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Scientific Dating

Great Gransden Windmill, Mill Road, Great Gransden, Cambridgeshire

Tree-ring Dating of Oak Timbers

Martin Bridge

Discovery, Innovation and Science in the Historic Environment

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SUMMARY

Thirteen samples were taken from this mill, including one *ex situ* timber of uncertain origin lying on the upper floor. Six of the nine samples considered suitable for analysis were successfully dated. Three dated timbers from the buck appear to be coeval and have a likely felling date range of AD 1803–32. The dated right sheer appears to be a little older with a likely felling date range of AD 1768–1800, whilst the windshaft is slightly later with a likely felling date range of AD 1845–77. The final dated timber is the main-post, which is clearly substantially earlier. Its outermost ring potentially marks the heartwood-sapwood boundary in which case a felling date range of AD 1628–60 is obtained.

CONTRIBUTOR

Dr M C Bridge

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2012

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INTRODUCTION

This Grade II* post and open trestle windmill is a Scheduled Ancient Monument, situated on the east side of the settlements of Great and Little Gransden (Figs 1 and 2) in the District of Huntingdon in Cambridgeshire. The listing description suggests that this may be the oldest mill of this type in England with a documentary suggestion of construction in *c* AD 1612, although, as has been pointed out elsewhere (Bridge 2006), the dating of windmills is problematic because of the degree of rebuilding and repair associated with such structures, especially the reuse of the large main posts which are generally exceptional timbers.

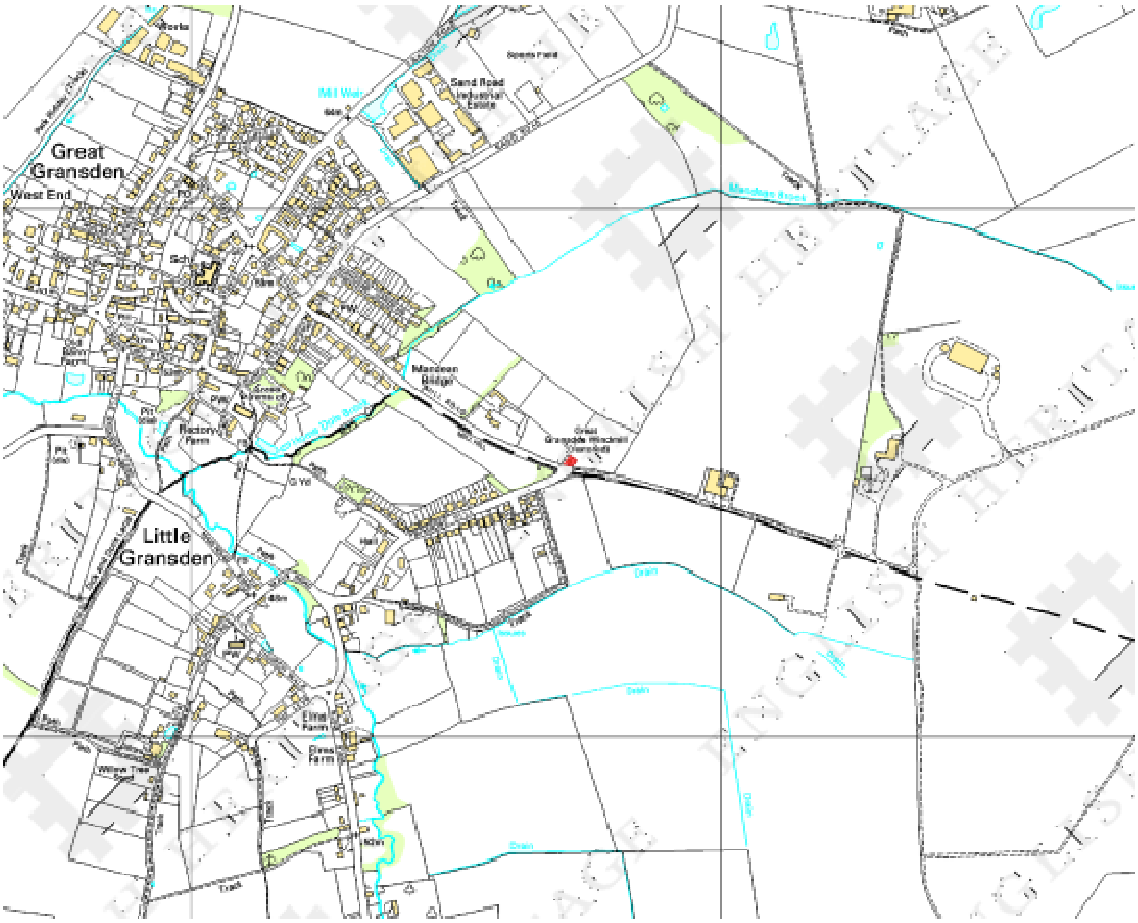

Figure 1: Location of the mill in relation to the nearby settlements of Great and Little Gransden. © Crown Copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100024900

Figure 2: Immediate environs of the mill © Crown Copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100024900

METHODOLOGY

Fieldwork for the present study was carried out in November 2012 following an initial assessment of the potential for dating some weeks beforehand. In the initial assessment, accessible oak timbers with more than 50 rings and where possible traces of sapwood were sought, although slightly shorter sequences are sometimes sampled if little other material is available. Those timbers judged to be potentially useful were cored using a 15mm auger attached to an electric drill. The cores were glued to wooden laths, labelled, and stored for subsequent analysis.

The cores were polished on a belt sander using 80 to 400 grit abrasive paper to allow the ring boundaries to be clearly distinguished. The samples 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). Cross-

matching was attempted by a combination of visual matching and a process of qualified statistical comparison by computer. 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*-value ranges 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.

Ascribing felling dates and date ranges

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. With samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. Depending on the completeness of the final ring, ie if it has only the spring vessels or early wood formed, or the latewood or summer growth, a precise felling date and season can be given. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an estimated felling date range can be given for each sample. The number of sapwood rings can be estimated using an empirically derived sapwood estimate with a given confidence limit. If no sapwood or heartwood/sapwood boundary survives then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* (*tpq*) or felled-after date.

A review of the geographical distribution of dated sapwood data from historic timbers has shown that a sapwood estimate relevant to the region of origin should be used in interpretation, which in this area is 9–41 rings (Miles 1997). It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure or object under study.

RESULTS, INTERPRETATION, AND DISCUSSION

Details of the 13 samples, taken from the timbers assessed as the most promising for analysis, are given in Table 1 and illustrated in Figures 3 and 4. Sample 10 is from the right-hand side girt, not illustrated in these figures, but it is the equivalent timber to the left-hand side girt shown in Figure 3, and sample 12 is an *ex situ* timber. Four of the timbers yielded cores with ring sequences too short to justify further analysis.

The nine measured sequences were compared. Cross-matching was found between five of these (Table 2) and confirmed by comparison of each individual sequence to the reference chronologies. The level of cross-matching was so good between three samples (ggm06, ggm11, and ggm13) that the timbers represented were thought likely to have been derived from the same parent tree, despite the variation in their heartwood-sapwood boundary dates. These three ring series were therefore combined prior to being incorporated with the other two matching series into a single site chronology, GRANSDEN, which dates to the period AD 1706–1836, the dating evidence being shown in Table 3a, and the relative positions of overlap of these dated timbers being shown in Figure 5. In addition the series ggm01 was dated individually to AD 1496–1619 (Table 3b; Fig 5). Thus, there appear to be four possible phases of construction represented within the six dated samples.

The main post (ggm01) yielded a sequence of 124 years which was thought to end at the heartwood-sapwood boundary. This boundary was evident on the timber itself, but not positively identified on the core. If the outermost ring is taken as the heartwood-sapwood boundary, this gives a likely felling date range of AD 1628–60. This is later than the *c* AD 1612 date suggested in the listing description which was derived from a documentary source. The main post is an exceptionally large timber and such timbers were probably relatively rare. They were, therefore, potentially a valuable commodity reused several times, as seen elsewhere at Pitstone Mill (Miles *et al* 2004), Nutley Mill (Bridge 2006), and Drinkstone Mill (Bridge 2001). These three examples are all older than the post at Great Gransden, and indeed they have older buck timbers, suggesting that in fact this mill is not the oldest of its type in the country, as suggested in the listing description.

The three dated timbers (ggm06, ggm11, and ggm13) from the frame of the buck, all thought to be derived from the same parent tree, have a mean heartwood-sapwood boundary date of AD 1791. This results in a likely felling date range for these timbers of AD 1800–32, which can be modified in the light of the rings present on ggm06 to 1803–32.

The ring sequence of the right sheer (ggm02) dates to the period AD 1708–63 and includes four sapwood rings, making the likely felling date range for this timber AD 1768–1800. The right sheer may be a reused timber but it is difficult to draw any firm conclusions on the basis of a single dated timber. However, the slightly earlier felling date

suggests there may have been an earlier superstructure than the current buck, the only dated parts of which are early nineteenth century.

The ring sequence from the windshaft (ggm09) dates to the period AD 1731–1836 with the outermost ring marking the heartwood-sapwood boundary. The likely felling date range of AD 1845–77 makes it younger than the other dated timbers. This is not surprising, as this element of the mill has to take a lot of strain and is often replaced. The dating of the windshaft, therefore, suggests another phase of repair within the current structure.

All the timbers appear to be relatively local in origin, as shown by the matches obtained and detailed in Tables 3a and 3b.

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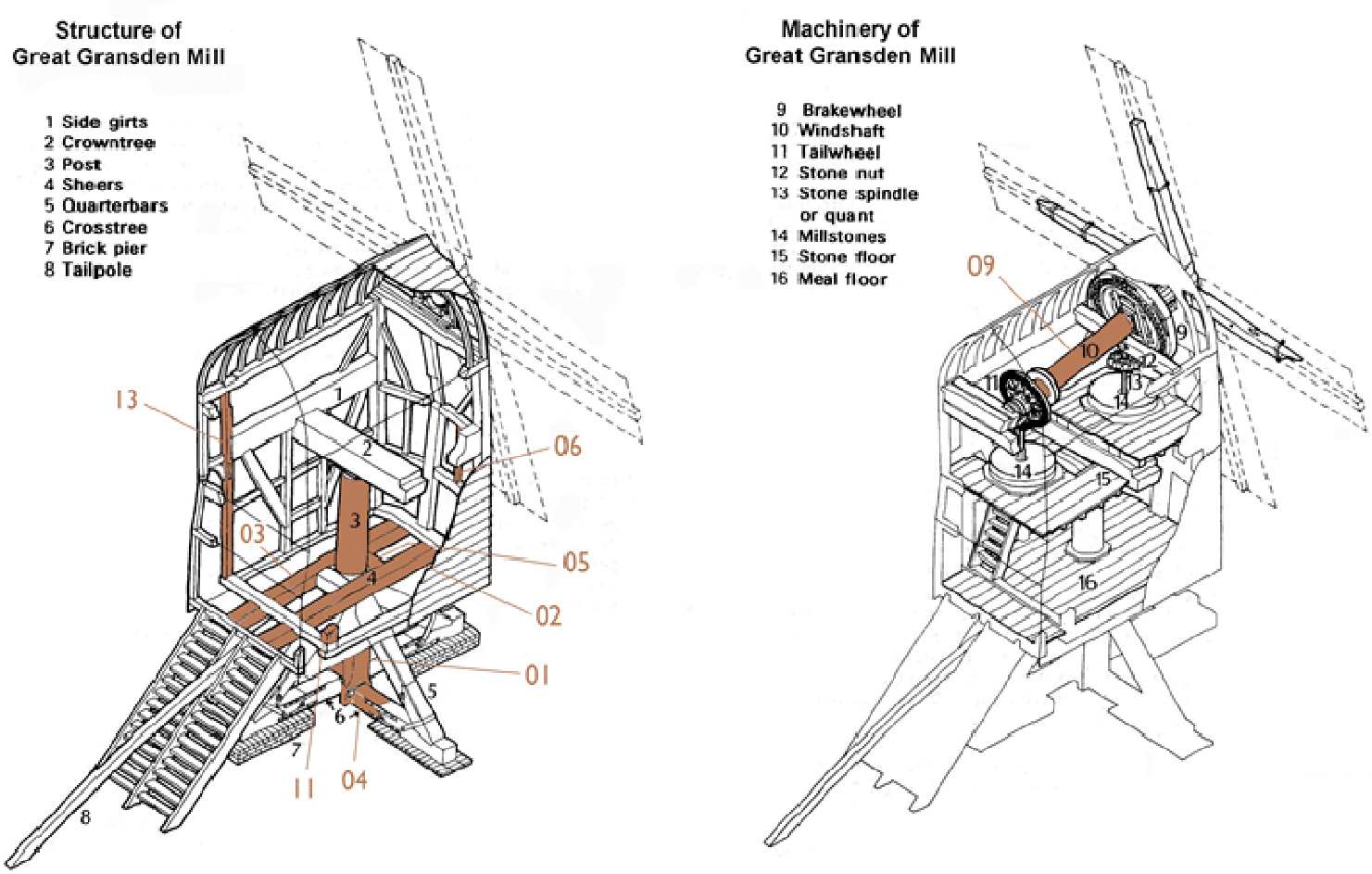

Figure 3: Drawings of the mill showing some of the timbers sampled for dendrochronology numbered in brown. Adapted from an original drawing by Graham Black

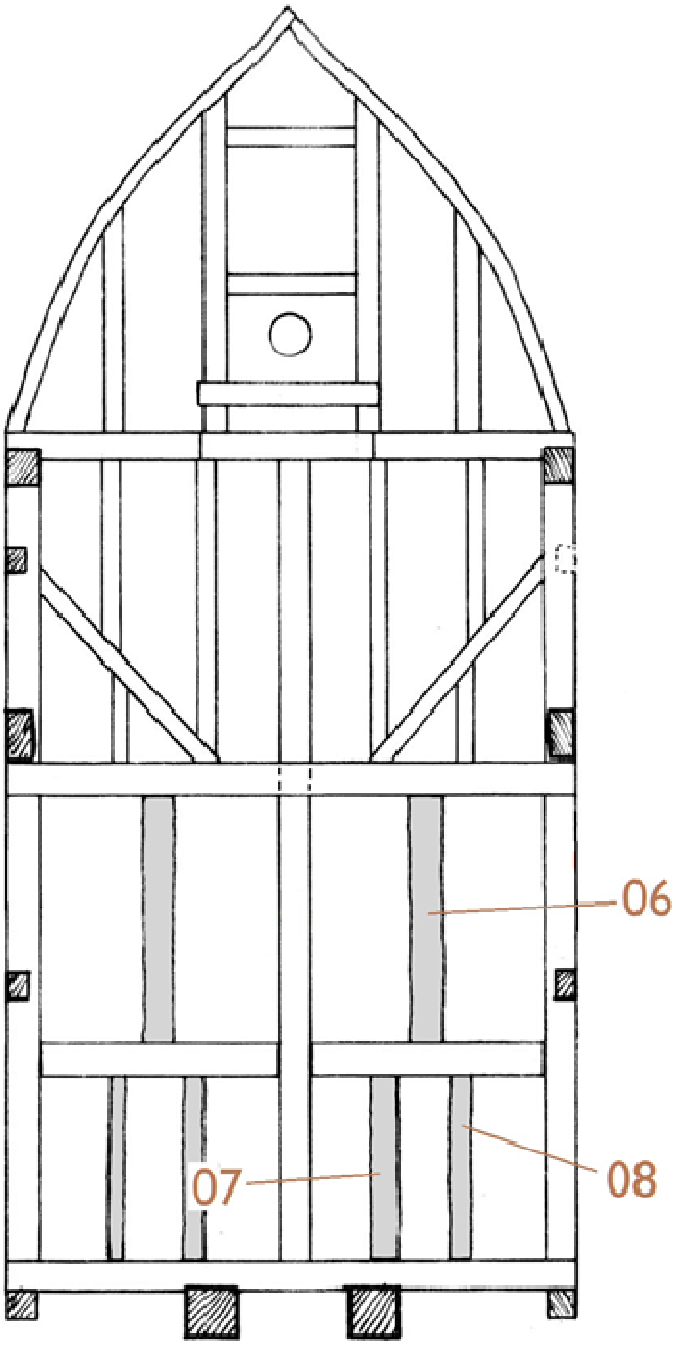

Figure 4: Front elevation of the mill seen from the inside, with grey shading representing timbers thought to be original. The timbers sampled for dendrochronology are numbered in brown. Adapted from an original drawing by Luke Bonwick

Table 1: Details of the samples taken from Great Gransden Windmill, Cambridgeshire

Sample Number	Timber and position	No of rings	Mean HW ring width (mm)	Dates Spanning (AD)	h/s bdry AD	Sapwood rings	Mean sens	Felling date ranges (AD)
ggm01	Main post	124	2.38	1496–1619	1619	?h/s	0.31	1628–60?
ggm02	Right sheer	56	2.97	1708–63	1759	4	0.19	1768–1800
ggm03	Left sheer	<40	-	-	-	-	NM	-
ggm04	Cross tree	90	2.24	-	-	29C	0.20	-
ggm05	Front sheer separator	53	3.65		-	8 (+1NM)	0.25	-
ggm06	Stud, right upper front	63	2.33	1740–1802	1802	h/s	0.33	1811–43
ggm07	Stud, right front lower section, inner	<40	-	-	-	-	NM	-
ggm08	Stud, right front lower section, outer	<40	-	-	-	-	NM	-
ggm09	Windshaft	106	1.95	1731–1836	1836	h/s	0.19	1845–77
ggm10	Right side girt	44	2.23	-	-	h/s	0.24	-
ggm11	Rear right post, upper floor	85	1.70	1706–90	1790	h/s	0.32	1799–1831
ggm12	*Ex situ* timber of unknown origin	<40	-	-	-	-	NM	-
ggm13	Rear left post	69	2.05	1716–84	1782	2	0.32	1791–1823

Key: NM = not measured; HW = heartwood; h/s = heartwood-sapwood boundary; C = complete sapwood, winter felled

Table 2: Cross-matching between dated elements from the site master chronology GRANSDEN. t-values in excess of 3.5 are significant

			t-values	
Sample	ggm06	ggm09	ggm11	ggm13
ggm02	1.9	3.1	6.0	3.9
ggm06		4.3	10.4	14.4
ggm09			4.6	3.6
ggm11				17.9

Table 3a: Dating evidence for the site series GRANSDEN AD 1706–1836

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD)	Overlap (years)	*t*-value
Regional Reference Chronologies						
England	South Central England	(Wilson *et al* 2012)	SCENG	663–2009	131	12.5
Hampshire	Hampshire Master Chronology	(Miles 2003)	HANTS02	443–1972	131	9.1
Southern England	Southern England Master	(Bridge 1998)	SENG98	944–1790	85	8.5
East Anglia	East Anglia Master Chronology	(Bridge 2003)	ANGLIA03	944–1789	84	7.7
Individual Site Chronologies						
Bedfordshire	Chicksands Priory	(Howard *et al* 1998)	CHKSPQ02	1611–1814	109	10.3
Leicestershire	Church Farm, Bringhurst	(Groves *et al* 2004)	BRNGHST1	1664–1781	76	10.2
Buckinghamshire	The Hovel, Ludgershall	(Miles and Worthington 1999)	THEHOVEL	1671–1811	106	9.5
Oxfordshire	Oriel College Tennis Court	(Miles and Haddon-Reece 1994)	ORIEL1	1534–1776	71	9.0
Hampshire	H.M.S. Victory	(Barefoot 1978)	VICTORY	1640–1800	95	8.5
Essex	Tilbury Fort	(Groves 1993)	TILBURY	1678–1777	72	8.5
Oxfordshire	Kiln Farm House, Upper Basildon	(Miles and Bridge 2011)	KILNFMHS	1692–1798	93	8.3
Warwickshire	Baddesley Clinton	(Miles and Worthington 2002)	BADESLY7	1711–89	79	8.2
London	White Tower, Tower of London	(Miles 2007)	WHTOWR9	1629–1782	77	8.2

Table 3b: Dating evidence for the site series ggm01 AD 1496–1619

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD)	Overlap (years)	*t*-value
Regional Reference Chronologies						
England	South Central England	(Wilson *et al* 2012)	SCENG	663–2009	124	6.4
Hampshire	Hampshire Master Chronology	(Miles 2003)	HANTS02	443–1972	124	5.8
East Anglia	East Anglia Master Chronology	(Bridge 2003)	ANGLIA03	944–1789	124	5.8
East Midlands	East Midlands Master	(Laxton and Litton 1988)	EASTMID	882–1981	124	5.2
Individual Site Chronologies						
London	White Tower, Tower of London	(Miles 2007)	WHTOWR7	1463–1616	121	6.7
Leicestershire	Church Farm, Bringhurst	(Groves *et al* 2004)	BRNGHST2	1520–1572	53	6.1
Suffolk	St Mary's Church bellframe, Cratfield	(Bridge 2008)	CRATFLD1	1503–1639	117	6.0
Oxfordshire	Wadham College	(Miles *et al* 2010)	WADHAM	1426–1610	115	5.6
Hampshire	Blaegrove Cottage, Up Nately	(Bridge *et al* 2011)	BLAEGROV	1347–1610	115	5.6
Oxfordshire	Bodleian Library	(Miles and Worthington 1999)	BDLEIAN3	1395–1610	115	5.4
Hampshire	Old Farm Cottages, Kings Worthy	(Miles *et al* 2005)	KNGWRTHY	1485–1609	114	5.3
Buckinghamshire	Boarstall Tower	(Miles and Worthington 1999)	BOARSTL2	1450–1614	119	5.2
Gloucestershire	Owlpen Manor	(Miles *et al* 2010)	OWLPEN	1424–1585	90	5.2

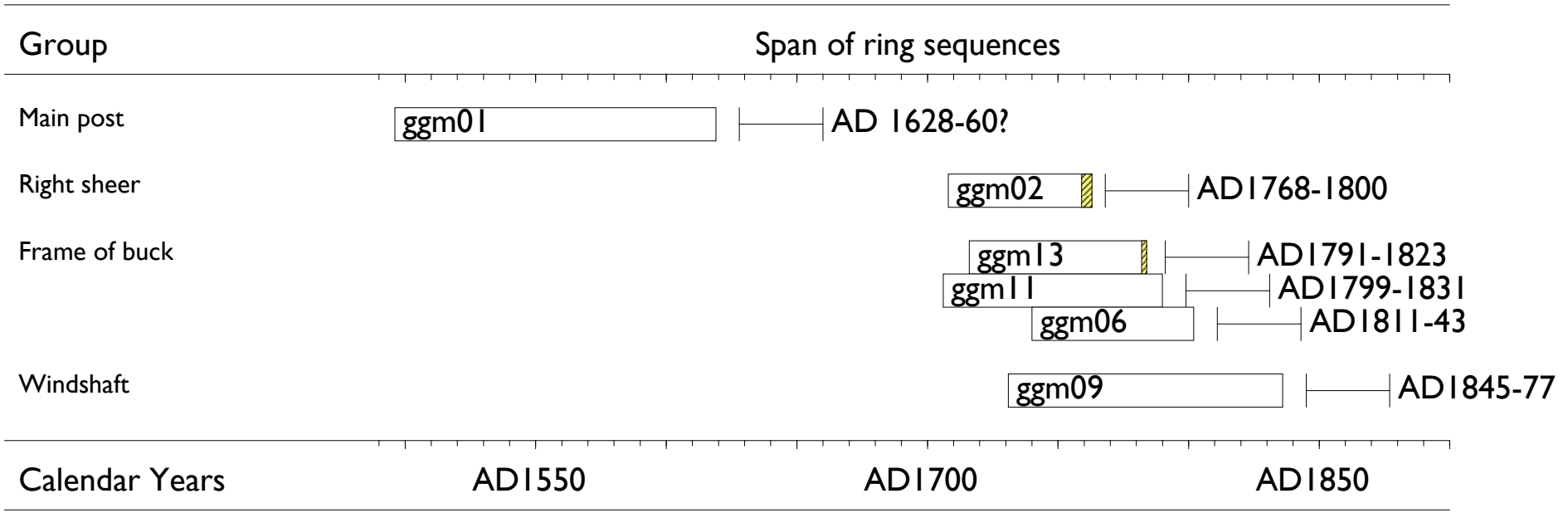

Figure 5: Bar diagram showing the relative positions of overlap of the dated timbers from Great Gransden Mill. White bars represent heartwood rings and hatched yellow sections represent sapwood rings

APPENDIX

Ring width values (0.01mm) for the sequences measured

ggm01

324	224	198	365	305	366	310	498	484	462
337	340	99	62	54	75	114	119	147	102
124	107	150	127	171	157	130	150	125	92
126	114	158	171	143	274	70	51	59	70
80	84	128	199	238	163	110	149	223	297
247	192	426	573	123	110	75	108	130	137
64	130	150	200	254	97	181	92	129	149
140	124	158	221	334	286	157	220	256	254
232	337	243	273	377	154	241	217	206	266
423	352	431	276	176	249	171	355	496	644
621	564	521	499	386	195	271	308	326	223
582	370	467	210	148	158	209	479	460	365
338	289	212	249						

ggm02

305	368	180	248	319	344	223	238	264	288
257	269	396	448	426	323	453	515	462	430
304	263	268	202	264	260	276	369	309	286
446	429	289	249	193	162	170	280	322	278
264	181	170	280	332	212	253	297	272	268
253	266	251	268	194	335				

ggm04

478	497	633	446	482	426	301	330	231	416
388	218	217	254	366	372	275	276	322	281
279	203	127	150	127	158	94	113	119	158
180	121	127	179	156	174	212	178	182	174
190	204	166	194	205	199	241	181	206	212
182	303	157	199	124	171	196	195	207	127
163	202	228	166	121	101	105	120	121	123
204	121	162	137	169	158	138	138	94	81
73	96	82	66	54	62	46	55	37	44

ggm05

276	462	681	661	547	651	450	441	697	587
484	499	443	272	402	534	686	400	248	459
550	513	315	227	323	304	253	260	279	225
220	189	285	322	177	130	223	218	303	208
196	223	201	230	153	191	249	161	219	189
269	184	169							

ggm06

80	70	108	144	132	270	381	314	144	98
176	186	342	263	246	208	283	155	105	323
242	284	169	299	211	165	251	498	501	388
326	201	165	260	331	322	354	379	267	188
133	210	357	237	332	151	123	186	231	382
240	247	166	178	98	213	238	221	225	188
122	178	203							

ggm09

120	88	86	230	336	286	253	384	289	187
204	213	240	210	348	308	327	175	137	172
223	209	172	324	242	276	193	267	210	241
245	202	393	310	214	268	274	292	232	241
220	152	209	243	260	245	295	202	194	213
156	216	194	220	131	121	130	140	184	158
151	250	156	169	212	172	211	144	136	130
127	108	136	162	192	165	193	142	121	133
132	167	178	163	158	153	166	139	165	135
161	151	181	136	129	138	119	139	181	159
152	141	151	159	133	153				

ggm10

124	154	172	164	222	238	287	304	242	284
314	383	455	465	402	227	197	171	218	286
316	369	314	291	179	127	77	139	105	254
340	205	155	125	145	117	179	168	117	162
139	186	129	158						

ggm11

220	234	277	249	203	222	346	516	181	257
247	215	126	88	130	219	210	122	151	213
182	131	320	262	275	220	205	145	110	270
232	172	299	215	97	47	100	85	108	226
323	295	133	91	112	200	216	150	128	156
152	113	81	150	150	189	110	146	110	104
124	241	314	213	163	92	70	152	156	169
149	170	148	76	65	109	130	129	117	70
42	42	65	113	99					

ggm13

242	256	186	140	182	288	333	143	184	218
154	115	282	295	253	241	236	176	129	264
281	204	302	299	116	80	105	113	136	245
315	318	141	97	135	239	310	210	187	131
168	122	85	267	231	203	143	181	116	115
127	320	428	335	277	146	107	196	292	276
278	280	198	109	85	130	245	136	171	

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