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7 and 9 Market Street
Chipping Norton
Oxfordshire

Further Dendrochronology and Radiocarbon Wiggle-matching of Elm and Oak Timbers

Martin Bridge, Cathy Tyers, Alex Bayliss, Michael Dee, and
Sanne Palstra

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Front Cover: 7 and 9 (either side of no. 8, the white house) Market Street, Chipping Norton, Oxfordshire © Historic England. Photograph by Martin Bridge

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SUMMARY
Ring-width dendrochronology has been undertaken previously on three adjacent properties, with the front range of the high-status building at 8 Market Street yielding a likely felling date range of AD 1424–56. The oak samples from 7 Market Street showed abrupt growth changes and could not be dated, and a mix of oak and elm samples from 9 Market Street also remain undated.

There was some question as to whether all three buildings may once have been a single entity, and so radiocarbon dating was undertaken on samples from Nos. 7 and 9 to determine whether they were contemporaneous with those from No. 8. This demonstrated that two purlins from No. 7 were felled in *cal AD 1386–1408 (95% probability)*, making them rather earlier than the fabric dated by dendrochronology in No. 8. A further six timbers from these buildings, however, were all probably felled in the early eighteenth-century.

CONTRIBUTORS
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INTRODUCTION

This research arises from architectural and documentary evidence assessed during the *Early Fabric in Chipping Norton* project (Rosen and Cliffe 2017), and from dendrochronology undertaken on timbers from 7 and 8 Market Street as part of that project (Bridge and Tyers 2020`a–b) and on 9 Market Street as part of the *Developing the dendrochronology of elm in historic buildings* project (Bridge and Tyers 2019; Bridge 2020).

7, 8, and 9 Market Street

These properties lie on the western side of the old market square in the centre of Chipping Norton (Fig 1), and are all listed at Grade II (LEN 1052627 here, LEN 1183239 here, and LEN 1052628 here respectively).

Dendrochronology has established that the roof and cross-passage of the front range of 8 Market Street were constructed of timbers felled in AD 1424–56 (Bridge and Tyers 2020b). This stands out in the project as the most prestigious and high status building that has been found so far in Chipping Norton, although further evidence of the town's medieval past has been identified at 1–5 Spring Street (Bridge and Tyers 2020c) and further down Market Street at The Chequers (Bridge and Tyers 2020d).

The key question that this study aims to address is whether the fifteenth-century hall house at 8 Market Street originally extended north into 9 Market Street and south into 7 Market Street. The architectural and documentary evidence hint that this may be the case.

A truss buried in the party wall between 7 and 8 Market Street suggests that these roofs may have been continuous, as does the timberwork in the northern bay which has purlins with empty windbrace slots reminiscent of those in 8 Market Street. The truss and purlins of the southern bays of the roof in 7 Market Street also exhibit medieval features such as empty stave holes and mortices that do not relate to the present structure, but their arrangement suggests that the roof has been largely reconfigured.

Previous dendrochronological analysis at 7 Market Street identified two pairs of cross-matching samples, a pair of oak principal rafters (cn7mkt07 and cn7mkt08, *t*= 8.3 with 75 years overlap; Bridge and Tyers 2020a; Fig 2) and a pair of oak purlins (cn7mkt04 and cn7mkt09, *t*=6.6 with 52 years overlap; Bridge and Tyers 2020a; Fig 3). The ring-width series were combined from each pair of samples to produce two mean series (cn7mkt78 and cn7mkt49) of 115-years and 64-years respectively. The highest *t*-value obtained when cross-matching these two-timber means (*t*=3.7 with 64 years overlap) is poor and hence inconclusive and neither could be dated securely by ring-width dendrochronology against the available reference chronologies for oak.

The tree-ring analysis at 9 Market Street was curtailed as only one sample had more than 60 rings and was measured (Bridge and Tyers 2019, table 1). There is a high-status fireplace in the southern wall of 9 Market Street, however, which shares a flue with 8 Market Street to the north. It also has elm joists in the ground-floor ceiling which are very unusual in having diagonal cut chamfer stops, with the only comparable examples dated to AD 1446–7 (Hall 2005, 159 and fig 6.11). Levels suggest that this ceiling may have been raised and these timbers reset when the first-floor ceiling and roof above were constructed. The first-floor ceiling beams are similar in size and arrangement to those dated in the Guildhall to AD 1514–20 (Bridge and Tyers 2020e), although the roof is of seventeenth-century form.

RING-WIDTH DENDROCHRONOLOGY

Following the decision to undertake further scientific dating on timbers from 7 and 9 Market Street, additional tree-ring analysis was undertaken on the samples previously taken from these buildings. Three of the 12 samples from 7 Market Street (Bridge and Tyers 2020a, table 1) and all but one of the eight samples from 9 Market Street (Bridge and Tyers 2019, table 1) had not been measured as part of the original programme of tree-ring analysis as they were assessed as containing too few rings for reliable dating by ring-width dendrochronology. They might, however, have potential for dating by radiocarbon wiggle-matching.

All these samples, bar cn9mkt02 (which could not be located at the time of this study), had their tree-ring sequences measured to an accuracy of 0.01mm, using a specially constructed system utilising a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004). The ring-widths of elm sample cn9mkt03 were measured to a break in the core at the heartwood/sapwood boundary, with an additional 20 rings of sapwood counted to the bark. This part of the timber was, however, so worm eaten that it was not possible to distinguish every ring boundary with certainty and it is not known whether any rings were lost at the break in the core. The additional ring-width data from these samples from both 7 and 9 Market Street are provided in the Appendix.

Cross-matching of all samples from 7 and 9 Market Street was attempted by a process of qualified statistical comparison by computer, supported by visual checks. The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). Ring sequences were plotted on the computer monitor to allow visual comparisons to be made between sequences. This method provides a measure of quality control in identifying any potential errors in the measurements when the samples cross-match.

In comparing one sample or site master against other samples or chronologies, *t*-values over 3.5 are considered significant, although in reality it is common to find demonstrably spurious *t*-values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some *t*-values in the range of 5, 6, and higher, and for these to be well replicated from different, independent chronologies with both local and regional chronologies well represented, except where imported timbers are identified. Where two individual samples match together with a *t*-value of 10 or above, and visually exhibit exceptionally similar ring patterns, they may have originated from the same parent tree. Same-tree matches can also be identified through the external characteristics of the timber itself, such as knots and shake patterns. Lower *t*-values, however, do not preclude same-tree derivation.

This process confirmed the cross-matching between cn7mkt07 and cn7mkt08 (Fig 2) and that between cn7mkt04 and cn7mkt09 previously identified (Fig 3), but did not provide any further cross-matching between the ring-width series of the timbers from this building. Details of the relative dating of the samples identified by the dendrochronology are provided in Table 1.

As previously noted for 7 Market Street, the ring-width series at 9 Market Street showed abrupt growth changes (Figs 4 and 5). The ring-width series from two of the oak samples from the roof of 9 Market Street, cn9mkt05 and cn9mkt06, cross-matched (t = 8.0 with a 49-year overlap; Fig 4), as did the ring-width series from two of the elm samples from the first-floor ceiling, cn9mkt03 and cn9mkt04 (t = 5.3 with a 37-year overlap; Fig 5). The ring-width series were combined from each pair of samples to produce two mean series (cn9mkt56 and cn9mkt34) of 71-years and 50-years respectively, although these could not be dated conclusively by ring-width dendrochronology against the available reference chronologies for oak. The highest *t*-value obtained when cross-matching these two-timber means (t=4.0 with 34 years overlap) is inconclusive. Details of the relative dating of the samples identified by the dendrochronology are provided in Table 2.

RADIOCARBON DATING

Following the extended programme of tree-ring analysis from 7 and 9 Market Street, four timbers were selected for radiocarbon dating and wiggle-matching.

Radiocarbon dating is based on the radioactive decay of ^{14}C, which trees absorb from the atmosphere during photosynthesis and store in their growth-rings. The radiocarbon from each year is stored in a separate annual ring. Once a ring has formed, no more ^{14}C is added to it, and so the proportion of ^{14}C versus other carbon isotopes reduces in the ring through time as the radiocarbon decays. Radiocarbon ages, like those in Table 3, measure the proportion of ^{14}C in a sample and are expressed in radiocarbon years BP (before present, ‘present’ being a constant, conventional date of AD 1950).

Nine radiocarbon measurements have been obtained from single tree-rings from four timbers, one from each of the mean tree-ring sequences identified by dendrochronology (Table 3). Three rings have been dated from oak timber cn7mkt08 (Fig 6) and two from oak timber cn7mkt09 (Fig 7). Two rings have also been dated from elm timber cn9mkt04 (Fig 8) and two from oak timber cn9mkt05 (Fig 9). One further sample from cn9mkt05 failed in laboratory processing, due to a petroleum-derived contaminant. Dissection was undertaken by Alison Arnold and Robert Howard at the Nottingham Tree-Ring Dating Laboratory. Prior to sub-sampling, the core was checked against the tree-ring width data. Then each annual growth ring was split from the rest of the tree-ring sample using a chisel or scalpel blade. Each radiocarbon sample consisted of a complete annual growth ring, including both earlywood and latewood. Each annual ring was then weighed and placed in a labelled bag. Rings not selected for radiocarbon dating as part of this study have been archived by Historic England.

Radiocarbon dating was undertaken by the Centre for Isotope Research, University of Groningen (GrM-), the Netherlands in 2021. Each ring was converted to α-cellulose using an intensified aqueous pretreatment (Dee *et al* 2020) and combusted in an elemental analyser (IsotopeCube NCS), coupled to an Isotope Ratio Mass Spectrometer (Isoprime 100). The resultant CO_2 was graphitised by hydrogen reduction in the presence of an iron catalyst (Wijma *et al* 1996; Aerts-Bijma *et al* 1997). The graphite was then pressed into aluminium cathodes and dated by Accelerator Mass Spectrometry (AMS) (Synal *et al* 2007; Salehpour *et al* 2016).

Data reduction was undertaken as described by Wacker *et al* (2010), and the facility maintains a continual programme of quality assurance procedures (Aerts-Bijma *et al* 2021), in addition to participation in international inter-comparison exercises (Scott *et al* 2017; Wacker *et al* 2020). These tests demonstrate the reproducibility and accuracy of these measurements.

The results are conventional radiocarbon ages, corrected for fractionation using $\delta^{13}C$ values measured by Accelerator Mass Spectrometry (Stuiver and Polach 1977; Table 3). The $\delta^{13}C$ values presented in Table 3 were measured by Isotope Ratio Mass Spectrometry, and more accurately reflect the natural isotopic composition of the sampled wood.

WIGGLE-MATCHING

Radiocarbon ages are not the same as calendar dates because the concentration of ^{14}C in the atmosphere has fluctuated over time. A radiocarbon measurement has thus to be calibrated against an independent scale to arrive at the corresponding calendar date. That independent scale is the IntCal20 calibration curve (Reimer *et al* 2020). For the period covered by this study, this is constructed from radiocarbon measurements on tree-ring samples dated absolutely by dendrochronology. The probability distributions of the calibrated radiocarbon dates from 7 and 9 Market Street, derived from the probability method (Stuiver and Reimer 1993), are shown in outline in Figures 10–14 and 16.

Wiggle-matching is the process of matching a series of calibrated radiocarbon dates which are separated by a known number of years to the shape of the radiocarbon calibration curve. At its simplest, this can be done visually, although statistical methods are usually employed. Floating tree-ring sequences are particularly suited to this approach as the calendar age separation of tree-rings submitted for dating is known precisely by counting the rings in the timber. A review of the method is presented by Galimberti *et al* (2004).

The approach to wiggle-matching adopted here employs Bayesian chronological modelling to combine the relative dating information provided by the tree-ring analysis with the calibrated radiocarbon dates (Christen and Litton 1995). It has been implemented using the program OxCal v4.4 (http://c14.arch.ox.ac.uk/oxcal.html; Bronk Ramsey *et al* 2001; Bronk Ramsey 2009). The modelled dates are shown in black in Figures 10–14 and 16 and quoted in italics in the text. The Acomb statistic shows how closely the assemblage of calibrated radiocarbon dates as a whole agrees with the relative dating provided by the tree-ring analysis that has been incorporated in the model; an acceptable threshold is reached when it is equal to or greater than An (a value based on the number of dates in the model). The A statistic shows how closely an individual calibrated radiocarbon date agrees with its position in the sequence (most values in a model should be equal to or greater than 60).

Figure 10 illustrates the chronological model for cn7mkt08. This model incorporates the gaps between each dated annual ring known from tree-ring counting (eg that the carbon in ring 2 of the measured tree-ring series (GrM-25680) was laid down 44 years before the carbon in ring 46 of the series (GrM-25679); Fig 6). It also incorporates the radiocarbon measurements from cn7mkt08 (Table 3) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer *et al* 2020).

The model has good overall agreement (Acomb: 57.4, An: 40.8, n: 3), and two of the dates on the single rings have good individual agreement (A > 60) with their positions in the sequence except for GrM-25680 (A: 51) which is slightly earlier than expected. This is, however, no more than might be expected on statistical grounds. This model suggests that the outermost ring, in this instance the last complete ring formed before felling of the tree, of cn7mkt08 was formed in *cal AD 1688–1713 (95% probability; cn7mkt08 felling*; Fig 10), probably in *cal AD 1690–1700 (44% probability)* or *cal AD 1702–1710 (24% probability).*

Figure 11 illustrates the chronological model for cn7mkt09. This model also incorporates the gaps between each dated annual ring known from tree-ring counting (Fig 7), along with the radiocarbon measurements from cn7mkt09 (Table 3) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer *et al* 2020).

This model also has good overall agreement (Acomb: 91.6, An: 50.2, n: 2), and both the dates on the single rings have good individual agreement (A > 60). This model suggests that the last surviving ring of cn7mkt09 formed in *cal AD 1371–1390 (95% probability; cn7mkt09 last ring*; Fig 11), probably in *cal AD 1374–1383 (68% probability).*

Figure 12 illustrates the chronological model for cn9mkt04. This model also incorporates the gaps between each dated annual ring known from tree-ring counting (Fig 8), along with the radiocarbon measurements from cn9mkt04 (Table 3) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer *et al* 2020).

This model also has good overall agreement (Acomb: 109.2, An: 50.2, n: 2), and both the dates on the single rings have good individual agreement (A > 60). This model suggests that the last surviving ring of cn9mkt04 formed in *cal AD 1705–1731 (53% probability; cn9mkt04 ?felling*; Fig 12) or *cal AD 1819–1847 (42% probability)*, probably in *cal AD 1709–1727 (43% probability)* or *cal AD 1822–1828 (11% probability)* or *cal AD 1837–1843 (14% probability).*

Figure 13 illustrates the chronological model for cn9mkt05. This model also incorporates the gaps between each dated annual ring known from tree-ring counting (Fig 9), along with the radiocarbon measurements from cn9mkt05 (Table 3) calibrated using the internationally agreed radiocarbon calibration data for the northern hemisphere, IntCal20 (Reimer *et al* 2020).

This model also has good overall agreement (Acomb: 118.2, An: 50.2, n: 2), and both the dates on the single rings have good individual agreement (A > 60). This model suggests that the last surviving complete ring of cn9mkt05 formed in *cal AD 1697–1716 (95% probability; cn9mkt05 felling*; Fig 13), probably in *cal AD 1702–1711 (68% probability).*

The wiggle-matching clearly demonstrates that the highest *t*-value (*t*=3.7 with 64 years overlap) obtained when comparing the two mean series from 7 Market Street, cn7mkt78 and cn7mkt49, is clearly spurious (Amodel: 0; model not shown). The timbers forming cn7mkt89 date to the late seventeenth or early eighteenth century (Fig 10), whilst the timbers forming cn7mkt49 date to the end of the fourteenth century (Fig 11).

As noted above, the highest *t*-value obtained when comparing the two mean series from 9 Market Street, cn9mkt56 (oak) and cn9mkt34 (elm) was *t*=4.0 with 34 years overlap, although, without further independent support, this was deemed inconclusive. When the radiocarbon dates are combined with the relative sequence suggested for the growth rings of cn9mkt04 and cn9mkt05 by this highest *t*-value, however, the model has good overall agreement (Amodel: 136.9; Fig 14) and all the dates have good individual agreement (A > 60). This allows us to accept the highest cross-matching identified between cn9mkt34 and cn9mkt56 by the tree-ring analysis producing a group of four relatively dated oak and elm samples (Fig 15; Table 4). The subscript $_{\mathrm{DR}}$ denotes that this is not a mean sequence derived independently by dendrochronology, but a radiocarbon-supported dendrochronological sequence. The wiggle-matching suggests that the final ring of this group of four relatively dated samples formed in *cal AD 1713–1729 (95% probability; cn9mkt3456 last ring*; Fig 14), probably in *cal AD 1718–1726 (68% probability).*

ESTIMATING FELLING DATES

Once a tree-ring sequence has been dated, it is necessary to estimate the dates of felling of the trees included in each mean sequence. With samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. The felling date is the estimated date for the last ring of the timber and, depending on the completeness of the final ring (ie if it has only the spring vessels or earlywood formed, or the latewood or summer growth) a season for felling is also indicated.

If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an estimated felling date can be given for each sample by adding the probability distribution for the number of sapwood rings expected for oak trees that grew in this region (Miles 1997, fig 5) to the estimated date for the last ring of the timber. This sapwood distribution is modified to account for any surviving sapwood rings (Bayliss and Tyers 2004, 960).

Where neither any sapwood nor the heartwood/sapwood boundary survives, the sapwood distribution may be applied in the same way, although in this case the resultant posterior distribution provides a *terminus post quem* for the felling date of the timber rather than an estimate of the felling date itself.

Of the four timbers that have been dated from 7 Market Street, only cn7mkt08 has complete sapwood. For cn7mkt07, cn7mkt04, and cn7mkt09, the probability distribution of the expected number of rings in this region has been applied (Miles 1997, fig 5), truncated respectively by 18, 1, and 4 rings to account for surviving sapwood (Bayliss and Tyers 2004). The two timbers in the cross-matching pair cn7mkt07 and cn7mkt08 were certainly not felled in the same year as, although the final ring of both formed in relative year 115 of the mean sequence, cn7mkt08 had complete sapwood but cn7mkt07 did not. With their heartwood/sapwood boundaries being only five years apart, at relative years 97 and 92 respectively, it does however appear likely that they were felled at a broadly similar time, potentially as part of a single period of felling spanning a number of years. The heartwood/sapwood boundaries of cn7mkt04 and cn7mkt09, however, formed in relative years 63 and 60 respectively of the mean chronology, which would be consistent with a single period of felling. The radiocarbon date estimates are in good agreement with the interpretation of a single felling episode (Acomb: 121.5, An: 50.0, n: 2; Fig 16), when a combined felling date is calculated as described by Millard (2002).

All four timbers dated from 9 Market Street retained complete sapwood, although in the case of cn9mkt03 this was detached from the measured part of the core and so 20–30 sapwood rings have been added to allow for the potential loss of a few rings at the break. In the case of cn9mkt04, it was impossible to determine how many sapwood rings were present, as it was not clearly distinguishable from the heartwood. Clearly, these four timbers, whilst broadly coeval, were not all felled at the same time as their final rings formed up to 16 years apart from ring 70 of the cn9mkt3456 (cn9mkt06) to ring 87 (cn9mkt04).

The estimated felling dates of all eight dated timbers from 7 and 9 Market Street are illustrated in Figure 16 and their posterior density estimates are given in Tables 1 and 2.

It must be emphasised that scientific dating can only date when a tree has been felled, not when the timber was used to construct the structure or object under study.

DISCUSSION

The radiocarbon dating has enabled the potential matches between various timbers found by ring-width dendrochronology to be reassessed, and the associations between timbers in the three contiguous buildings to be analysed in more detail.

Interestingly, possible matches between the mean ring-width series from two oak timbers and from two elm timbers from 9 Market Street were supported by the radiocarbon wiggle-matching. Although all four timbers were found to be of similar age (Fig 14), they do not represent timbers felled at the same time (Fig 17).

The results suggest substantial rebuilding of the roofs over these properties at the very end of the seventeenth century or in the first decades of the eighteenth century, although this may not have happened at the same time (Fig 17). This work on the roofs may be slightly earlier than the early eighteenth-century cross beams dated from the ceiling in 9 Market Street (cn9mkt03 and cn9mkt04). Only one timber of those dated by radiocarbon analysis (cn7mkt09) had much earlier origins, suggesting that two timbers, both purlins, in 7 Market Street date to the late fourteenth century or to the first decade of the fifteenth century, this being earlier than the early-to-mid fifteenth-century dating of some timbers in 8 Market Street by dendrochronology (Bridge and Tyers 2020b).

Overall, therefore, no evidence was found to support the hypothesis that 7 Market Street and/or 9 Market Street were once part of the early fifteenth-century 8 Market Street high-status building.

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TABLES

Table 1: Details of the samples taken from 7 Market Street, Chipping Norton

Sample number	Timber and location	No of rings	Mean ring width (mm)	Sapwood rings	Mean sensitivity	Relative date span	*Estimated felling date (95% probability)*
Roof timbers in attic rooms							
cn7mkt01	East principal rafter, south truss	61	1.81	-	0.20	-	-
cn7mkt02	South-east purlin, south room	87	1.25	27	0.29	-	-
cn7mkt03	Collar, south truss	39	3.26	?h/s	0.20	-	-
cn7mkt04	South-west purlin, south room	52	1.43	1	0.25	13-64^{49}	*cal AD 1386–1408*
cn7mkt05	West principal rafter, south truss	33	3.19	-	0.22	-	-
cn7mkt06	North-west purlin, south room	35	2.51	?h/s	0.20	-	-
cn7mkt07	West principal rafter, north truss	75+	1.15	15+3NM	0.23	38-112^{78}	*cal AD 1690–1726*
cn7mkt08	East principal rafter, north truss	115	1.16	23C	0.21	1-115^{78}	*cal AD 1688–1713*
cn7mkt09	West purlin, north room	64	1.37	4	0.26	1-64^{49}	*cal AD 1386–1408*
cn7mkt10	'Knee' added to west purlin, north room	60	1.85	17C	0.25	-	-
First-floor ceiling beams							
cn7mkt11	South ceiling beam	60	2.78	24C	0.19	-	-
cn7mkt12	North ceiling beam	33	3.18	11	0.27	-	-

Key: NM=not measured, h/s=heartwood/sapwood boundary, C=complete sapwood, winter felled; ^{49}=relative date span within mean series cn7mkt49; ^{78}=relative date span within mean series cn7mkt78

Table 2: Details of the samples taken from 9 Market Street, Chipping Norton

Sample number	Timber and position	No of rings	Mean ring width (mm)	Sapwood rings	Mean sensitivity	Relative date span	*Estimated felling date (95% probability)*
Elm samples from ceilings							
cn9mkt01	East ceiling beam, ground floor north room	62	2.97	½C	0.24	-	-
cn9mkt02	East joist, 3rd from south, ground floor north room	<30	NM	h/s	-	-	-
cn9mkt03	South secondary cross beam, first floor north room	40	2.77	h/s (+20NMC)	0.26	1–40^{34}	*cal AD 1727–1746*
cn9mkt04	North secondary cross beam, first floor north room	47	3.70	?C	0.25	4–50^{34}	*cal AD 1713–1730*
Oak roof timbers							
cn9mkt05	North-west lower purlin	71	1.94	21¼C	0.29	1–71^{56}	*cal AD 1697–1713*
cn9mkt06	Collar to north truss	49	1.26	24¼C	0.20	22–70^{56}	*cal AD 1696–1712*
cn9mkt06a	ditto	34	1.12	21	0.18	-	-
cn9mkt06b	ditto	49	1.22	24¼C	0.21	-	-
cn9mkt07	West principal rafter, north truss	69	2.64	?C	0.21	-	-

Key: NM = not measured; h/s = heartwood-sapwood boundary; C = complete sapwood, winter felled; ¼C = complete sapwood, felled the following spring; ^{34} = relative date span within mean series cn9mkt34; ^{56} = relative date span within mean series cn9mkt56.

Table 3: Radiocarbon and stable isotope measurements from 7 and 9 Market Street, Chipping Norton

Laboratory Number	Sample	Radiocarbon Age (BP)	$\delta^{13}C_{IRMS}$ (‰)
7 Market Street			
GrM-25680	cn7mkt08, ring 2 (*Quercus* sp. heartwood)	368±17	−24.70±0.15
GrM-25679	cn7mkt08, ring 46 (*Quercus* sp. heartwood)	308±17	−24.23±0.15
GrM-25683	cn7mkt08, ring 112 (*Quercus* sp. sapwood)	145±18	−24.03±0.15
GrM-25678	cn7mkt09, ring 16 (*Quercus* sp. heartwood)	558±17	−24.01±0.15
GrM-25682	cn7mkt09, ring 62 (*Quercus* sp. sapwood)	667±18	−24.20±0.15
9 Market Street			
GrM-25684	cn9mkt04, ring 4 (*Ulmus* sp.)	188±18	−21.56±0.15
GrM-25685	cn9mkt04, ring 38 (*Ulmus* sp.)	92±18	−22.80±0.15
GrM-25690	cn9mkt05, ring 2 (*Quercus* sp. heartwood)	298±15	−23.63±0.15
GrM-25691	cn9mkt05, ring 40 (*Quercus* sp. heartwood)	179±19	−23.97±0.15

Table 4: Cross-matching between the four samples at the relevant offsets in brackets indicated by a combination of dendrochronology and radiocarbon dating

	t-values / overlap length		
Sample (relative date)	cn9mkt04 (41–87)	cn9mkt05 (1–71)	cn9mkt06 (22–70)
cn9mkt03 (38–77)	5.29 / 37	1.76 / 34	3.16 / 33
cn9mkt04 (41–87)		2.82 / 31	6.43 / 30
cn9mkt05 (1–71)			8.03 / 49

FIGURES

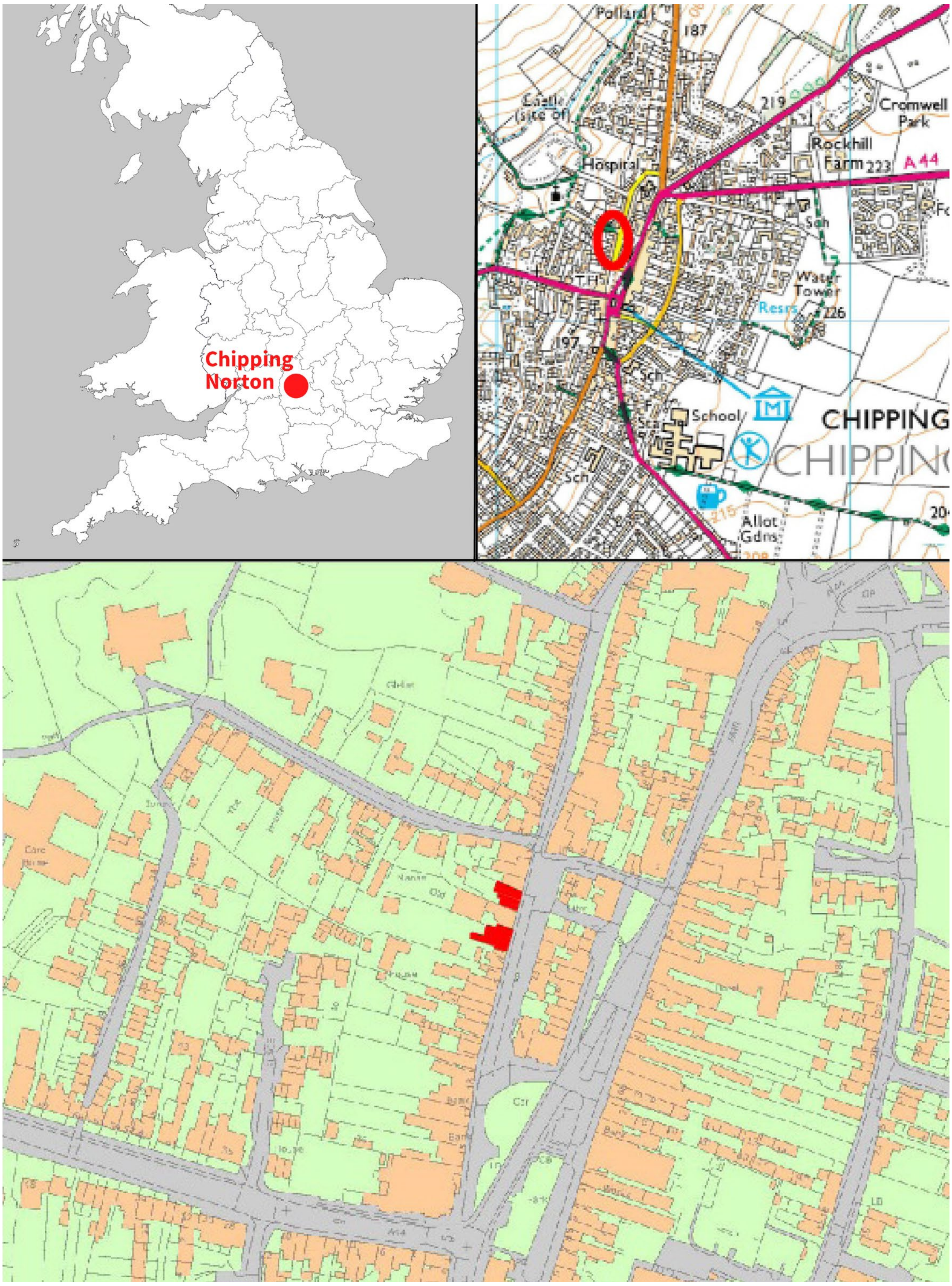

Figure 1: Maps to show the location of 7 and 9 Market Street in Chipping Norton, marked in red. Scale: top right 1:15000; bottom 1:2000. © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100024900

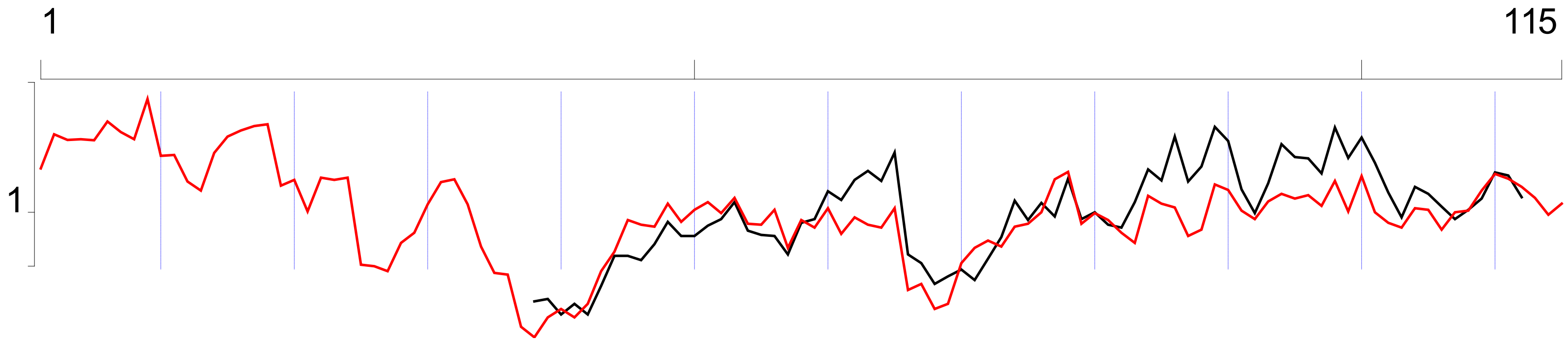

Figure 2: Plots showing the relative positions of overlap for samples cn7mkt07 (black) and cn7mkt08 (red), showing their similarity in growth. The y-axis is ring width (mm) on a logarithmic scale

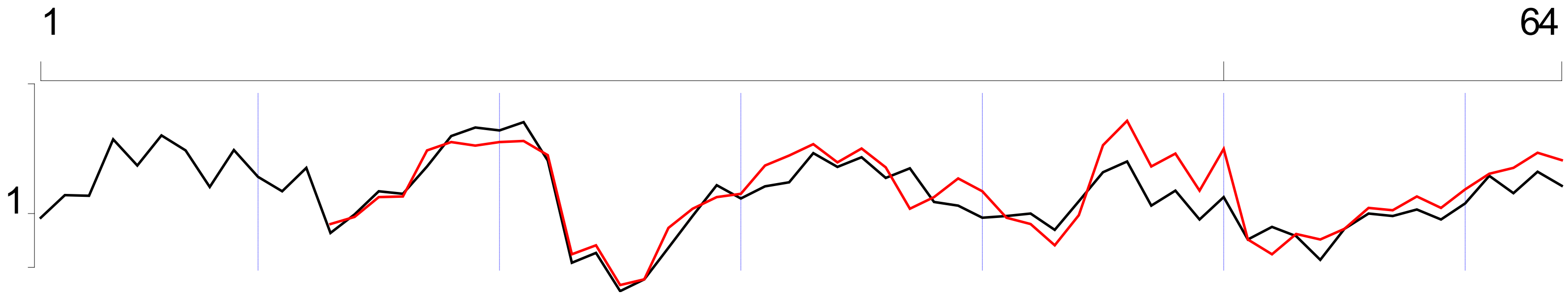

Figure 3: Plots showing the relative positions of overlap for samples cn7mkt04 (black) and cn7mkt09 (red), showing their similarity in growth. The y-axis is ring width (mm) on a logarithmic scale

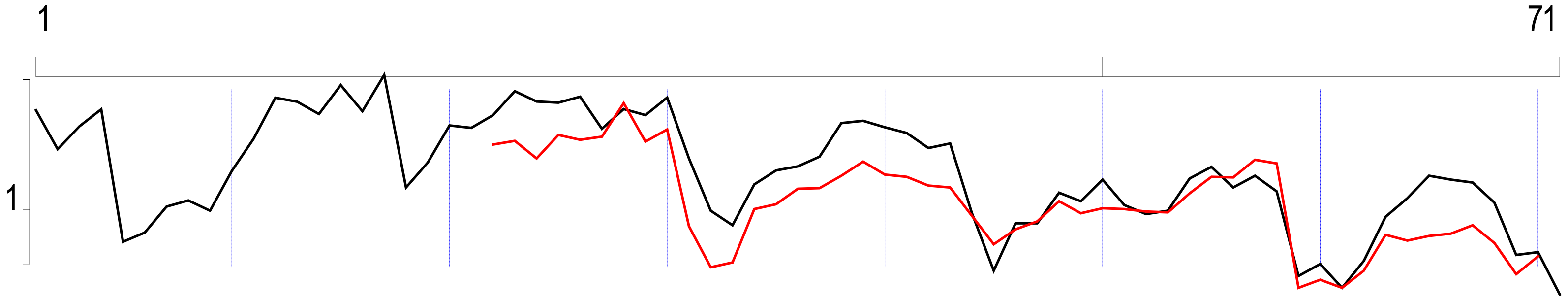

Figure 4: Plots showing the relative positions of overlap for samples cn9mkt05 (black) and cn9mkt06 (red), showing their similarity in growth. The y-axis is ring width (mm) on a logarithmic scale

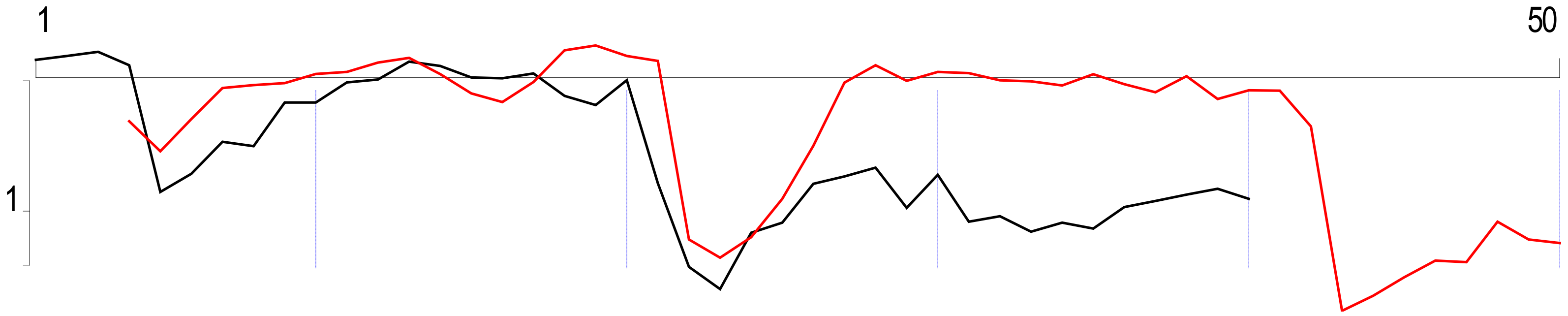

Figure 5: Plots showing the relative positions of overlap for samples cn9mkt03 (black) and cn9mkt04 (red), showing their similarity in growth. The y-axis is ring width (mm) on a logarithmic scale

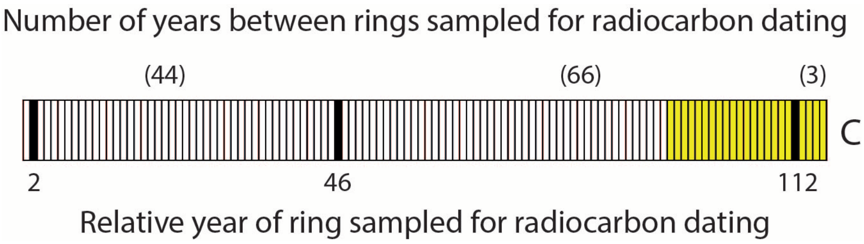

Figure 6: Schematic illustration of sample cn7mkt08 to locate the single-ring sub-samples submitted for radiocarbon dating (yellow = sapwood; C = complete sapwood)

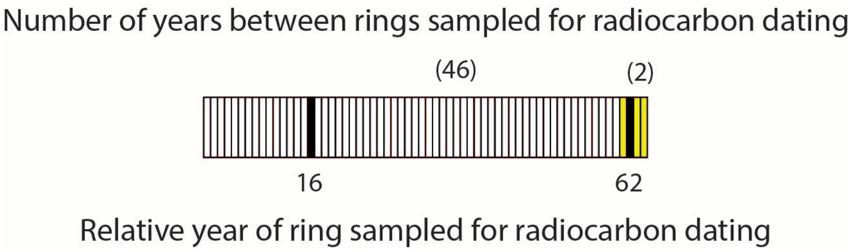

Figure 7: Schematic illustration of sample cn7mkt09 to locate the single-ring sub-samples submitted for radiocarbon dating (yellow = sapwood)

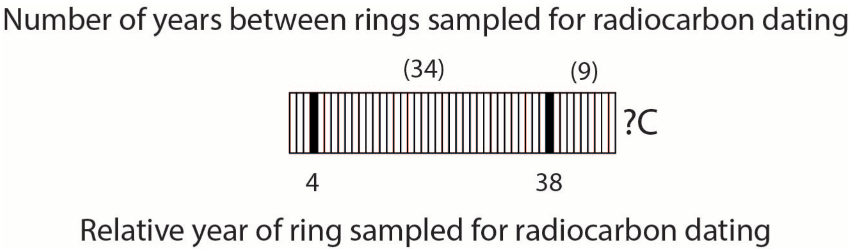

Figure 8: Schematic illustration of sample cn9mkt04 to locate the single-ring sub-samples submitted for radiocarbon dating (?C = probably complete sapwood)

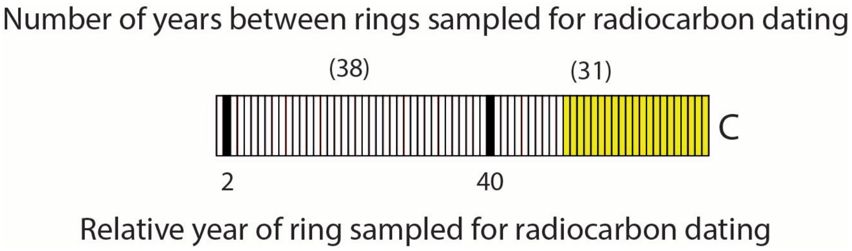

Figure 9: Schematic illustration of sample cn9mkt05 to locate the single-ring sub-samples submitted for radiocarbon dating (yellow = sapwood; C = complete sapwood)

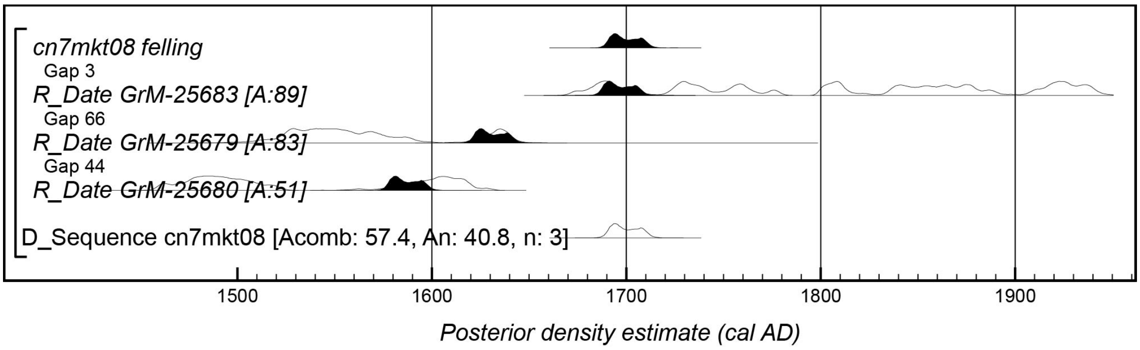

*Figure 10: Probability distributions of dates from cn7mkt08. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the simple radiocarbon calibration, and a solid one, based on the wiggle-match sequence. Distributions other than those relating to particular samples correspond to aspects of the model. For example, the distribution '*cn7mkt08 felling*' is the estimated date when the tree which produced this timber was felled. The large square brackets down the left-hand side along with the OxCal keywords and the description of the sapwood estimates in the text defines the overall model exactly*

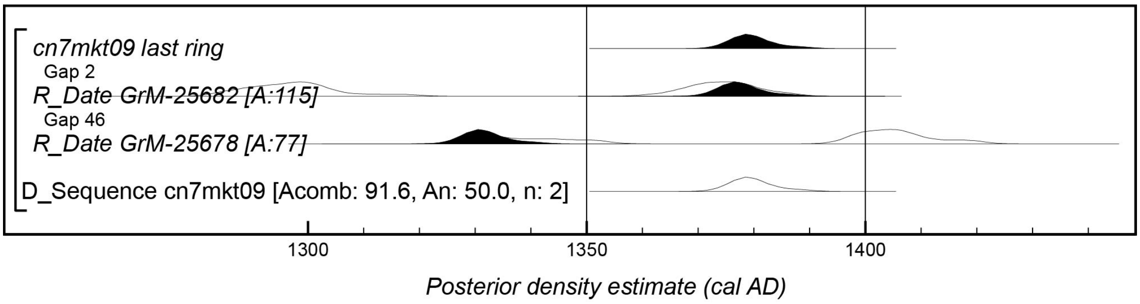

Figure 11: Probability distributions of dates from cn7mkt09. The format is identical to that of Figure 10. The large square brackets down the left-hand side along with the OxCal keywords and the description of the sapwood estimates in the text defines the overall model exactly

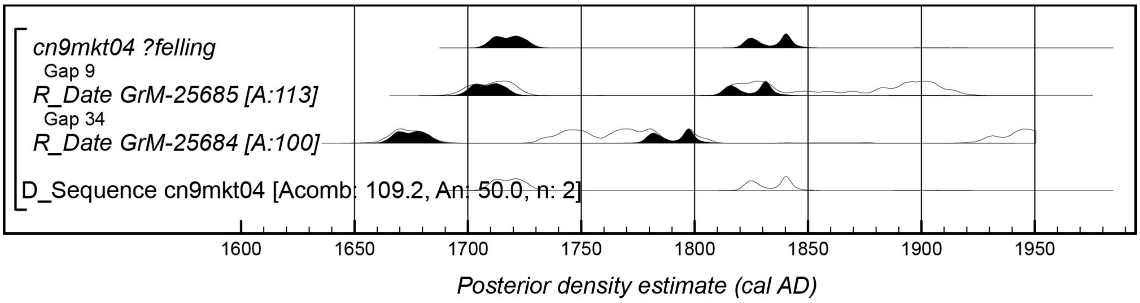

Figure 12: Probability distributions of dates from cn9mkt04. The format is identical to that of Figure 10. The large square brackets down the left-hand side along with the OxCal keywords and the description of the sapwood estimates in the text defines the overall model exactly

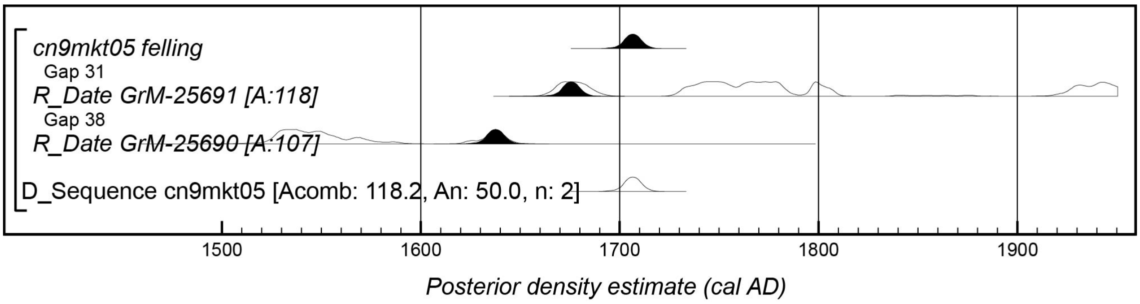

Figure 13: Probability distributions of dates from cn9mkt05. The format is identical to that of Figure 10. The large square brackets down the left-hand side along with the OxCal keywords and the description of the sapwood estimates in the text defines the overall model exactly

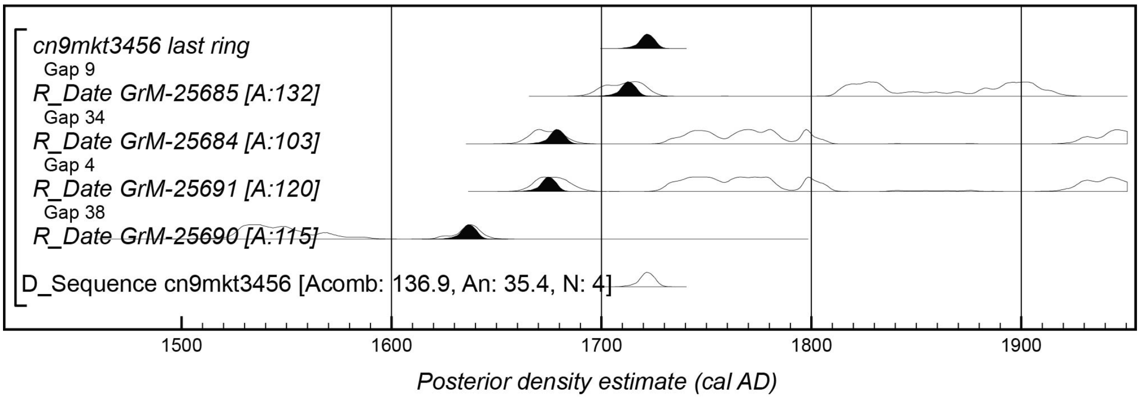

Figure 14: Probability distributions of dates from cn9mkt3456. The format is identical to that of Figure 10. The large square brackets down the left-hand side along with the OxCal keywords and the description of the sapwood estimates in the text defines the overall model exactly

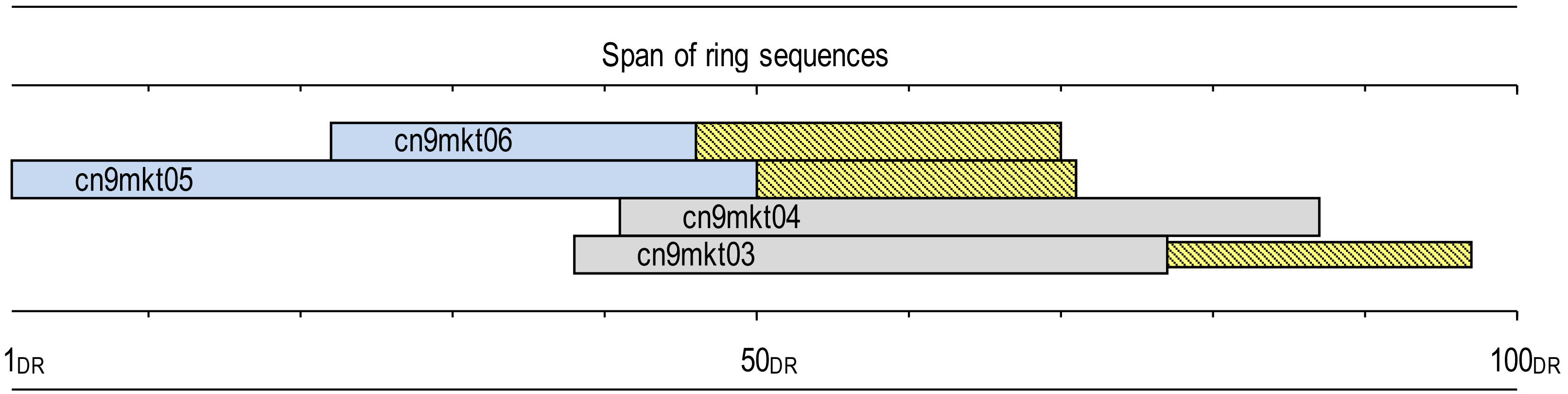

Figure 15: Bar diagram showing the relative positions of overlap of the samples, as identified by a combination of dendrochronology and radiocarbon, from 9 Market Street, Chipping Norton. Grey bar – elm heartwood; blue bar – oak heartwood; yellow hatched bar - sapwood; narrow bar sections – additional unmeasured rings

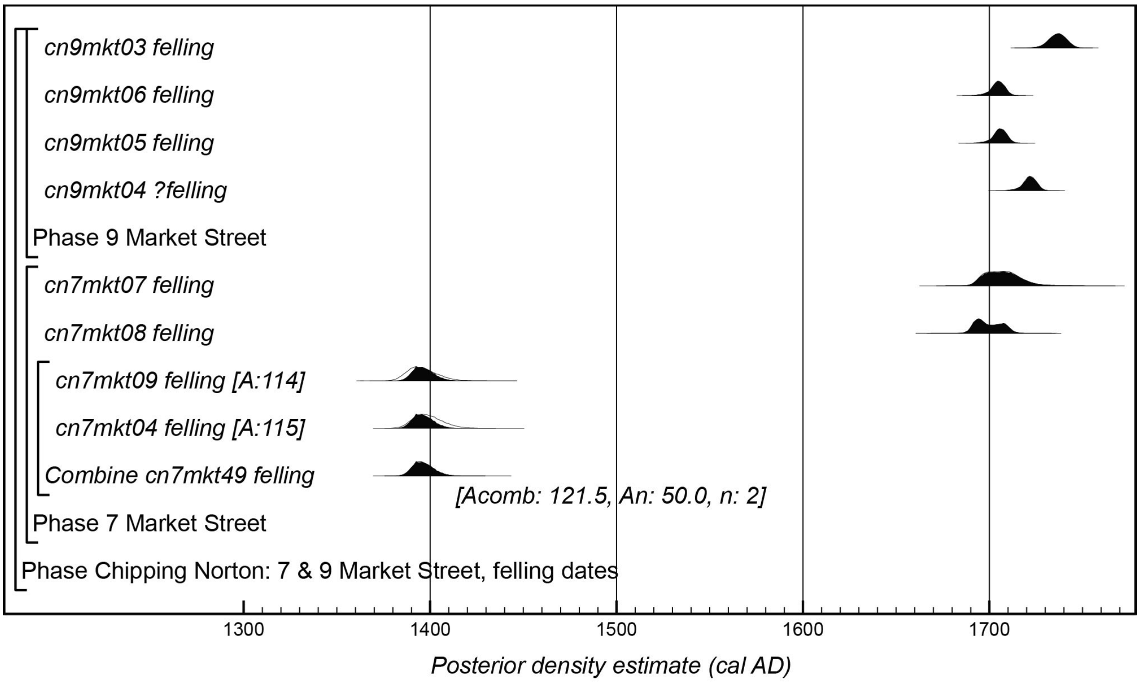

Figure 16: Probability distributions of estimated felling dates from 7 and 9 Market Street, Chipping Norton. The format is identical to that of Figure 10.

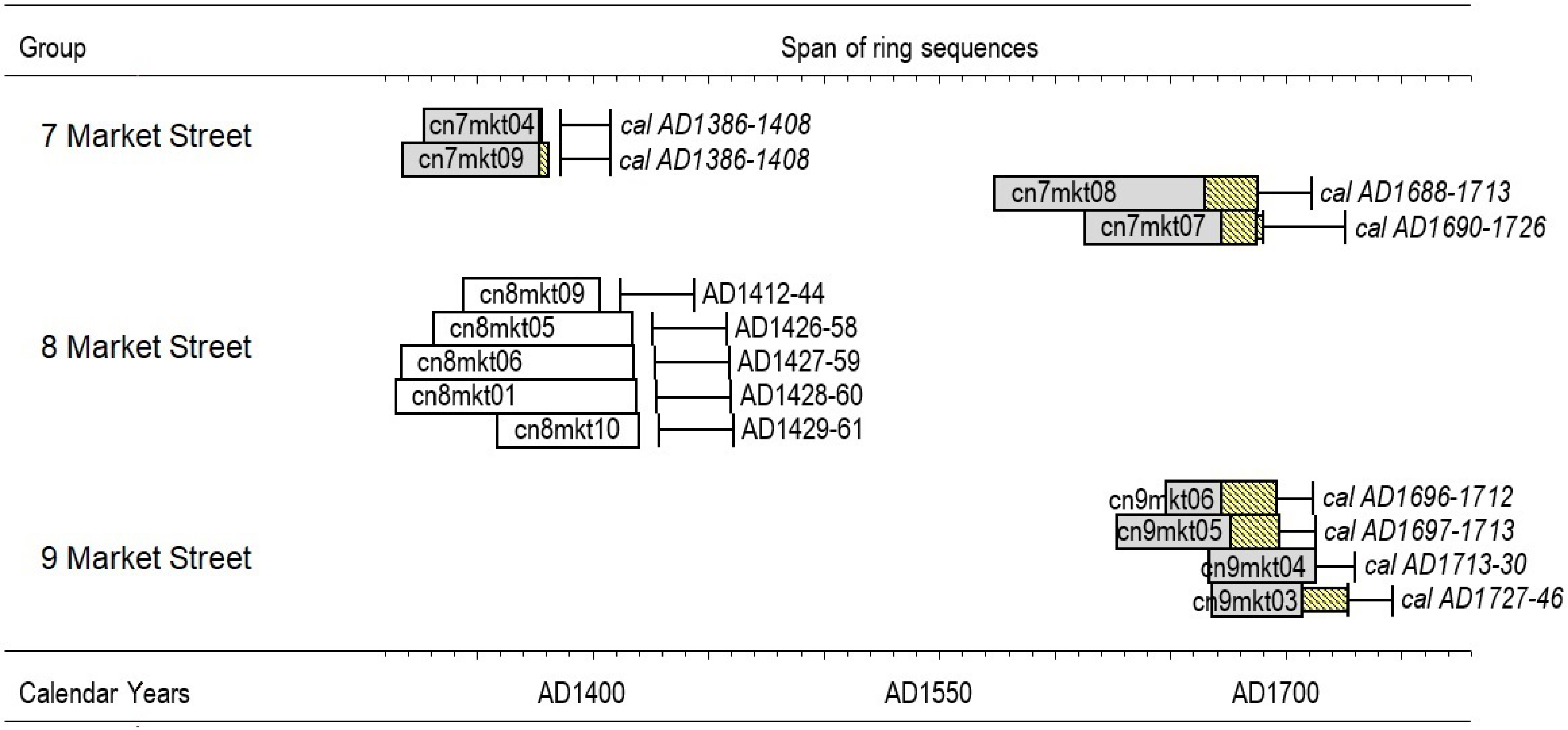

Figure 17: Bar diagram showing the relative matching positions of tree-ring dated samples (white bars) and samples dated by radiocarbon wiggle-matching (grey bars) with their appropriate likely felling date ranges. Yellow hatched sections represent sapwood

APPENDIX

Ring width values (0.01mm) for the sequences measured as part of this study.

7 Market Street

(*see* Bridge and Tyers 2020a for data of samples previously measured)

cn7mkt03
187 250 241 488 445 463 349 437 222 462
505 421 360 423 371 392 325 209 226 244
272 305 273 288 332 296 382 421 373 378
338 354 351 290 369 310 100 125 147

cn7mkt05
155 195 192 259 180 295 309 252 406 401
532 299 518 401 247 264 360 325 411 394
298 359 445 504 456 362 294 345 291 262
261 132 131

cn7mkt06
352 382 277 410 518 531 373 352 346 325
237 352 333 238 222 195 192 163 210 178
236 257 206 172 136 145 169 136 162 108
97 195 144 224 201

9 Market Street

(*see* Bridge and Tyers 2019 for data of sample previously measured)

cn9mkt03
621 651 684 582 126 157 231 219 371 371
473 490 608 577 502 497 527 402 360 486
140 51 39 77 87 139 152 169 104 155
88 94 78 87 81 105 113 122 131 116

cn9mkt04
296 206 304 442 458 469 524 537 601 636
523 414 373 475 697 739 651 613 71 57
73 116 220 472 582 482 537 529 485 479
456 522 463 420 510 387 430 428 278 30
36 45 55 54 88 71 68

cn9mkt05
333 208 274 337 68 76 104 112 99 160
236 387 369 318 451 329 510 131 177 277
269 314 419 370 365 392 266 338 314 388
186 99 83 136 161 169 190 285 293 271
253 211 223 96 48 85 85 123 111 144
106 95 99 146 168 131 151 125 45 52
39 54 92 115 151 144 139 109 58 60
36

cn9mkt06a

110	116	136	138	161	190	181	168	157	138
97	65	90	97	114	95	98	100	108	93
130	152	159	201	190	43	34	38	47	79
69	72	72	85						

cn9mkt06b

220	230	186	247	233	242	363	228	264	82
50	53	92	98	122	123	142	169	126	130
111	125	89	68	69	77	108	98	106	102
89	102	114	146	137	166	160	36	52	41
50	70	70	75	78	82	67	46	57	

cn9mkt07

186	248	274	313	395	398	379	261	296	316
187	314	284	246	237	190	195	146	132	88
86	128	131	195	181	188	165	180	188	191
240	207	214	200	186	237	347	448	472	432
495	558	429	543	380	356	393	348	420	157
81	131	158	322	249	334	322	257	310	292
333	156	100	132	193	246	271	316	251	

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