
- A discrete line of 'internal' bark in the middle, separating the wood masses where two main separate trunk elements had come together
- Multiple narrow radial cracks
- Darker areas, possibly fungal decay.

The reverse face was also photographed (Figure 6).

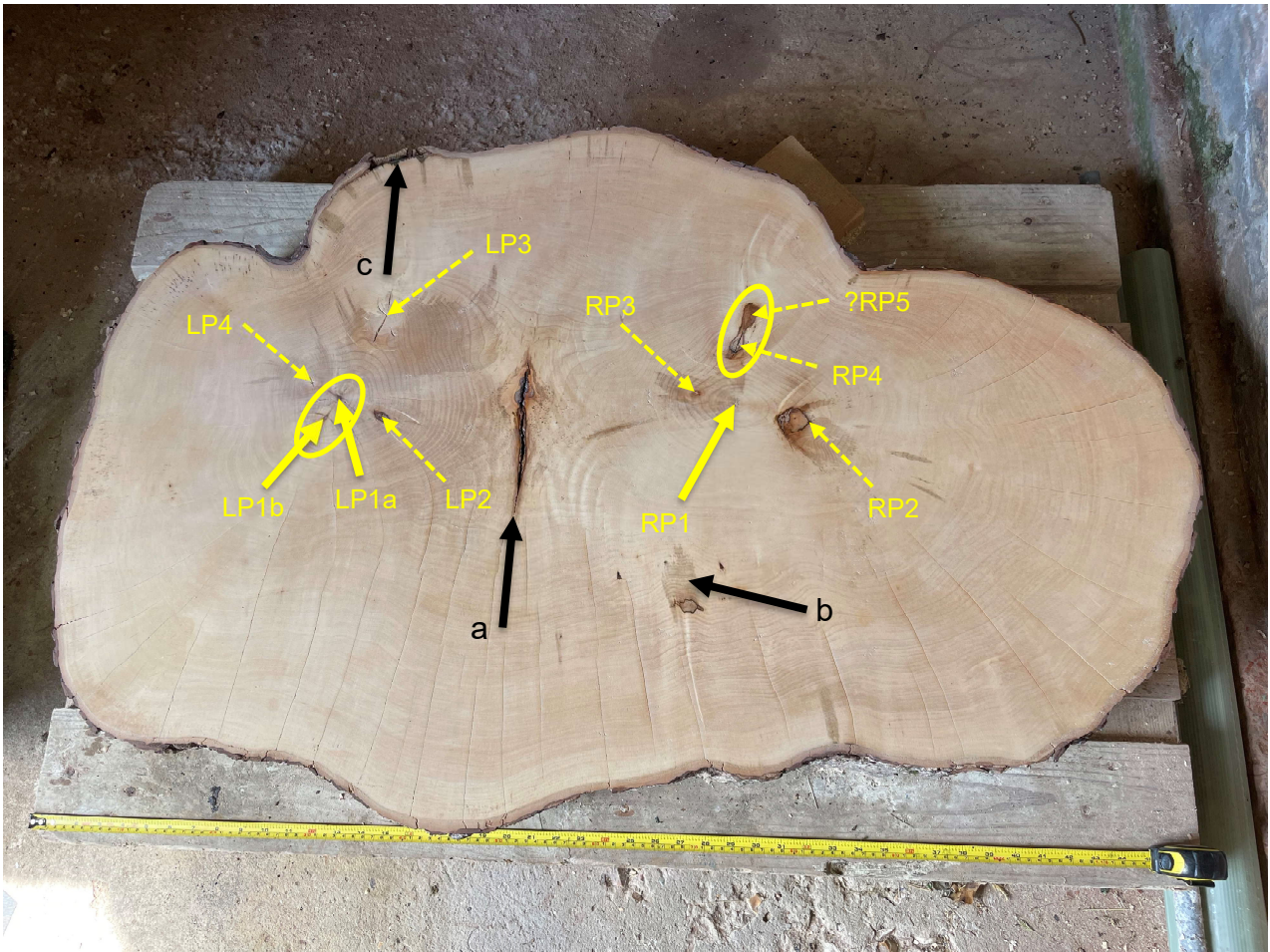


Figure 5. The slice after its Danish oil treatment, showing its main features (18 June 2024). It shows the main piths (solid yellow arrows LP1a, LP1b, and RP1) and the additional secondary piths (dotted yellow arrows LP2, LP3, LP4, RP2, RP3, RP4, ?RP5). LP = Left Pith, RP = Right Pith. It also shows the other main features (black arrows): the internal bark section (a), an area of possible fungal attack (b), and the point where the outer bark was glued on to secure it in place (c). Note also the multiple radial cracks. Image: Zoë Hazell, © Historic England.



Figure 6. The reverse, underside, unprepared and untreated face of the slice. Note that whilst the internal bark is absent, there is a crack present in that same position. Image: Zoë Hazell, © Historic England

4.2 Magnifying set-up

A temporary laboratory bench was set up inside, on which the wood slice was placed. A Luxo magnifying lamp (unlabelled, but thought to be a Dioptré 3 lens, i.e. x1.75 magnification) (Figure 7), together with an oblique light source (Schott KL1500 HAL), was used to examine the wood surface for the ring count. It should be noted that the current prepared surface precluded any benefits from using a higher magnification microscope.



Figure 7. Examining the wood slice.
Image: Zoë Hazell, © Historic England

4.3 Approach to the ring count

Features present within the wood suggest that the tree was at one time multiple individual stem elements, that grew together. This is suggested by the multiple piths, of which there are at least two main ones, each with multiple secondary ones. The two main stem centres in the slice reflect the two main stems clearly distinguishable higher up the tree (shown in Figure 1).

For recording purposes, the trunk was considered as a left side and a right side, equivalent to the inferred SE and NW sides, respectively. The transects on the left side were numbered consecutively (1–5), and those on the right side were lettered alphabetically (a, b1, b2, c, d) (see Figure 8).

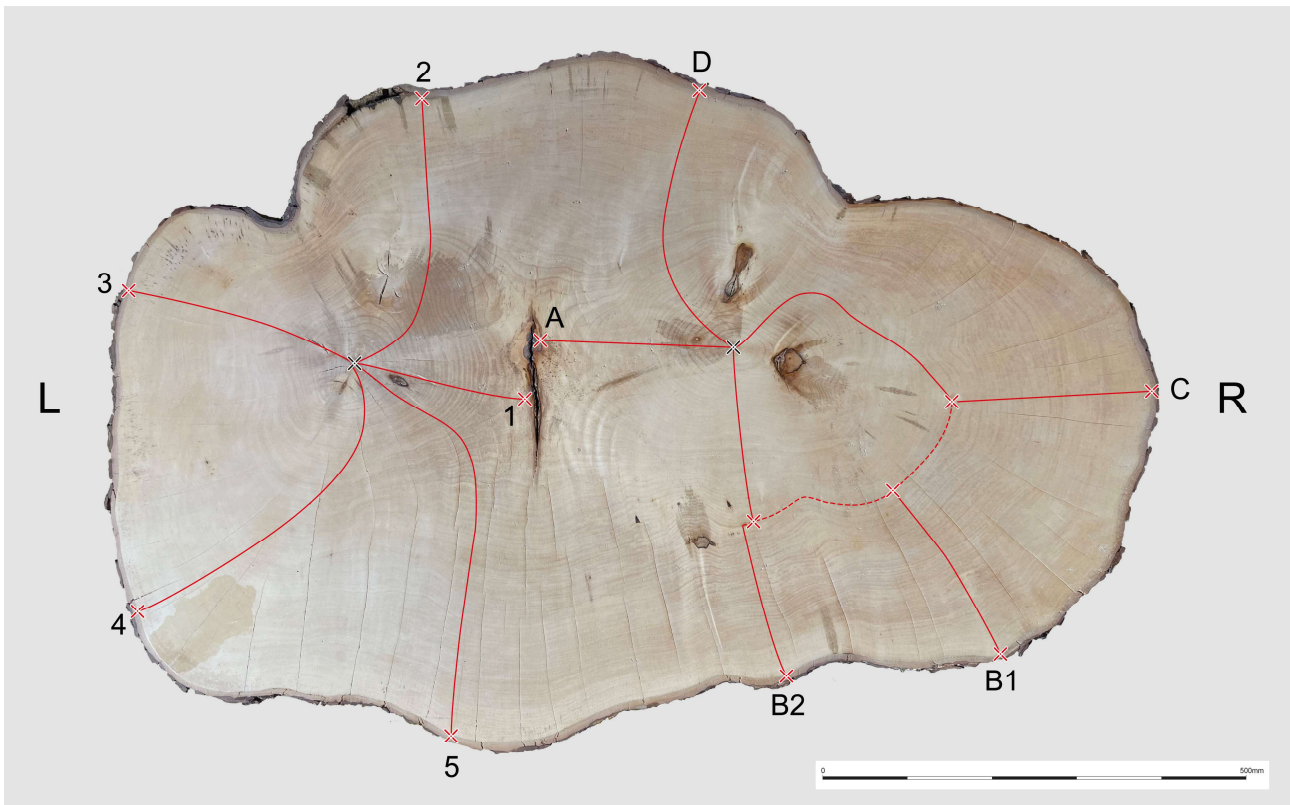


Figure 8. Tree slice showing the transects along which the rings were counted. L = Left (SE side) and R = Right (NW side). Image: © Historic England.

The rings were counted between each main pith and the outside bark, along four transects for each. The rings were also counted between each pith and the inner surface of bark, to see if it would be possible to determine an age of each minor trunk at the height of the slice in the tree. The ring counts along each transect were in all cases best estimates due to the presence of indistinct ring boundaries, in part arising from the surface only having been prepared using grit down to 240, and in part from anatomical anomalies (see below).

These ring counts are a first step in establishing the minimum age of the Sycamore Gap Tree, attempted on the surface of the available cross-sectional slice. Ring-width measurement, or other scientific dating techniques (see below), have not been undertaken as part of this analysis which is aimed at establishing an age estimate only.

5. Results

5.1 Ring count results

The ring counts for each transect are presented in Table 1.

Table 1. Ring counts obtained from the tree slice.
The transects are shown on Figure 9. The Left side is the SE side, and the Right side is the NW side.

Trunk side	Transect	Transect description	Estimated ring count ranges	Estimated overall ring count (rounded out)
Left	1	Pith to internal bark	34 ± 3	c. 80–120 rings
	2	Pith to external bark	87 ± 5	
	3		96 ± 5	
	4		109 ± 5	
	5		112 ± 5	
Right	A	Pith to internal bark	32 ± 3	c. 100–120 rings
	B1	Pith to external bark	110 ± 5	
	B2		110 ± 5	
	C		105 ± 5	
	D		113 ± 5	

These results indicate that the two halves of the trunk are potentially of similar age.

The ring counts from the primary piths to the internal bark are both in the low 30s, indicating the age at which these two discrete stems fused together at the height where the cross-section was taken in the tree (i.e. c. 1m above ground level).

5.2 General description of the growth rings

As indicated above, the width of a tree-ring reflects the growth conditions for that tree, with wider rings indicating more favourable conditions and vice versa. However, this basic premise, vital for successful dendrochronological analysis, can be compromised by growth anomalies that cause distortion of the growth rings, such as branching, coming together of stems, and, towards the lower trunk, root buttressing. There are at least two growth periods where there are series of consecutive narrow rings; seen at around rings 52–62 (in radius 2), and one further out towards the edge of the slice, both visible further around the stems. It is also possible to see the wider rings at the centre of the two main stems near

the piths, where the young stems would have been growing faster initially in order to lay down wood mass for strength.

The clarity of the growth ring boundaries was variable across the slice. In some places, particularly towards the stem centres, the rings were relatively clear. But further out, particularly where the rings are distorted, the ring boundaries are less distinctive. Growth anomalies are also a feature. For instance, in one location, a single ring boundary splits to become three separate apparent ring boundaries for a limited extent before rejoining to reform into one. Nearby, a ring boundary seems to stop abruptly. Both are shown in Figure 9 and serve to demonstrate the challenges of obtaining precise ring counts for this sample.



Figure 9. Close up of the slice showing areas of complex ring development. The image shows where a single ring boundary line becomes three (solid arrows), and where a ring stops abruptly (dotted arrow). Image: Zoë Hazell, © Historic England

6. Discussion

Based on the ring counts, an age range has been suggested for the two main stems of the tree represented in this cross-sectional slice, and hence a minimum age for the tree which is between c. 100–120 years. However, this comes with a series of caveats, as set out below.

6.1 Assumptions and caveats

The ring count results are from this particular cross-sectional slice of wood. Therefore, bearing in mind the height at which the slice was taken, it will not contain a growth ring sequence for the entire life span of the tree. The oldest rings representing the initial growth of the tree will only be represented lower down the trunk in the extant stump.

There is an assumption that each growth ring is an annual growth ring, however it should be noted that missing rings and/or false rings can be features of a tree's growth, particularly where there are growth anomalies due to multiple stems growing together. Further to this, counting the rings presented some practical challenges. It was therefore not possible to obtain precise ring counts for the following reasons:

- the growth history of the tree is complex, with multiple piths present on this particular cross-sectional slice which, combined with root buttressing, result in distortion of the growth rings,
- the surface preparation (sanding) was adversely affected by the fact that the slice is not fully seasoned and hence the surface preparation employed was unable to produce a surface on which every ring was clearly defined in this diffuse porous wood; this made it particularly challenging to identify ring boundaries where there were very narrow rings, and
- further growth anomalies were observed in places, including where a ring boundary split into what appear to be multiple ring boundaries; this increased the apparent number of rings for this section the tree's radius.

6.2 Next steps

The achievable surface preparation at the time of writing meant that in places on all selected radii some of the rings could not be reliably distinguished. Once seasoning has progressed further, it may be possible to prepare a cross-sectional surface (by sanding down through much finer grits) which may reveal the ring boundaries more clearly. A limited experiment using a double-edged razor blade on a tiny area of the outermost edge of the unprepared face demonstrated the potential for revealing the ring boundaries more

clearly (Figure 10) using a cut surface. The use of a combination of bladed tools is standard practice for the preparation of waterlogged samples, although such samples can be sub-sectioned into wedges to allow easy access for surface preparation. Sub-sampling the currently intact cross-sectional slice into wedges was deemed at odds with retaining it as a whole, however, thus investigation into the practicalities of producing an area of cut surface along a series of radii is on-going. However, this will clearly present challenges on such a large and unwieldy slice. If additional surface preparation is successful, following further seasoning, then a dendrochronological approach (i.e. measuring the ring-widths), as opposed to a ring count, may be feasible. This would potentially allow the identification of anomalies between radii and hence provide a more precise estimate of the age of the tree at this cross-sectional slice's height. This information could then be used to inform further research as to the likely overall age of the tree, allowing for the fact that the cross-sectional slice analysed was from c. 1 metre height, and hence a better indication of the date when the tree first appeared in this landscape.



Figure 10. Close up of a test area producing a cut surface with a razor blade. The cut surface is highlighted by the yellow frame, within which the tree's growth rings are visible. As an example, three consecutive ring boundaries are highlighted with yellow arrows. Image: Zoë Hazell, © Historic England

6.2.1 Potential imaging approaches

The application of other techniques, namely using photogrammetry, reflectance transformation imaging (RTI) and laser scanning, are also currently being explored in conjunction with the University of Exeter, to determine if these can be used to improve the visualisation of the tree rings to provide a more accurate tree-ring count.

6.2.2 Potential additional scientific dating approaches

In principle, other forms of scientific dating may produce calendar dating for a tree-ring sequence that cannot be dated by ring-width dendrochronology and hence may also help to address some of the issues encountered during this initial analysis; namely oxygen isotope dendrochronology and radiocarbon wiggle-matching (see Appendix 1). However, these still require being able to clearly distinguish individual growth rings for sampling.

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Appendix 1

Oxygen isotope dendrochronology uses the ratio of heavy to light oxygen isotopes (McCarroll and Loader 2004) in the latewood cellulose ($\delta^{18}\text{O}$) of a series of growth-rings. These values reflect summer rainfall in the area where the tree grew. The method relies on cross-matching against a regional master chronology constructed using oak timbers previously dated by ring-width dendrochronology. The current master chronology (Loader et al. 2019) is centred on Oxfordshire, in south-central England and covers AD 1200–2000 with annual replication of 10 trees. So far, most oxygen isotope dendrochronology in Great Britain has been undertaken on oak timbers, although there have been studies which have successfully dated other species against the oak master chronology (e.g. Bridge et al. 2019; Loader et al. 2021a). The summer rainfall signal that is dated by oxygen isotopes may, therefore, be present in the Sycamore Gap specimen, although its growing location may be too far away from the centre of the present master chronology for calendar dating to be viable (e.g. Loader et al. 2020; 2021b). Like ring-width dendrochronology, the measurement of multiple oxygen isotope sequences from the piths of the tree would enable cross-matching and thus resolution of some of the uncertainties in ring counting.

Radiocarbon wiggle-matching uses a series of measurements on the ^{14}C taken up from the atmosphere by a tree and laid down in its annual growth ring. Samples that grew during the 20th century can be dated exactly by matching the ‘bomb spike’ in radiocarbon produced by atmospheric nuclear testing between 1945 and the 1960s. A series of measurements made at intervals known from ring-counting can be matched to a known-age reference curve for the relevant hemisphere and latitude – in the case of the Sycamore Gap Tree, to the NH2 curve (Hua et al. 2022).

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