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Dendrochronological Dating of Known-age Tree-ring Radiocarbon Standards from Windsor Castle, Berkshire

Alex Bayliss, Robert Howard and Cathy Tyers

Scientific Dating

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Summary

Ten cross-sections from timbers recovered from the Great Kitchen at Windsor Castle following the fire on 20 November 1992 were selected to provide known-age tree-ring reference standards for radiocarbon dating. The rings formed in AD 1503, AD 1515 and AD 1524 were dissected for this purpose.

Contributors

Alex Bayliss, Robert Howard and Cathy Tyers

Acknowledgements

The front cover image shows the recovery and recording of timbers following the fire at Windsor Castle on 20 November 1992 (© Historic England).

Archive location

Historic England Archive, The Engine House, Fire Fly Avenue, Swindon SN2 2EH

Date of research

2019

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Tree-ring analysis

Following a fire on 20 November 1992, tree-ring analysis was undertaken on a total of 44 oak (*Quercus* sp.) timbers from the Great Kitchen, the roof trusses of St George's Hall, and the floor of the Grand Reception Room at Windsor Castle, Berkshire (51.48°N, 0.60°W; Fig. 1; https://historicengland.org.uk/listing/the-list/list-entry/1117776). A full report on this analysis is provided by Hillam et al. (forthcoming).

Samples were taken for dendrochronology either by sawing slices from the thickest part of the timber taking care to include the outer sapwood band if it was present, or by removing core samples using a hollow borer, 15mm in diameter, attached to an electric drill. The cross-sections were polished using a sander attachment on an electric drill. The surfaces were finished by hand polishing or paring with a sharp knife. The ring widths were measured to an accuracy of 0.01mm on a travelling stage which is connected to a microcomputer (Tyers 1997).

The ring-width series were then cross-matched as described by English Heritage (1998), using *t*-values identical to those produced by the first CROS program (Baillie and Pilcher 1973). Any potential matches were checked visually. Two site chronologies were produced by this process, "Windsor early" containing 14 ring sequences and "Windsor late" containing 21 ring sequences. Ten samples from "Windsor late", 12003, 12009, 12013, 12017, 12024, 12054, 12070B, 12073, 12074, and 12076, were selected to supply the single-year tree-ring standards for radiocarbon dating. All were from the roof of the Great Kitchen.

The details of the timbers included in this chronology are provided in Table 1 (those providing the tree-ring standards are indicated by *), and the *t*-value matrix between the ring-width series are provided in Table 2. *t*-values over *c.* 10 usually indicate an origin in the same tree, although *t*-values less than 10 may be produced when different radii are measured on the same trunk. Visual matching and the study of the wood samples themselves can sometimes aid the decision as to whether timbers come from the same tree. On this basis, it is not thought likely that any of the timbers sampled for the tree-ring standards derive from the same tree, although clearly all grew within the same locality.

Site chronology "Windsor late" is 151 years long, and dates from AD 1423 to AD 1573. Table 3 gives the correlation values of this site chronology with a range of other independent site chronologies within England.

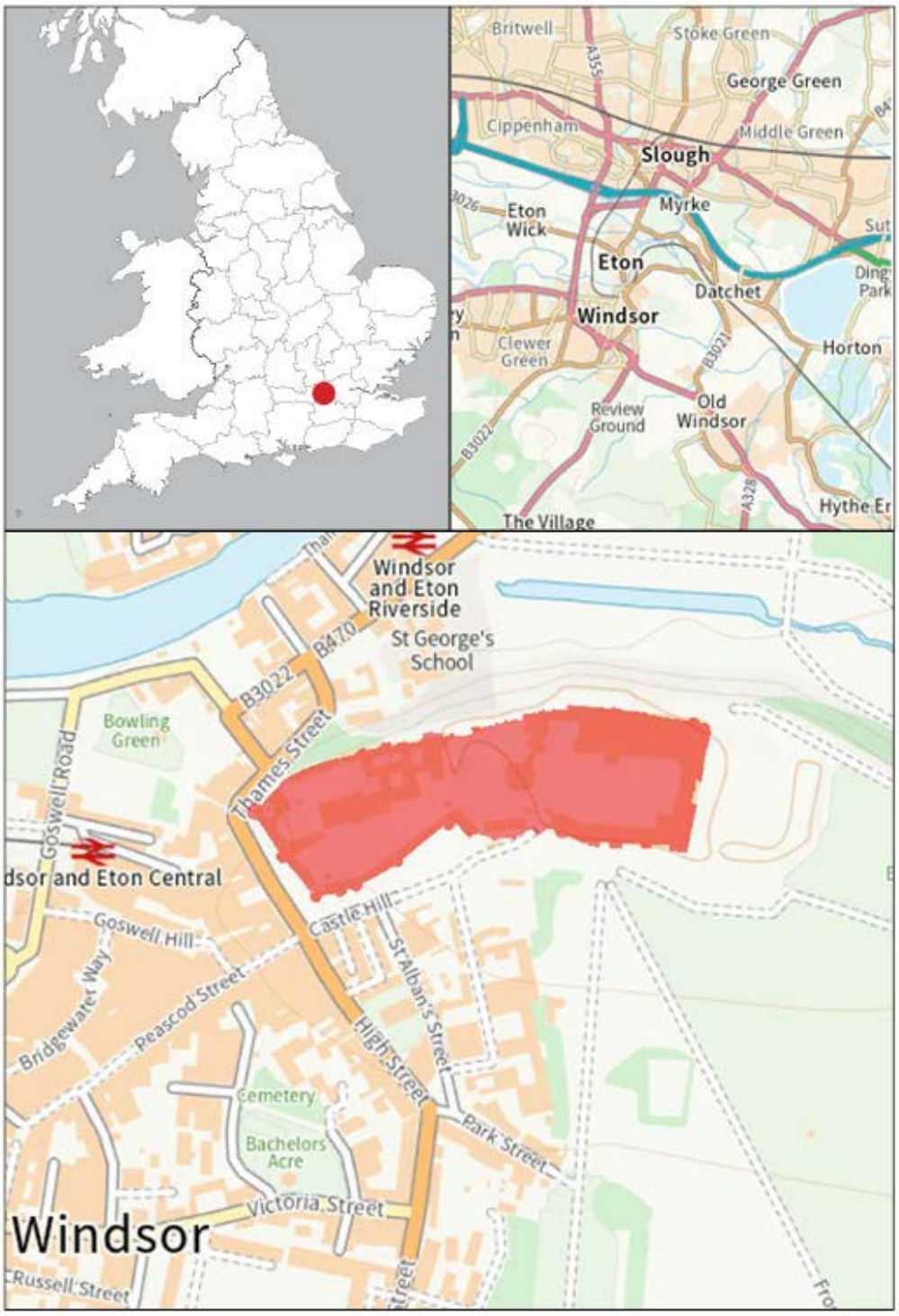

Figure 1: Maps to show the location of Windsor Castle, Windsor, Berkshire, in red. Scale: top right 1:100,000; bottom 1: 5,000. © Crown Copyright and database right 2023. All rights reserved. Ordnance Survey Licence number 100024900.

Table 1: Details of the samples included in “Windsor late” (HS = heartwood/sapwood transition; B = bark edge; (unmeasured sapwood rings); * = sampled for tree-ring standards)

Sample	Context	Provenance	Rings	Sapwood Rings	Absolute Dating (AD)
12003*	11064	Truss X king post	112	-	1442–1553
12009*	11248	Truss VIII wall piece, north side	87	-	1462–1548
12013*	11648	Upper wallplate	73	-	1463–1535
12017*	11298	Upper wallplate	79	-	1479–1557
12024*	11063	Truss X principal rafter	73	7	1501–1573
12049	11523	Truss I king post	111	14	1456–1566
12051	11634	Truss IX south wallpiece	53	-	1513–1565
12054*	-	Truss V-VI north ?purlin	70	HS?	1480–1549
12055	11632	Truss IX south hammer beam	87	-	1451–1537
12057	11549	Truss VII principal rafter	76	2	1479–1554
12060	11547	Truss VII king post	59	(12)	1501–1559
12062	11611	Truss VI N hammer beam	67	-	1484–1550
12066	11637	Truss VIII N wallpiece	58	-	1496–1553
12067	11595	Truss II S wallpiece	90	HS	1465–1554
12070A	11628	Truss X S wallpiece	57	-	1472–1528
12070B*	11628	Truss X S wallpiece	64	11(+*c.* 18)B	1496–1559
12071	11516	Truss 1–II upper wallplate?	61	-	1485–1545
12072	11807	SE wall lower wallplate	89	-	1423–1511
12073*	11589	West gable wallplate	88	-	1468–1555
12074*	11808	SE wall lower wallplate, next to 11807	109	-	1450–1558
12076*	11565	Mid-wallplate	71	-	1479–1549

Table 2. *t*-value matrix for ring-width series in the “Windsor late” site chronology (t-values less than 3.0 are not shown; \ overlap less than 15 years; values in bold indicate timbers from the same tree)

	12003	12009	12013	12017	12024	12049	12051	12054	12055	12057	12060	12062	12066	12067	12070A	12070B	12071	12072	12073	12074	12076
12003		-	10.0	-	-	3.7	-	4.1	3.4	3.8	3.9	4.4	3.3	3.5	-	-	3.6	-	4.3	3.7	3.1
12009			-	-	4.5	6.0	4.3	-	-	-	-	-	3.9	-	9.8	7.5	4.2	-	-	-	5.1
12013				4.0	3.5	-	3.2	3.4	3.7	-	5.1	3.3	4.6	-	-	-	-	-	3.9	3.9	-
12017					3.3	-	-	4.5	5.0	3.7	-	4.7	3.5	5.1	-	-	-	3.5	5.4	3.9	-
12024						4.1	8.5	-	4.0	-	5.6	3.9	6.3	7.0	-	5.7	3.6	\	5.0	5.4	5.5
12049							3.2	-	3.2	-	-	4.4	5.4	-	4.0	4.6	3.1	-	3.2	3.4	3.9
12051								-	4.5	-	4.4	3.1	5.2	7.2	-	4.6	3.8	\	5.6	4.5	4.5
12054									3.8	7.7	-	4.8	3.7	5.9	-	-	-	-	5.1	4.0	-
12055										-	5.3	3.1	4.0	6.1	-	4.1	3.1	3.3	3.7	5.6	-
12057											-	3.1	3.8	4.8	-	-	-	-	-	-	-
12060												-	4.4	8.4	-	4.2	3.8	\	4.6	4.1	5.4
12062													5.0	5.2	-	-	3.8	5.0	5.9	4.4	3.3
12066														5.5	-	3.3	-	-	4.7	3.6	3.4
12067															3.3	5.4	3.8	-	6.1	3.8	-
12070A																7.9	5.0	-	-	-	-
12070B																	-	-	-	3.3	10.1
12071																		-	3.2	-	4.9
12072																			3.2	**12.8**	-
12073																				4.9	-
12074																					-
12076																					

Table 3. Correlation values for the 151-year “Windsor late” site chronology with independent reference chronologies from England

Reference chronology	***t*-value**	**Span of chronology (AD)**	**Reference**
White Tower, Tower of London, London	12.7	1463–1616	Miles 2007
Hays Wharf, Southwark, London	9.6	1248–1647	Tyers 1996a; Tyers 1996b
Priory Barn, Little Wymondley, Hertfordshire	9.5	1450–1540	Bridge 2001
Cobham Hall, Gravesend, Kent	8.4	1317–1662	Arnold *et al* 2003
The Vyne (Garden House), Sherborne St John, Hampshire	8.4	1459–1630	Miles *el al* 1997
Dauntsey House, Dauntsey, Wiltshire	8.4	1393–1580	Tyers *et al* 2014
Longport Farmhouse, Newington, Kent	7.9	1334–1599	Tyers 1996c
Kingsbury Hall, Kingsbury, Warwickshire	7.9	1391–1564	Arnold et al 2006
Upper House Farm House, Nuffield, Oxfordshire	7.9	1404–1627	Haddon-Reece *et al* 1989
Apethorpe Hall, Northamptonshire	7.6	1458–1596	Arnold and Howard 2008

Dissection

The tree-rings dating to AD 1503 (Rijksuniversiteit Groningen, The Netherlands), AD 1515 (ETH Zürich, Switzerland), and AD 1524 (University of Bristol, UK) were chosen to provide the radiocarbon laboratory standards. Dissection was undertaken by Alison Arnold and Robert Howard at the Nottingham Tree-Ring Dating Laboratory (Fig. 2). Prior to sub-sampling the slices were checked against the tree-ring width data to ensure that the sample contained the required rings. Once this was determined the slices were split into radial wedges and then further reduced into radial slices of *c*. 5mm thickness using a bandsaw. The selected annual growth rings were then split from the rest of the sample using a chisel or scalpel blade. Each sample consisted of a complete annual growth ring, including both earlywood and latewood.

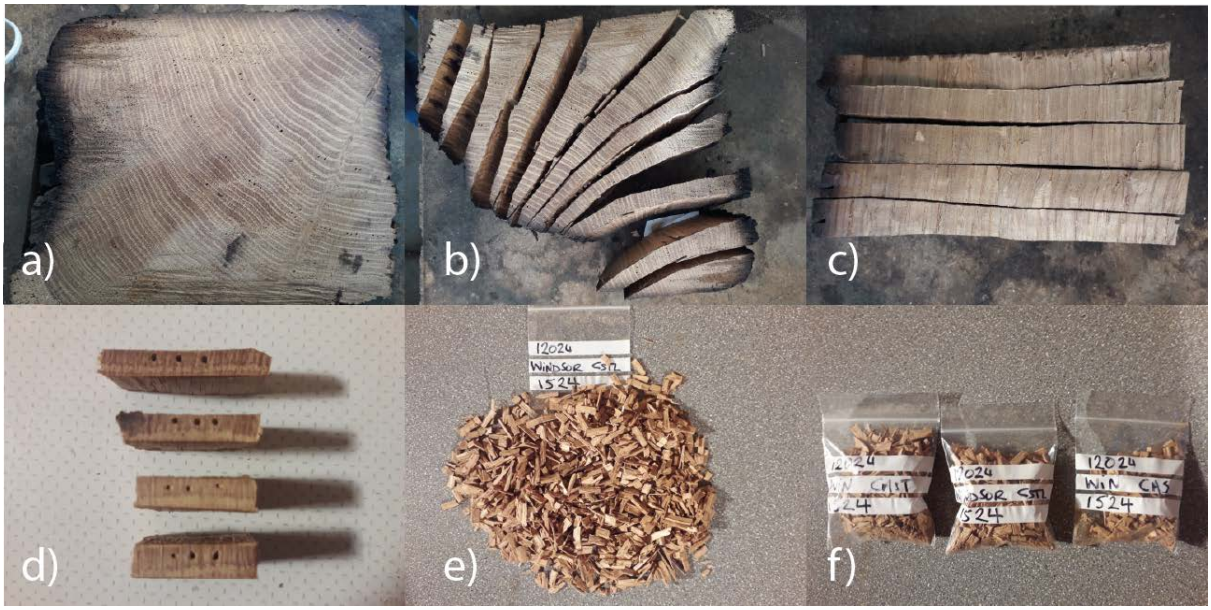

Figure 2. Dissecting single-ring tree-ring samples from timber 12024: a) original slice with ring-widths checked and selected rings marked out, b) slice split into wedges, c) wedges cut into slices, d) selected rings marked out on slices; e) chipped rings, f) bagged rings (photographs by R Howard).

Archive

The remainder of the samples are stored by Historic England, at Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth, PO4 9LD. Ring-width data for all the measured samples from the fire-damaged areas of Windsor Castle can be found in Hillam et al. (forthcoming) and at (www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring). Ring-width measurements for the timbers sampled for the radiocarbon standards are provided in the Appendix.

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Appendix

Ring-width data for the timbers which provided tree-ring standards for radiocarbon dating (Heidelberg format).

HEADER:
DateEnd=1553
Length=112
Species=QUSP
Pith=1
SapWoodRings=0
KeyCode=WC12003
DATA:Tree

293	214	238	147	182	162	131	233	170	198
235	292	299	322	319	233	416	396	483	312
363	485	354	395	452	360	424	431	386	293
264	250	263	418	373	264	339	379	355	318
263	243	283	313	403	399	402	313	294	227
264	209	192	257	290	186	126	131	107	140
157	173	158	155	155	180	187	215	238	243
224	215	201	230	190	170	162	142	122	122
184	143	183	123	144	137	127	122	89	148
157	176	183	155	246	221	178	205	152	205
113	156	156	252	189	186	230	182	188	170
173	212	0	0	0	0	0	0	0	0

HEADER:
DateEnd=1548
Length=87
Species=QUSP
Pith=1
SapWoodRings=0
KeyCode=WC12009
DATA:Tree

140	276	104	197	171	96	150	217	237	279
330	264	363	379	277	419	392	494	456	468
481	359	292	390	335	320	478	432	378	370
298	360	416	318	598	463	326	377	289	286
415	308	421	382	300	266	216	219	205	294
282	296	303	363	238	241	283	284	229	361
272	243	223	157	199	220	176	166	141	191
145	184	145	240	199	181	179	172	120	169
112	131	152	177	168	126	173	0	0	0

HEADER:
DateEnd=1535
Length=73
Species=QUSP
SapWoodRings=0
KeyCode=WC12013
DATA:Tree

516	423	516	733	651	687	809	570	347	386
402	400	615	567	325	398	368	363	394	299
352	462	314	376	427	392	311	329	296	371
258	196	337	351	270	162	167	138	219	244

287 200 178 196 236 203 244 247 259 305
358 347 304 281 205 296 257 235 264 343
265 397 246 287 264 288 222 168 392 254
370 257 288 0 0 0 0 0 0 0

HEADER:
DateEnd=1557
Length=79
Species=QUSP
SapWoodRings=0
KeyCode=WC12017
DATA:Tree
335 486 501 358 310 301 194 294 347 334
381 325 213 250 306 214 280 299 169 134
195 185 257 197 229 162 204 257 332 278
264 245 332 314 260 242 206 302 294 252
294 134 233 214 190 276 186 258 164 257
235 188 321 202 174 149 255 196 165 201
231 145 111 141 239 155 261 164 196 243
192 187 186 220 329 326 233 222 161 0

HEADER:
DateEnd=1573
Length=73
Species=QUSP
SapWoodRings=7
KeyCode=WC12024
DATA:Tree
536 496 481 497 525 588 694 579 819 606
740 476 582 526 560 378 422 684 568 327
295 400 285 387 294 537 410 376 296 281
474 265 294 190 524 354 383 389 456 380
315 190 258 272 398 289 319 389 551 349
443 283 381 328 390 274 244 188 232 288
237 474 377 372 345 307 452 360 470 479
461 311 246 0 0 0 0 0 0 0

HEADER:
DateEnd=1549
Length=70
Species=QUSP
SapWoodRings=0
KeyCode=WC12054
DATA:Tree
289 368 524 367 414 188 280 351 535 497
359 192 194 242 275 357 350 207 173 207
168 269 208 337 217 251 296 236 231 220
194 286 246 187 280 183 221 198 257 193
151 169 295 154 329 187 225 193 184 145
120 167 152 166 139 177 206 272 242 181
129 142 85 123 98 176 201 179 212 194

HEADER:
DateEnd=1559
Length=64
Species=QUSP
SapWoodRings=11

KeyCode=WC12070B
DATA:Tree
525 402 333 330 329 319 417 298 337 411
349 375 280 291 270 313 349 375 325 427
281 224 322 326 240 321 283 267 334 233
354 281 314 250 232 242 219 231 224 399
266 228 296 272 162 225 198 253 247 336
266 157 260 316 194 239 165 205 212 281
211 193 230 240 0 0 0 0 0 0

HEADER:
DateEnd=1555
Length=88
Species=QUSP
SapWoodRings=0
KeyCode=WC12073
DATA:Tree
344 389 450 305 273 212 111 162 175 304
387 400 441 513 317 329 396 143 201 432
610 547 419 197 229 222 139 171 299 157
99 171 184 202 289 551 250 206 436 829
509 347 466 328 310 244 166 230 208 191
209 133 71 78 219 161 144 113 270 243
241 159 150 255 161 137 128 302 343 333
394 371 230 161 53 97 85 233 172 158
222 250 368 373 301 336 601 449 0 0

HEADER:
DateEnd=1558
Length=109
Species=QUSP
SapWoodRings=0
KeyCode=WC12074
DATA:Tree
458 520 311 361 571 327 367 229 334 344
318 288 294 337 162 297 332 220 402 375
348 234 282 299 272 267 376 268 267 301
310 366 313 254 264 154 299 350 304 367
312 311 259 353 392 315 446 314 301 235
342 335 267 305 227 235 338 386 241 290
285 325 346 293 283 294 244 127 268 185
173 162 232 188 234 205 266 169 227 170
182 260 163 334 166 320 278 247 206 203
196 163 112 181 132 239 180 174 192 206
211 225 279 284 334 369 270 190 225 0

HEADER:
DateEnd=1549
Length=71
Species=QUSP
SapWoodRings=0
KeyCode=WC12076
DATA:Tree
415 354 353 115 61 181 255 181 240 286
301 287 327 252 345 354 256 491 357 268
237 256 298 389 274 312 295 252 271 242
249 252 303 350 331 311 375 289 267 334

329	257	316	297	298	266	194	298	279	279
264	179	250	187	203	165	284	211	201	192
193	120	190	109	179	172	249	196	148	206
255	0	0	0	0	0	0	0	0	0

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