Ancient Monuments Laboratory
Report 25/98

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Summary

Cann Hall, Clacton, Essex, is a two-storey timber-framed house surrounded by modern residential development on the north-west edge of Clacton. It has a large two-bay hall which is aligned east-west, an in-line service end to the east, and an upper-end cross-wing to the west which projects to the north. To the north of this main block are the fragmentary remains of a further timber-framed building, interpreted as a detached kitchen; this is now attached to the cross-wing by later modifications. Dendrochronological analysis of thirty-six timbers from the hall and service range, the cross-wing, and the kitchen range produced a tree-ring chronology for the period AD 1301-1511. The latest timbers were felled in the winter/spring of AD 1511/12.

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Introduction

This document is a technical archive report on the tree-ring analysis of timbers from Cann Hall, Clacton (NGR TM166167). It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. As part of a multifaceted and multidisciplinary study of the building, elements of this report may be combined with detailed descriptions, drawings, and other technical reports at some point in the future to form either a comprehensive publication or an archive deposition on the building. The conclusions presented here may therefore have to be modified in the light of subsequent work.

Cann Hall, is a two-storey timber-framed house with a long and imposing combined hall and in-line service range which has a cross-wing that only projects to the rear (Fig 1). There are also fragmentary remains of a further timber-framed structure that is currently thought to have been a detached kitchen block. The building is on the former estate of the nearby St Osyth's Priory, suppressed in the dissolution of AD 1539. It is thought that the property remained first with Thomas Cromwell, then Princess Mary, until AD 1553 when it passed to Lord Darcy. Stylistically the hall and service range is thought to date to the second quarter of the sixteenth century, with some of the decoration suggesting a pre-dissolution date. The cross-wing is thought to be either contemporary or nearly contemporary with the hall and service range, whilst the kitchen block may be either contemporary or slightly earlier.

The property is owned by an absentee landlord; it has been boarded up for some years but is now the victim of increased vandalism from the surrounding housing estates. The long term survival of the property has become the subject of great concern to both Essex County Council (ECC) and Tendring District Council (TDC), as well as to English Heritage (EH) and the Royal Commission on the Historical Monuments of England (RCHME). The property has been recently surveyed by RCHME (Menuge 1997), and is the subject of a listing proposal to the Department of Culture, Media and Sports. The dendrochronological analysis, funded by EH, was requested by the local EH inspector, Andrew Derrick, to help inform the listing advice.

The aims of the analysis were as agreed on-site with Andrew Derrick and are as follows:

1. to determine the construction date of the hall and service range; this range is thought to be of a single build,
2. to determine whether the cross-wing is contemporary with the hall and service range or whether it is a later addition,

3. to provide dating evidence to assist in the interpretation of the possible kitchen block; this is potentially a very rare survival and therefore important to the understanding of the building as a whole.

Methodology

A brief survey identified those timbers with the most suitable ring sequences for analysis and allowed a sampling strategy to be formulated. This was discussed briefly with Andrew Derrick on the day of sampling. Those timbers of oak (*Quercus* spp.), or other dendrochronologically viable species, with more than 50 annual rings and some survival of the original sapwood and bark-edge were sought.

The most promising timbers were sampled using a 15mm diameter corer attached to an electric drill. The absence of electrical services to the building required the provision of electricity by portable generator. The cores were taken from the timbers in the most suitable direction for maximising the numbers of rings for subsequent analysis. The core holes were left open. The ring sequences in the cores were revealed by sanding.

The complete sequences of growth rings in the samples that were selected for dating purposes were measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The ring sequences were plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition cross-correlation algorithms (Baillie and Pilcher 1973; Munro 1984) were employed to search for positions where the ring sequences were highly correlated. These positions were checked using the graphs and, where these were satisfactory, new mean sequences were constructed from the synchronised sequences. The *t*-values reported below are derived from the original CROS algorithm (Baillie and Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative or absolute position must be obtained from a range of independent sequences, and that these positions are supported by satisfactory visual matching (Baillie 1982).

All the measured sequences from this assemblage were compared with each other and any found to cross-match were combined to form a site master curve. These, and any remaining unmatched ring sequences, were tested against a range of reference chronologies, using the same matching criteria: high *t*-values, replicated values against a range of chronologies at the same position, and satisfactory visual matching. Where such positions are found calendar dates can be assigned to the ring sequence.

The tree-ring dates produced by this process initially date only the rings present in the timber. The interpretation of these dates relies upon the nature of the final rings in the sequence. If the sample ends in the heartwood of the original tree, a *terminus post quem (tpq)* for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of missing sapwood rings. This *tpq* is the earliest possible felling date, but it may be decades prior to the real felling date depending on how many heartwood rings were removed during timber conversion. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a felling date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimates applied throughout this report are a minimum of 10 and maximum of 55 annual rings, where these figures indicate the 95% confidence limits of the range. These figures are applicable to oaks from the British Isles (Hillam *et al* 1987). If bark edge survives, then a felling date can be directly utilised from the date of the last surviving ring. It is sometimes possible to distinguish between either late-summer/winter felling or late-spring/early-summer felling on the basis of the completeness of the final ring: the former has a complete ring, the latter is incomplete.

The dates obtained by the technique do not by themselves necessarily indicate the date of the structure from which they are derived. It is necessary to incorporate other specialist evidence concerning the reuse of timbers and/or repairs to the structure before the dendrochronological dates can be reliably interpreted as reflecting the construction date of phases within the structure.

A further important element of the tree-ring analysis of buildings and archaeological assemblages is the identification of 'same-tree' groups within the sampled material. Inspection of *in-situ* timbers often suggests that the patterns of knots or branching in timbers are so similar that they appear to be derived from a single tree. Tree-ring analysis is often used to support these suggestions. The identification of 'same-tree' groups is based on a combination of high levels of matching between samples and extremely similar longer term growth trends or anatomical anomalies within the timbers. Timbers originally derived from the same parent log generally have t-values of greater than 10.0, though lower t-values do not necessarily exclude the possibility. It is the balance of a range of information that provides the link.

Results

Cann Hall is the eastern most building to be analysed in Essex, a county notorious for its problems as far as dendrochronological analyses are concerned (see eg Tyers 1996a, 1997a). In order to overcome these potential problems a relatively extensive sampling program was undertaken. A total of 36 timbers were selected for sampling from the three groups of timbers identified as important to the understanding of the building. Descriptions of the samples and their locations are provided in Table 1 and Figs 1-3; all the sampled timbers except one were oak (*Quercus* spp.). As is common with medieval oak timbers the sapwood was prone to disintegration and several cores lost some or all of the sapwood; several samples also broke or hit unexpected voids.

Hall and Service range

In the hall and service range the dendrochronological sampling programme focused upon the roof trusses and the jowled upper ends of the storey posts. These types of structural elements either contained long ring sequences, vital for producing a long well-replicated site chronology, and/or showed good sapwood and bark edge survival, vital for producing precise felling dates. The elaborate decoration of the ceiling joists at ground-floor level in the hall meant that all of the sapwood had been removed. Coring of these elements would have to have been at the point of decoration and, as these were unlikely to add any additional information, sampling was in this instance not felt to be justified.

Twenty samples were from this range, comprising two jack rafters, ten rafters, two crown posts, a collar, two tie-beams, and three storey posts. These samples were labelled **1** to **15** and **30** to **34** (Table 1a; Figs 1, 2). Samples **7** and **8** from hall/service range rafters had too few rings (see Table 1). Seventeen of the measured sequences were found to match (Table 2) and combined to form a 211-year master curve for the hall/service range.

Cross-wing

In the cross-wing the dendrochronological sampling programme again focused upon the roof trusses and the jowled upper ends of the storey posts, for the same reasons as those outlined for the hall/service wing. Eleven timbers were selected, comprising six rafters, both crown posts, the collar purlin (or crown plate, see Alcock *et al* 1996) and two storey posts. These samples were labelled **16** to **24** and **35** to **36** (Table 1b; Figs 1, 2). Sample **24** from a cross-wing rafter had too few rings, whilst sample **35** from a storey post was badly fragmented due to cracks within the timber (see Table 1). Seven of the measured sequences were found to match (Table 2) and combined to form a 185-year master curve for the cross-wing.

Kitchen

The timbers in the kitchen range identified as potentially part of the early structure consisted of two rails, both with relict stud housings and a series of ceiling joists. Most of these were clearly borderline as far as the minimum number of rings required were concerned, and in this area the sapwood survival was poor. However the potential importance of this range to the understanding of the building meant that both the rails and a two of the joists were selected for sampling. These samples were labelled **25** to **28** (Table 1c; Fig 3). In addition joist **29** was sampled for species identification as it was clearly not an oak timber. Both the kitchen rails, samples **25** and **26,** proved to have insufficient rings (see Table 1), whilst joist sample **28** fragmented badly, and joist sample **29** was elm (*Ulmus* spp.). Only one core, **27,** was suitable for measurement.

The hall/service wing master and the cross-wing master match extremely well (t = 17.7), whilst sample **27** matches both site masters (t = 4.6; 3.6). As a result all twenty five sequences were combined to form a single 211-year master curve, CANNHALL. This was tested against a comprehensive collection of dated tree-ring chronologies from England in an attempt to identify a date for the sequence. It was immediately apparent that the master sequence dates to AD 1301 - AD 1511 inclusive (Table 3). The ring sequence from this master is listed in Table 4. The remaining measured samples **10** and **19** have failed to produce any visually and statistically acceptable matches and are thus undated by the analysis. A broken section in sample **21** prevented the entire sequence from this core being measured. However the two sections were measured and matched independently, both visually and statistically (Table 2, inner section **21a**, outer section **21b**). Only the longer inner section is included in the master.

Interpretation

The bark-edges of the trees were successfully sampled on seven of the dated timbers. Sapwood was present on a further five of the dated samples and the heartwood-sapwood transition on another five (Fig 4). The range of heartwood-sapwood transitions is consistent with a group of timbers which were felled at the same time (Baillie 1982, 57), indicating that they were all probably contemporary. Two samples with bark-edge both exhibit an apparently complete ring for AD 1510 and thus the felling of this material took place in the dormant period between late summer AD 1510 and the early spring of AD 1511. One of these was from the hall/service range (rafter sample **12**) and the other was from the cross-wing (rafter sample **23**). By contrast five other samples with bark-edge exhibit an apparently complete ring for AD 1511 and thus the felling of this material took place in the dormant period between late summer AD 1511 and the early spring of AD 1512. Three of these samples were from the hall/service range (jack rafter sample **1** and rafter samples **2** and **7**) and two were from the cross-wing (rafter samples **16** and **21**).

The widespread presence of the AD 1511 material throughout the roofs of both parts of the main building implies the completion of the roofing of the hall/service range and cross-wing occurred simultaneously, using a common stockpile of timbers at this point or shortly afterwards. It therefore seems likely that the entire hall/service and cross-wing are the product of a single campaign of construction. The presence of trees of very similar origin (if not actually derived from the same trees) in both parts (samples **1**, **5**, and **22** provide one such group) also supports the hypothesis. Clearly the analysis demonstrates the hall/service and cross-wing are of pre-dissolution origin, and a quarter-century earlier than the interpretation favoured by Menuge (1997). The single date obtained for a joist from the kitchen is more difficult to interpret satisfactorily. This sample, **27**, includes some sapwood and ends at AD1505. Sampling notes indicate a small outer band of sapwood was lost during coring and thus it seems reasonable to assume this sample was felled at about the same time as the other dated material. However, the presence of at least one re-used joist in the ceiling and at least one elm joist may indicate that this structure has been disturbed during later modifications and that the date of this joist may not truly reflect the construction date of the kitchen block.

There are a number of interesting aspects to the results obtained. The material is derived from trees of great age. Eighteen cores include more than 100 rings and the tree-ring sequence of 211 years is remarkably long for a single phase Essex building. The extensive use of large trees cut into quartered sections, although widespread in the larger elements at Cann Hall, is not usual in medieval structures (Rackham 1990, 67). It seems particularly unusual here since the scantling required for the roof structure is not exceptionally large and much smaller trees could easily have been used. Many of the rafters in particular appear to be sub-sections of much larger trees. There are some markedly slow grown sequences of rings within the material derived from the longer lived trees, perhaps indicating that the woodland management regime of the St Osyth's estates went through some sort of crisis in the later fourteenth century. There are clear indications that several different sources of timber are present in the building. This is perhaps most easily demonstrated by the presence of two felling phases. It is possible that the rafters include some offcuts from the decorated or principal timbers which were felled a year earlier at the inception of the building program, and it was only once the decoration was completed that a second group of trees were felled to complete the roof structure. These observations suggest that from a timber supply point of view Cann Hall may warrant further study. Additionally the remarkably complete and unaltered structure, and level of decoration of the building, yields an opportunity to examine an unusual assemblage of features such as the early example of soffit tenons with diminished haunches (Dave Stenning pers comm). Clearly, now that precise dating evidence is available, the understanding of the building could be enhanced by further recording and a detailed documentary search.

Finally, the tree-ring sequence produced is long, well replicated and unusually 'eastern' in character. The sequence provides highly significant matches only with material from south-eastern England (Essex and Kent particularly) and other East Anglian counties (Table 3). There is little significant matching beyond this region, although there is also some good cross-matching to French regional master sequences.

Conclusion

The dendrochronological analysis of timbers from Cann Hall convincingly demonstrates that the hall/service range and the cross-wing were constructed at the same time, probably using a common stock of trees. Since it is normal practise in dendrochronological analysis to assume medieval timbers were usually felled as required and used green (Rackham 1990, 69), the completion of the roof of this structure appears to be dated to the latter half of AD 1511 or early part of AD 1512. The results from the kitchen block are less useful. A single joist is presumed here to be of the same phase of construction, but whether this is the date of the structure or the date of a modification or repair to the structure is not clear without further structural analyses by vernacular buildings specialists.

Acknowledgements

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Figure 1

First floor plan of Cann Hall, after Menuge 1997 (Crown copyright), scale approx 1:110
The Kitchen Range is north of the Cross-wing, this plan also shows the location of samples 30-36 inclusive.

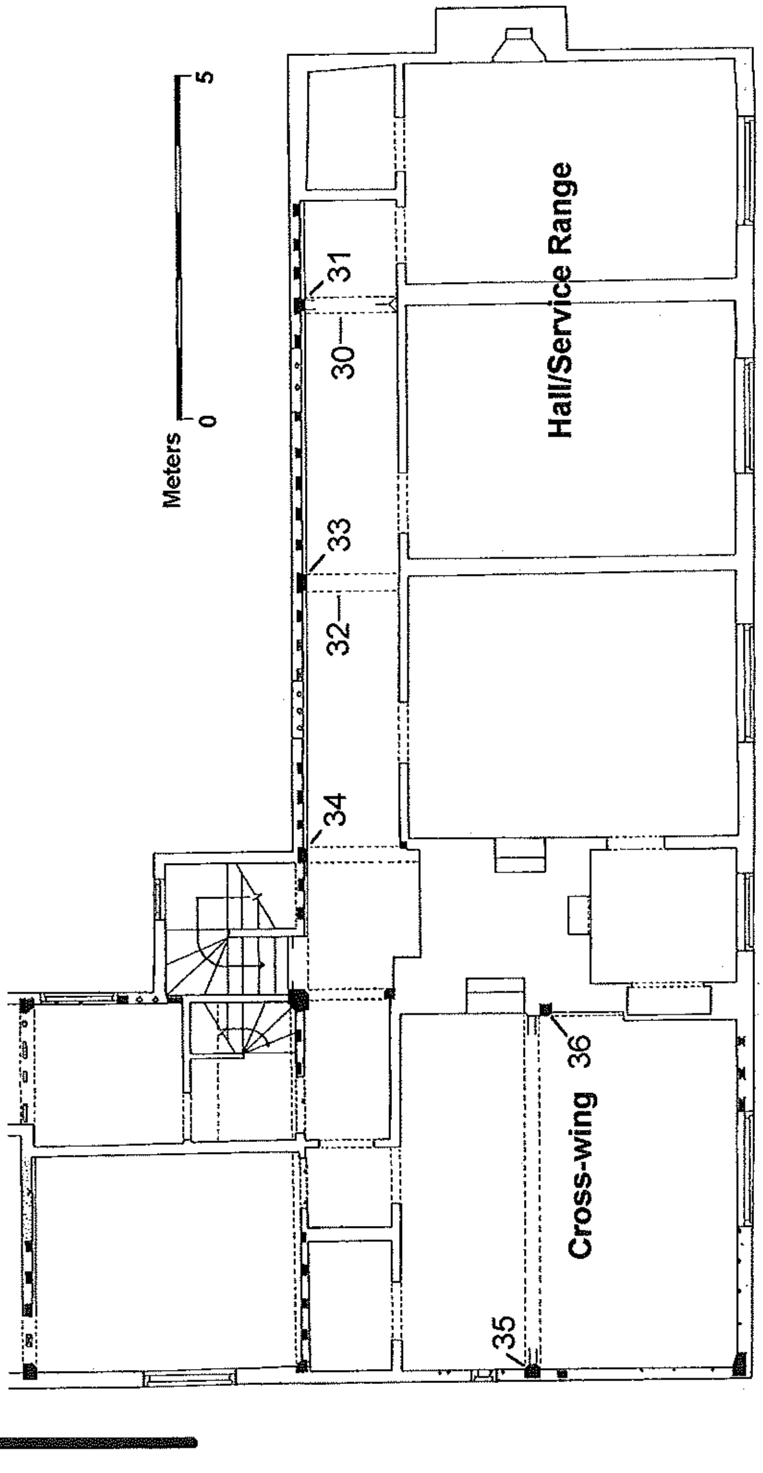

Figure 2

Sketch plan of the Hall/Service Range and Cross-wing rafters. No measured roof plans were made available during sampling. This is a sketch plan and is not intended to be an accurate representation of the rafter positions. This plan shows the approximate location of samples 1-24 inclusive

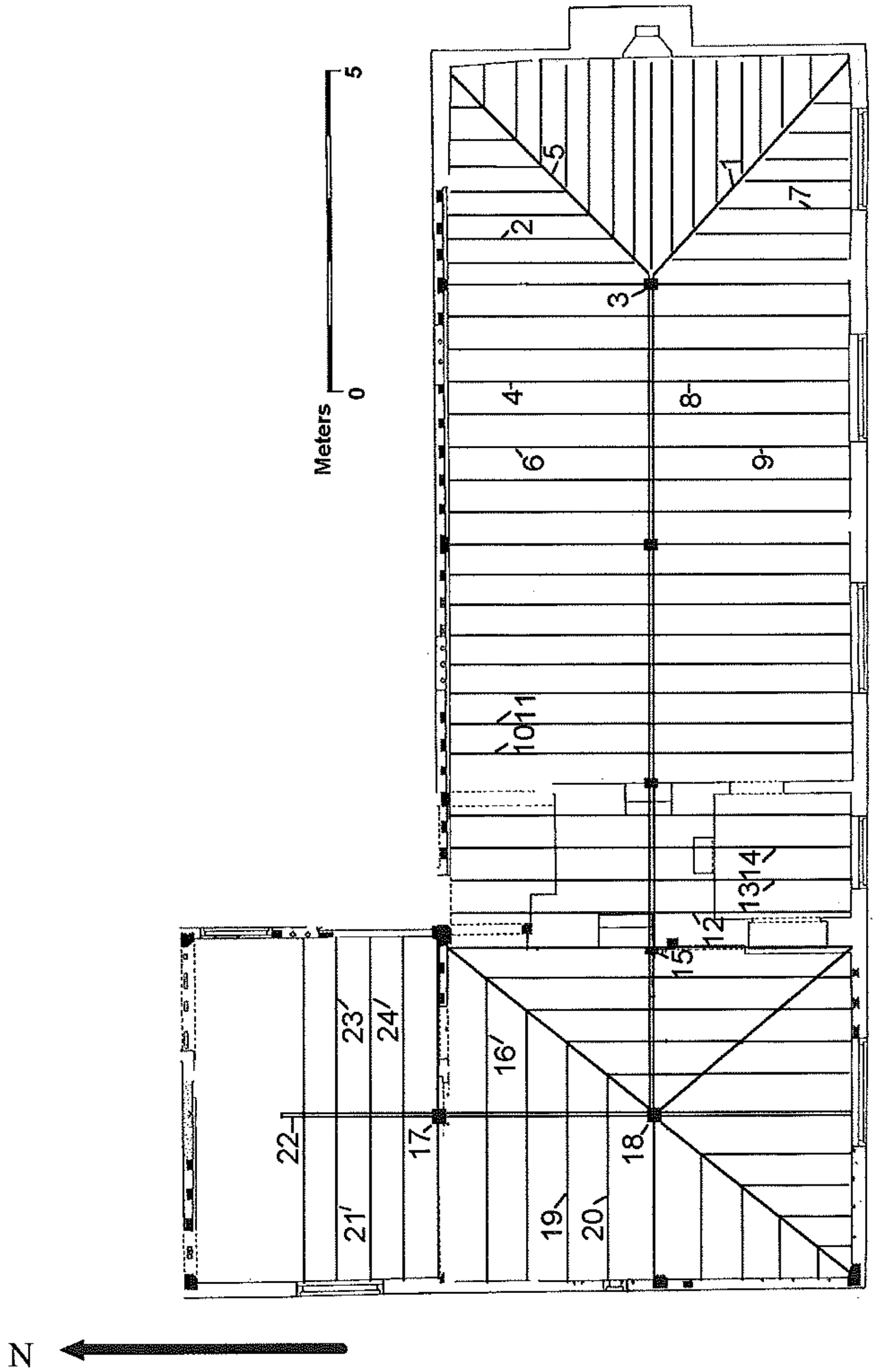

Figure 3

Sketch plan of the Kitchen Range rails and joists. This sketch is not intended to be an accurate representation of the joist positions. This plan shows the approximate location of samples 25-29 inclusive

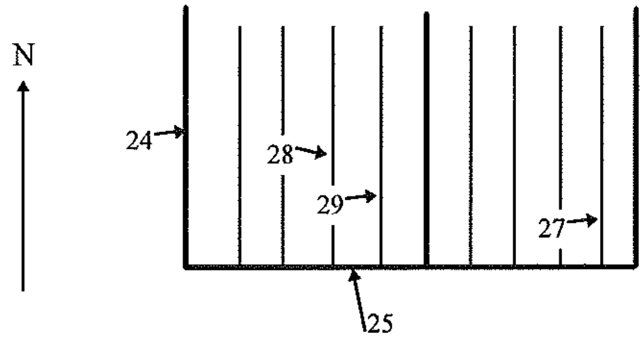

Figure 4

Bar diagram showing the position of the dated sequences; where necessary the interpretations are based on the 10-55 sapwood estimate (Hillam *et al* 1987).

White bars - heartwood rings
Hatching - sapwood rings
narrow bar - broken core lost rings

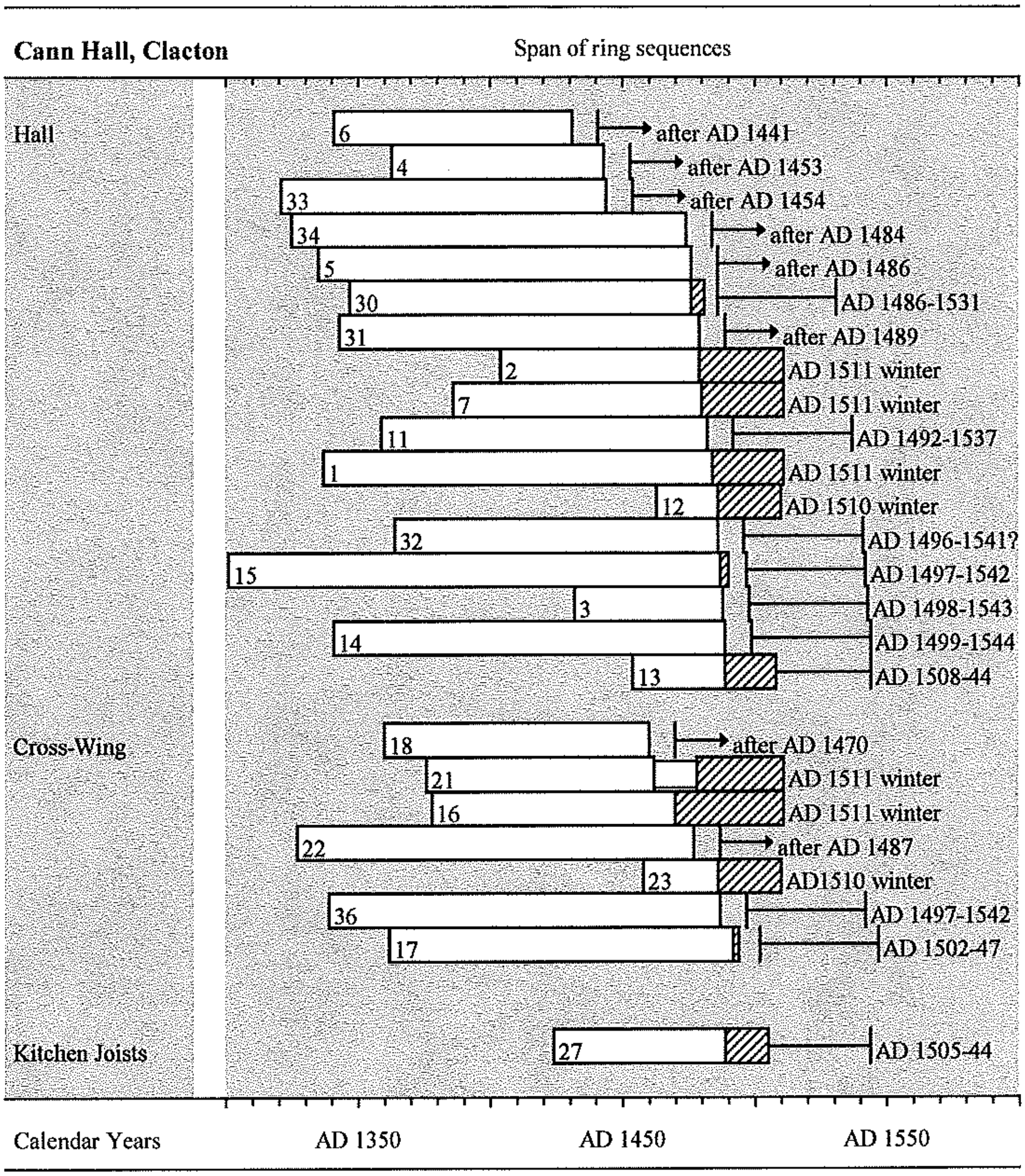

Table 1

a. List of samples from the Hall/Service Range at Cann Hall

Area	Sample	Origin	Species	No. of rings	Sapwood	Date of sequence	Growth rate (mm/year)	Felled
Hall/ Service Range	1	SE jack rafter	oak	175	27 sap + bark-edge	AD 1337 - 1511	0.90	AD 1511/12 winter
	2	N rafter	oak	108	32 sap + bark-edge	AD 1404 - 1511	0.96	AD 1511/12 winter
	3	E crown post	oak	57	heart/sap boundary	AD 1432 - 1488	2.16	AD 1498 - 1543
	4	N rafter	oak	81	-	AD 1363 - 1443	1.22	after AD 1453
	5	NE jack rafter	oak	142	-	AD 1335 - 1476	0.91	after AD 1486
	6	N rafter	oak	91	-	AD 1341 - 1431	1.28	after AD 1441
	7	S rafter	oak	126	31 sap + bark-edge	AD 1386 - 1511	1.07	AD 1511/12 winter
	8	collar	oak	too few rings	-	-	-	-
	9	S rafter	oak	too few rings	-	-	-	-
	10	N rafter	oak	79	?heart/sap boundary	undated	1.45	-
	11	N rafter	oak	124	heart/sap boundary	AD 1359 - 1482	1.08	AD 1492 - 1537
	12	S rafter	oak	48	24 sap + bark-edge	AD 1463 - 1510	1.78	AD 1510/11 winter
	13	S rafter	oak	55	19 sap	AD 1454 - 1508	1.83	AD 1508-44
	14	S rafter	oak	149	heart/sap boundary	AD 1341 - 1489	0.75	AD 1499 - 1544
	15	W crown post	oak	190	3 sap	AD 1301 - 1490	1.13	AD 1497 - 1542
	30	E tiebeam	oak	135	5 sap	AD 1347 - 1481	1.35	AD 1486 - 1531
	31	NE storey post	oak	137	-	AD 1343 - 1479	1.10	after AD 1489
	32	central tiebeam	oak	123	?heart/sap boundary	AD 1364 - 1486	2.03	AD 1496 - 1541?
	33	N central storey post	oak	124	-	AD 1321 - 1444	1.42	after AD 1454
	34	NW storey post	oak	150	-	AD 1325 - 1474	1.47	after AD 1484

b. List of samples from the Cross-wing at Cann Hall

Area	Sample	Origin	Species	No. of rings	Sapwood	Date of sequence	Growth rate (mm/year)	Felled
Cross-wing	16	E rafter	oak	134	41 sap + bark-edge	AD 1378 - 1511	0.91	AD 1511/12 winter
	17	N crown post	oak	133	2 sap	AD 1362 - 1494	1.22	AD 1502 - 47
	18	S crown post	oak	101	-	AD 1360 - 1460	1.23	after AD 1470
	19	W rafter	oak	60	-	undated	1.21	-
	20	W rafter	oak	too few rings	-	-	-	-
	21a	W rafter - inner	oak	87	-	AD 1376 - 1462	0.81	-
	21b	W rafter - outer	oak	33	33 sap + bark-edge	AD 1479 - 1511	0.77	AD 1511/12 winter
	22	collar purlin	oak	151	-	AD 1327 - 1477	0.91	after AD 1487
	23	E rafter	oak	53	24 sap + bark-edge	AD 1458 - 1510	1.51	AD 1510/11 winter
	24	E rafter	oak	too few rings				-
	35	W storey post	oak	too few rings				-
	36	E storey post	oak	149	heart/sap boundary	AD 1339 - 1487	1.00	AD 1497 - 1542

c. List of samples from the Kitchen at Cann Hall

Area	Sample	Origin	Species	No. of rings	Sapwood	Date of sequence	Growth rate (mm/year)	Felled
Kitchen	25	south rail	oak	too few rings	-	-	-	-
	26	west rail	oak	too few rings	-	-	-	-
	27	joist	oak	82	16 sap	AD 1424 - 1505	1.72	AD 1505 - 44
	28	joist	oak	too few rings	-	-	-	-
	29	joist	elm	too few rings	-	-	-	-

t-value matrix for the matching sequences, arranged by the area of the building the sample was derived from. Values less than 3.0 are not given.
NB The outer section of **21** is not included in the site master.

\ = overlap < 15 years
bold = same tree

Area		Hall/Service Range																Cross-wing								Kitchen
Sample		02	03	04	05	06	07	11	12	13	14	15	30	31	32	33	34	16	17	18	21a	21b	22	23	36	27
	01	3.22	3.03	4.22	**15.66**	9.95	-	5.90	-	4.03	8.02	7.43	7.99	8.83	5.77	6.96	7.84	5.35	3.83	5.93	4.01	-	9.43	3.64	6.13	-
	02		6.46	4.97	4.60	-	9.20	7.62	8.06	3.98	4.45	-	5.77	3.26	3.36	-	3.33	5.24	3.24	3.71	3.70	3.16	-	4.57	4.62	4.76
	03			\	-	\	4.21	5.76	6.04	6.88	5.64	-	5.19	4.33	4.44	\	3.43	4.49	3.56	3.90	-	\	-	9.07	6.27	4.02
	04				4.40	7.78	4.82	8.17	\	\	4.49	5.41	3.51	4.57	3.37	-	4.59	3.85	3.24	3.74	4.53	\	4.79	\	6.50	-
	05					9.81	-	6.48	\	-	8.62	6.80	7.72	10.50	5.94	6.90	10.66	4.36	4.84	5.19	3.70	\	10.25	-	5.41	-
	06						3.86	**12.00**	\	\	6.75	5.36	5.45	8.00	3.24	5.55	8.97	4.54	4.07	4.97	5.94	\	8.80	\	6.55	\
Hall/	07							5.38	5.70	3.34	4.00	-	3.06	3.12	-	-	-	5.05	3.68	-	4.87	3.04	-	4.91	-	4.52
Service	11								-	-	6.62	6.99	7.16	7.00	5.15	4.11	8.06	5.49	4.91	5.91	6.79	\	6.13	3.02	6.10	-
Range	12									6.25	3.81	-	-	-	-	\	\	3.04	-	\	\	3.58	-	8.50	-	3.44
	13										4.50	3.67	3.60	-	-	\	3.42	3.19	3.24	\	\	3.56	-	9.45	4.68	-
	14											5.91	7.23	11.28	4.72	5.49	7.75	4.22	4.91	-	4.75	\	7.78	4.12	5.61	-
	15												5.66	8.57	4.93	6.19	7.17	4.16	6.59	3.10	4.36	\	8.09	-	3.60	-
	30													7.63	8.29	6.48	7.37	4.69	-	4.44	5.31	\	6.12	-	4.03	3.43
	31														5.18	5.58	8.42	4.41	6.67	3.54	4.75	\	3.92	-	4.07	-
	32															3.63	5.35	3.76	-	4.44	4.14	\	6.06	-	3.04	-
	33																6.68	-	4.58	3.19	-	\	8.16	\	-	-
	34																	4.49	4.25	3.85	-	\	10.51	-	4.41	-
	16																		4.92	5.17	8.18	3.60	5.59	3.81	4.33	-
	17																			3.12	4.14	\	5.57	-	3.41	-
	18																				3.57	\	5.74	\	6.07	-
Cross	21a																					\	5.02	\	3.46	-
-wing	21b																						\	3.31	\	-
	22																							4.56	4.40	-
	23																								4.17	3.31
	36																									3.26

Table 3

Dating the CANNHALL chronology, AD 1301-1511. *t*-values with independent reference chronologies.

Area	Reference chronology	*t*-values
Berkshire	Windsor Castle Kitchen, AD 1331-1573 (Hillam forthcoming)	5.26
Essex	Harlow, Netteswellbury Barn, AD 1245-1439 (Tyers 1997a)	7.09
	Little Totham Church, AD 1380-1517 (Tyers 1996a)	5.82
	Woodham Walter Church, AD 1276-1372 (Tyers 1996a)	7.11
Kent	Kent Master, AD 1158-1540 (Laxton and Litton 1989)	8.79
	Deal, Walmer Castle, AD 1396-1523 (Howard *et al* 1997)	7.83
London	Eastbury Manor, AD 1250-1565 (Tyers 1997b)	6.42
	Upminster Tithe Barn, AD 1276-1414 (Tyers 1997c)	6.85
	Hays Wharf, AD 1248-1647 (Tyers 1996b and c)	10.01
	Sutton House, AD 1319-1534 (Tyers 1991)	8.32
	Trig Lane, AD 1130-1407 (Tyers 1992)	6.73
Norfolk	Kings Lynn, St George, AD1309-97 (Tyers 1996d)	6.67
	Norwich, Dragon Hall, AD 1289-1426 (Boswijk and Tyers 1998)	5.81
Surrey	Wanborough Barn, AD 1233-1388 (Tyers 1997d)	6.64

Table 4

Ring-width data from site master CANNHALL, dated AD 1301-1511 inclusive

Date	Ring widths (0.01mm)										No of samples									
AD 1301	473	333	254	239	222	179	326	226	208	256	1	1	1	1	1	1	1	1	1	1
	191	223	276	267	289	199	182	141	124	75	1	1	1	1	1	1	1	1	1	1
	186	220	164	133	136	106	201	216	303	195	2	2	2	2	3	3	4	4	4	4
	137	106	130	196	226	157	102	80	152	207	4	4	4	4	5	5	6	6	7	7
	173	171	119	133	220	184	209	140	114	182	9	9	10	10	10	10	11	11	11	11
AD 1351	241	133	149	113	99	131	169	111	111	110	11	11	11	11	11	11	11	11	12	13
	73	81	168	152	128	106	78	117	161	169	13	14	15	16	16	16	16	16	16	16
	113	126	81	71	87	98	112	122	104	123	16	16	16	16	16	17	17	18	18	18
	129	113	95	75	102	123	105	132	96	77	18	18	18	18	18	19	19	19	19	19
	81	81	92	90	88	89	83	118	108	104	19	19	19	19	19	19	19	19	19	19
AD 1401	117	108	101	169	159	148	95	121	128	145	19	19	19	20	20	20	20	20	20	20
	151	139	107	85	81	79	90	88	95	111	20	20	20	20	20	20	20	20	20	20
	144	94	118	117	90	85	94	105	125	110	20	20	20	21	21	21	21	21	21	21
	126	152	108	76	97	86	124	134	120	124	21	21	21	21	21	21	21	21	21	21
	113	113	113	96	94	94	92	95	124	112	21	21	21	20	19	19	19	19	19	19
AD 1451	101	108	95	119	127	123	110	115	109	138	19	19	19	20	20	20	20	21	21	21
	135	136	120	111	146	124	93	107	127	162	20	20	20	20	20	20	20	20	20	20
	132	125	114	116	136	109	104	109	138	134	20	20	20	20	19	19	18	17	17	16
	206	144	122	126	107	133	176	163	134	132	16	15	14	14	14	14	13	12	11	10
	132	116	140	164	132	190	150	119	134	124	9	9	9	9	8	8	8	8	8	8
AD 1501	117	104	99	122	144	147	118	101	94	79	8	8	8	8	8	7	7	7	6	6
	61										4									