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TREE RING ANALYSIS OF TIMBERS  
FROM HILL HALL, THEYDON MOUNT,  
ESSEX

M C Bridge

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Summary

This large country house is known to have been built by Thomas Smith, Secretary of State to Elizabeth I, between AD 1569- 1575, although the exact sequence of building remained uncertain. A north-west wing was added later, and its date had been the subject of some conjecture, its unusual curved principal rafters being rare in the region. The dendrochronological study has provided a date for the felling of timbers used in the north range of the house to the period AD 1564-1580, thus apparently ruling out a possible earlier date of AD 1557-8 derived from some documentary references, though one timber did have an earlier date (felled AD 1546). The roof of the north-west wing was found to date to the period AD 1683- 1701, over a century later than had previously been suggested.

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## TREE-RING ANALYSIS OF TIMBERS FROM HILL HALL, THEYDON MOUNT, ESSEX

### **Introduction**

Hill Hall (NGR TQ 488995) is a large country house consisting of four ranges surrounding a square open courtyard, with an additional range to the north-west. The property was extensively damaged by fire in AD 1969, but at the time of writing it was being recorded before major development. The building has been much studied in the past and much of its development has been documented in previous articles (eg Pevsner 1955; Drury 1983). The former importance of the building can be judged by its description as a landmark in the introduction of Renaissance forms into English architecture (Department of Culture, Media, and Sport 1997) and the fact that it was built by Sir Thomas Smith, Secretary of State to Elizabeth I, and ambassador to France.

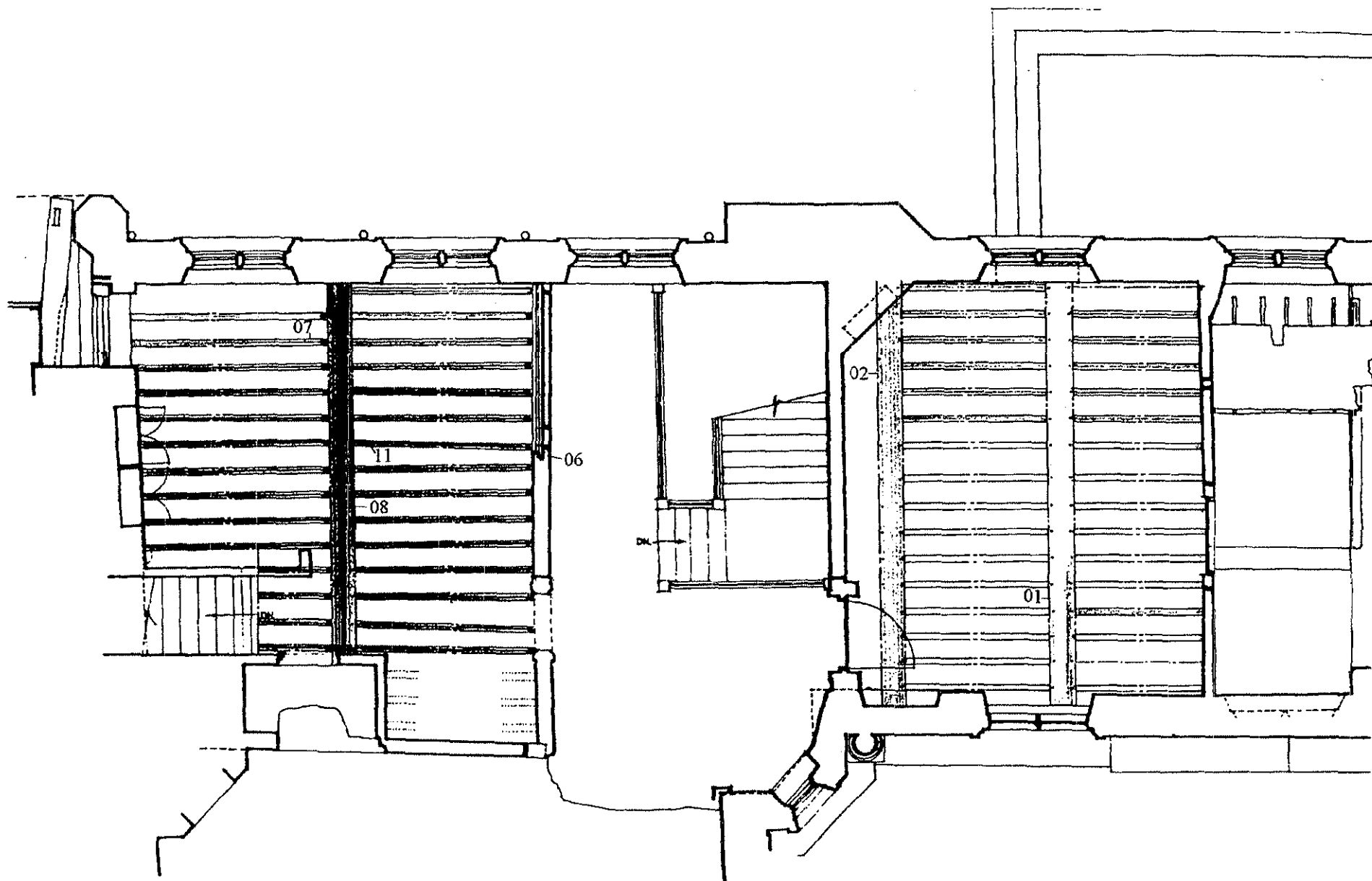
It is not appropriate in this report to enter into the complex discussion about the dating of all the various components of the house, this has been discussed elsewhere (Drury 1983) and an updated analysis, of which this study will form a small but important part, will follow in due course. The development of the main body of the house is known to have taken place between AD 1557 and 1581, with as many as five possible phases suggested. The date of the north-west range was unclear but was thought likely to belong to the latter part of this period. Secondary elements in the north-west wing had also been recognised. The north and west ranges were thought to date from AD 1568-1569, although an AD 1557-8 date was thought possible, and the south and east ranges were ascribed to AD 1573 (Drury 1983). It was also thought that some timbers in these various phases could have been reused from previous phases, making the investigation more complex.

The dendrochronological dating reported here was requested by English Heritage as part of the much wider multi-disciplinary recording exercise. Its purpose was to try and confirm the dating of the various ranges previously deduced from the structural sequence and documentary evidence, and to establish a more precise date for the north-west wing. As these phases were thought to differ in age by only a decade or so, it was clear from the outset of this study that timbers with full or extensive sapwood survival would be of most use in trying to distinguish individual phases.

### **Methodology**

The site was visited in December 1998, when the timbers were assessed for their potential use in dendrochronological study.

Core samples were obtained 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 prepared for measuring by sanding using an electric belt-sander with progressively finer grit papers down to 400 grit. Any further preparation necessary, eg where bands of narrow rings occurred, was done manually. Only samples with more than 45-50 rings were measured and used in subsequent analyses as sequences with fewer than this number of rings rarely give reliable crossmatching. Suitable samples had their tree-ring sequences measured to an accuracy of 0.01 mm using a specially constructed system utilizing a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to an Atari desktop computer. The software used in measuring and subsequent analysis was written by Ian Tyers (pers comm 1992).



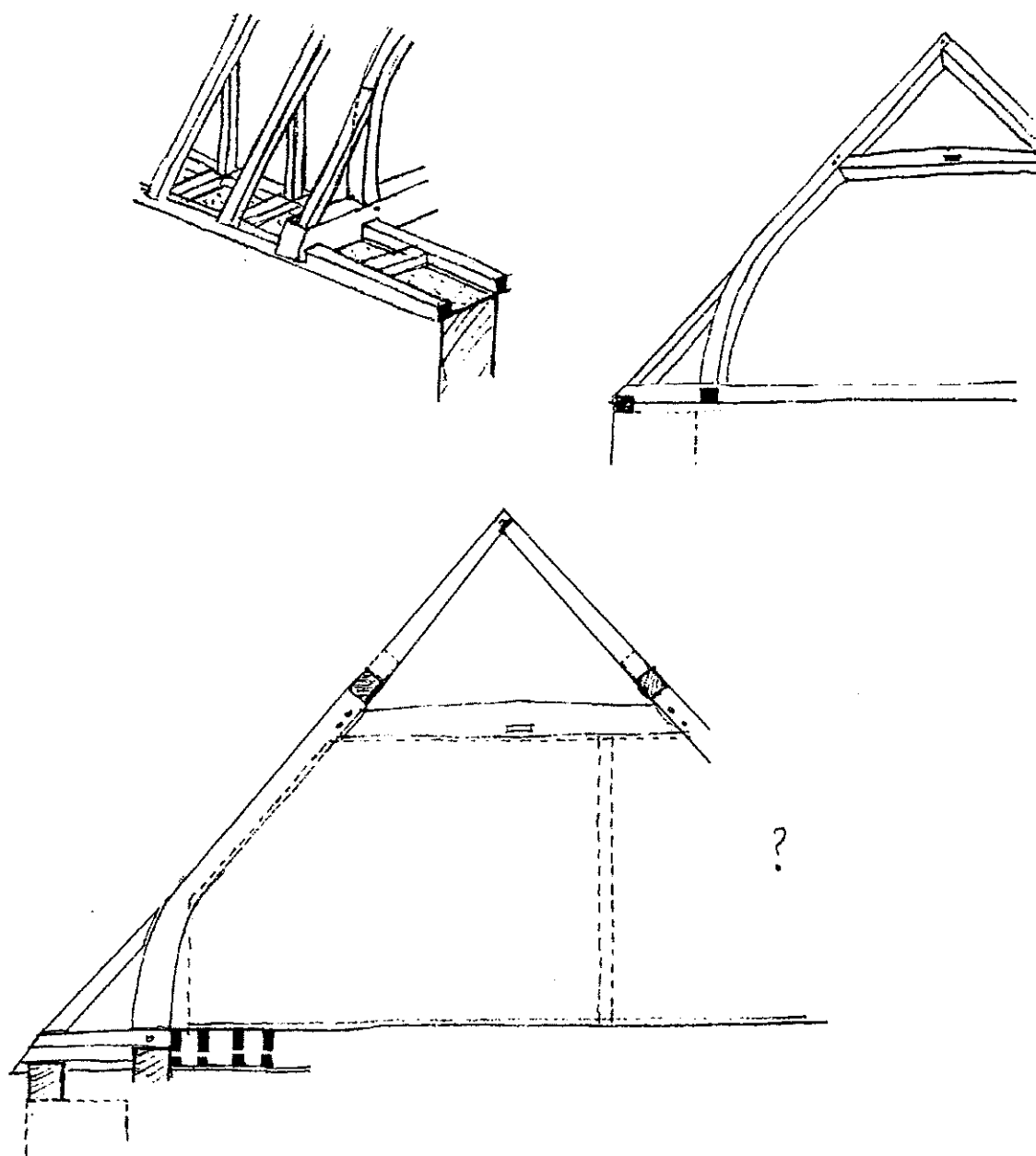
**Figure 1:** Plan of the north range, Hill Hall, Essex, showing locations of samples taken for dendrochronology



Figure 2: Drawing of the north wall of the north range, Hill Hall, Essex, showing locations of samples taken for dendrochronology



**Figure 3:** Drawing of the south wall of the north range, Hill Hall, Essex, showing locations of samples taken for dendrochronology



**Figure 4:** Sketches of the roof of the north west wing, Hill Hall, Essex, showing the general form of the trusses. Based on originals by Andy Wittrick (English Heritage)

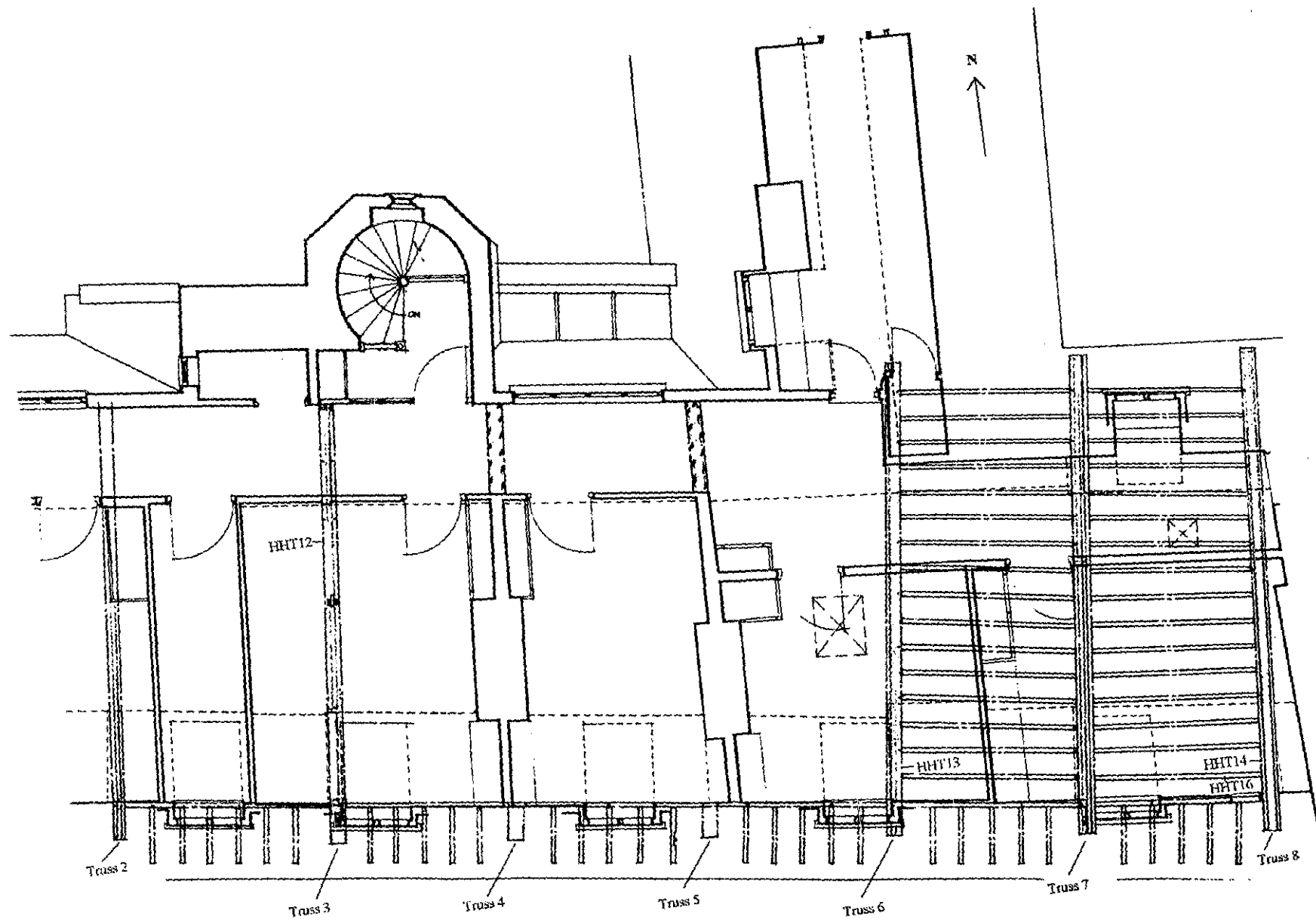


Figure 5: Plan of the first floor of the north west wing, Hill Hall, Essex, showing the truss numbering, and locations of samples taken for dendrochronology



Ring sequences were plotted on translucent semi-log graph paper to allow visual comparisons to be made between sequences on a light table. This activity also acts as a measure of quality control in identifying any errors in the measurements when the samples crossmatch. Statistical comparisons were made using Student's *t*-test (Baillie and Pilcher 1973; Munro 1984). The *t*-values quoted below were derived from the original CROS program (Baillie and Pilcher 1973). Those *t*-values in excess of 3.5 are taken to be indicative of acceptable matching positions provided that they are supported by satisfactory visual matches, and give consistent matching positions.

When crossmatching between samples is found, their ring-width sequences are meant to form an internal site mean sequence which is then compared with a number of reference chronologies (multi-site chronologies from a region) and dated individual site masters in an attempt to date it. Individual long series which are not included in the site mean(s) are also compared with the database to see if they can be dated.

The dates thus obtained represent the time of formation of the rings available on each sample. Interpretation of these dates then has to be undertaken to relate these findings to the construction date of the phase under investigation. An important aspect of this interpretation is the estimate of the number of sapwood rings missing. In this instance, the sapwood estimates are based on those proposed for this area by Miles (1997), in which 95% of samples are likely to have from 9 to 41 sapwood rings. Where bark is present on the sample the exact date of felling of the tree used may be determined.

The dates derived for the felling of the trees used in construction do not necessarily relate directly to the date of construction of the building. However, evidence suggests that, except in the re-use of timbers, construction in most historical periods took place within a very few years after felling (Salzman 1952; Hollstein 1965).

## **Results**

In the west, south, and east ranges, few original timbers remained. Those which were available included window lintels and spreaders within the brick walls. Many of the oak timbers viewed had too few rings to be dated dendrochronologically (see above) and few had any sapwood remaining. This was also true of timbers thought to have been reused from earlier phases of construction. After careful investigation therefore, none of the timbers in these three ranges were sampled. The timbers in the north-west range identified as possibly being from secondary repairs were similarly dismissed.

Timbers in both the north range and the north-west wing were sampled, the locations of those timbers sampled, are shown Figures 1-5, and described in Tables 1 and 2. Although not many timbers in either the north or north-west ranges had extensive sapwood surviving, enough timbers had some traces of sapwood that it was felt that the information they might yield justified the sampling done.

The oak ring series from the north range, samples HHT01 - HHT11 (Table 1, Figs 1 - 3) did not match each other, and therefore individual series were matched against a range of regional and site chronologies. Consistent significant matches were found for six of the timbers and the dates subsequently allotted to them are shown in Table 1, with the evidence for their dating in Table 3. The six series were combined into a site chronology Hill Hall 1 (Fig 6), which gave very good matches against a number of chronologies (see Table 4).

The timbers in the north-west range (samples HHT12-HHT28, Table 2, Figs 4 and 5) had had their sapwood crudely removed, making it more difficult to find useful timbers with extensive

**Table 1:** Oak (*Quercus* spp.) timbers sampled from the north range, Hill Hall, Essex

h/s = heartwood-sapwood boundary

| Sample No | Origin of core              | Total No of years | Average growth rate (mm yr <sup>-1</sup> ) | Sapwood details | Date of sequence AD | Felling date of timber AD |
|-----------|-----------------------------|-------------------|--|-----------------|---------------------|---------------------------|
| HHT01     | Ceiling beam                | 62                | 2.27                                       | -               | 1481 - 1542         | after 1551                |
| HHT02     | Ceiling beam                | 62                | 2.30                                       | 10*             | 1501 - 1562         | 1562 - 1593               |
| HHT03     | Window lintel in north wall | 51                | 1.77                                       | -               | 1484 - 1534         | after 1543                |
| HHT04     | Door lintel in south wall   | <40               | unmeasured                                 | -               | unknown             | unknown                   |
| HHT05     | Door jamb                   | 56                | 2.24                                       | 1               | unknown             | unknown                   |
| HHT06     | Stud in partition wall      | 116               | 2.01**                                     | -               | unknown             | unknown                   |
| HHT07     | Floor joist                 | 93                | 1.22**                                     | 22              | unknown             | unknown                   |
| HHT08     | Ceiling beam                | 64                | 2.41                                       | 20 + bark       | 1483 - 1546         | 1546                      |
| HHT09     | Stud in partition wall      | c48               | unmeasured**                               | -               | unknown             | unknown                   |
| HHT10     | First floor stud            | 104               | 1.98**                                     | 20              | 1461 - 1564         | 1564 - 1585               |
| HHT11     | Joist                       | 133               | 1.26                                       | 18              | 1425 - 1557         | 1557 - 1580               |

\* complete sapwood on beam, but outer rings disintegrated on sampling

\*\* variable ring-width bands with abrupt growth changes

**Table 2:** Oak (*Quercus* spp.) timbers sampled from the north-west wing, Hill Hall, Essex

h/s = heartwood-sapwood boundary

| Sample No | Origin of core                  | Total No of years | Average growth rate (mm yr <sup>-1</sup> ) | Sapwood details | Date of sequence AD | Felling date of timber AD |
|-----------|---------------------------------|-------------------|--|-----------------|---------------------|---------------------------|
| HHT12     | Tie beam, truss 3               | 61                | 1.48                                       | h/s             | 1613 - 1673         | 1682 - 1714               |
| HHT13     | Tie beam, truss 6               | 50                | 3.04                                       | -               | unknown             | unknown                   |
| HHT14     | Tie beam, truss 8               | 45                | unmeasured                                 | -               | unknown             | unknown                   |
| HHT15     | Principal rafter, truss 7 south | 39                | unmeasured                                 | -               | unknown             | unknown                   |
| HHT16     | Floor joist, bay 7              | c60*              | unmeasured                                 | -               | unknown             | unknown                   |
| HHT17     | Collar, truss 2                 | 106               | 1.21                                       | -               | 1525 - 1630         | after 1639                |
| HHT18     | Principal rafter, truss 2 north | 87                | 1.81                                       | 7               | 1584 - 1670         | 1672 - 1704               |
| HHT19     | Purlin, bay 3 south             | 32                | unmeasured                                 | 2               | unknown             | unknown                   |
| HHT20     | Collar, truss 3                 | 53                | 3.07                                       | h/s             | 1622 - 1674         | 1683 - 1715               |
| HHT21     | Common rafter, bay 3 north      | 42                | unmeasured                                 | 7               | unknown             | unknown                   |
| HHT22     | Purlin, bay 3 south             | 32                | unmeasured                                 | 3               | unknown             | unknown                   |
| HHT23     | Collar, truss 4                 | 116               | 1.27                                       | -               | 1534 - 1649         | after 1658                |
| HHT24     | Principal rafter, truss 4 north | 40                | unmeasured                                 | -               | unknown             | unknown                   |
| HHT25     | Purlin, bay 4 south             | 23                | unmeasured                                 | 2               | unknown             | unknown                   |
| HHT26     | Collar, truss 5                 | 78                | 1.58                                       | 13              | 1634 - 1681         | 1682 - 1709               |
| HHT27     | Principal rafter, truss 5 north | 52                | 2.19                                       | 1               | 1610 - 1661         | 1669 - 1701               |
| HHT28     | Collar, truss 6                 | 42                | unmeasured                                 | -               | unknown             | unknown                   |

\* abrupt growth changes with bands of very narrow rings

**Table 3:** Dating of the individual timbers in the Hill Hall 1 chronology from the north range

| Sample No    | Date Range (years AD) | <i>t</i> value, reference curve, (years of overlap), source  |
|--------------|-----------------------|--|
| <b>HHT01</b> | 1481 - 1542           | <b>5.9</b> Magdalen Laver, Essex, [54], (Tyers and Boswijk 1998)<br><b>3.9</b> Hereford and Worcester, [62], (Siebenlist-Kerner 1978)<br><b>3.8</b> Boyes Croft Maltings, Essex, [62], (Bridge 1999) |
| <b>HHT02</b> | 1501 - 1562           | <b>4.8</b> Hants97, [62], (Miles pers comm)<br><b>4.7</b> London1175, [62], (Tyers pers comm)<br><b>4.4</b> Broomfield, London, [62], (Bridge 1997)  |
| <b>HHT03</b> | 1484 - 1534           | <b>6.0</b> Bruce Castle 4, London, [51], (Bridge 1998a)<br><b>5.3</b> Wimborne, Dorset, [51], (Miles 1994)<br><b>4.1</b> Boyes Croft Maltings, Essex, [51], (Bridge 1999)                            |
| <b>HHT08</b> | 1483 - 1546           | <b>8.9</b> Wimpole1, Cambridgeshire, [64], (Bridge 1998b)<br><b>7.6</b> Gosfield, Essex, [55], Bridge (1998c)<br><b>7.6</b> Magdalen Laver, Essex, [52], (Tyers and Boswijk 1998)                    |
| <b>HHT10</b> | 1461 - 1564           | <b>5.6</b> Eastbury Manor, Essex, [104], (Tyers 1997)<br><b>5.0</b> Bruce Castle 4, London, [84], (Bridge 1998a)<br><b>4.7</b> Broomfield, London, [102], (Bridge 1997)                              |
| <b>HHT11</b> | 1425 - 1557           | <b>6.4</b> Eastbury Manor, Essex, [133], (Tyers 1997)<br><b>6.2</b> Windsor Castle kitchen, Berkshire, [133], (Hillam and Groves 1996)<br><b>5.5</b> Little Totham, Essex, [93], (Tyers 1996)        |

**Table 4:** Dating of the oak site chronology Hill Hall 1 from the north range

|  | <b>Hill Hall 1<br/>AD 1425 - 1564</b> |               |
|--|---------------------------------------|---------------|
| <b>Dated reference or site master chronology</b> | <i>t</i> -value                       | Overlap (yrs) |
| Wimpole1, Cambridgeshire (Bridge 1998b)          | 8.0                                   | 96            |
| Eastbury Manor, Essex (Tyers 1997)               | 7.8                                   | 140           |
| Windsor Castle kitchen (Hillam and Groves 1996)  | 7.7                                   | 140           |
| Little Totham, Essex (Tyers 1996)                | 6.8                                   | 93            |
| Mary Rose 'refit' (Bridge and Dobbs 1996)        | 6.5                                   | 111           |
| Boyes Croft Maltings, Essex (Bridge 1999)        | 5.8                                   | 84            |

**Table 5:** Crossmatching between dated oak samples from the north-west wing

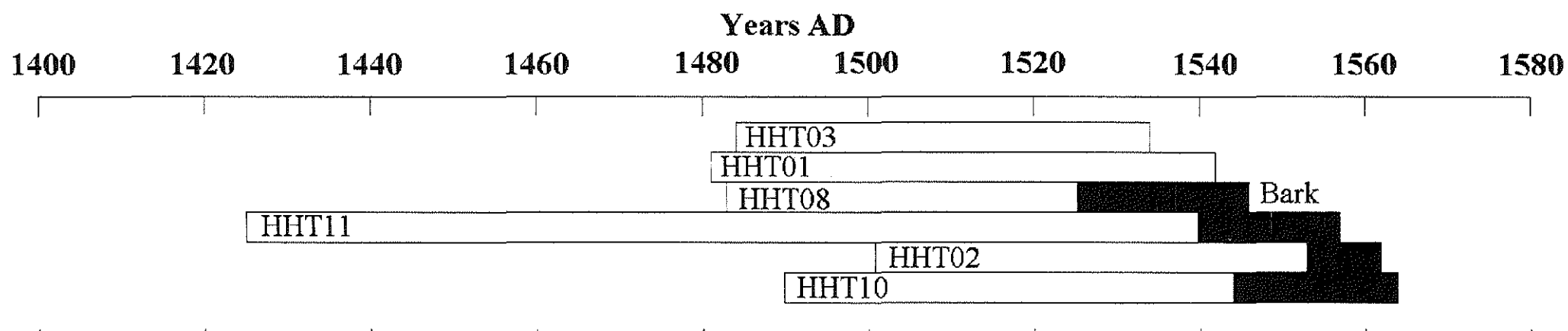
| Sample No | <i>t</i> values |      |     |      |     |     |
|-----------|-----------------|------|-----|------|-----|-----|
|           | 17              | 18   | 20  | 23   | 26  | 27  |
| 12        | *               | 10.2 | 7.5 | 7.4  | 3.2 | 5.1 |
| 17        |                 | 3.6  | *   | 14.3 | 5.8 | *   |
| 18        |                 |      | 7.2 | 3.7  | 4.4 | 6.4 |
| 20        |                 |      |     | *    | 3.1 | 5.8 |
| 23        |                 |      |     |      | 4.4 | 2.8 |
| 26        |                 |      |     |      |     | 4.2 |

\* = less than 30 years of overlap

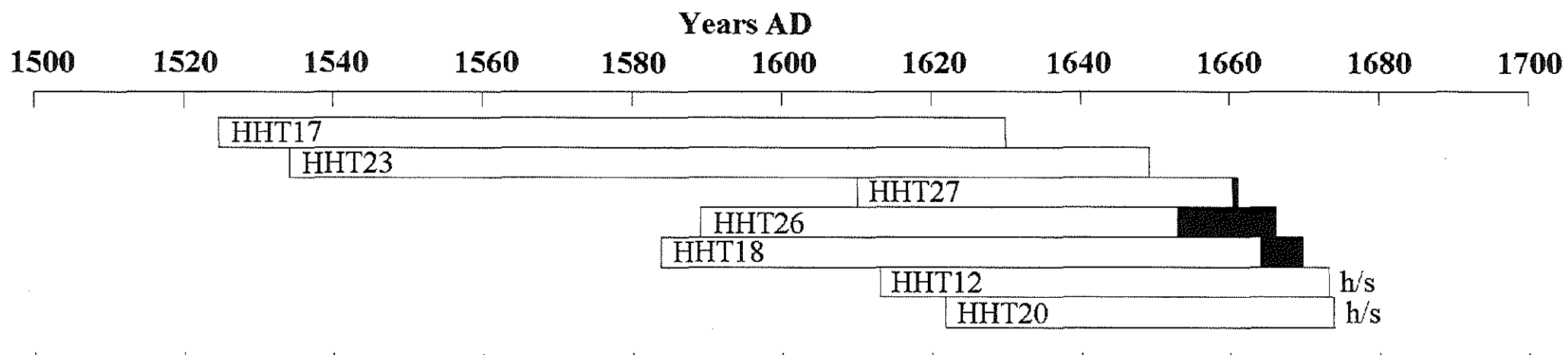
**Table 6:** Dating of the oak site master Hill Hall 2 from the north-west wing

| Dated reference or site master chronology   | Hill Hall 2<br>AD 1525 - 1681 |               |
|---|-------------------------------|---------------|
|   | <i>t</i> -value               | Overlap (yrs) |
| Oxon93 (Miles pers comm)                    | 8.6                           | 157           |
| Wimpole 1, Cambridgeshire (Bridge 1998b)    | 8.0                           | 91            |
| Brittany 3, France (Guibal 1987)            | 7.7                           | 157           |
| *Oriol College, Oxford (Miles pers comm)    | 6.1                           | 148           |
| Nostell 2, Yorkshire (Tyers 1998)           | 5.0                           | 147           |
| *Nuffield College, Oxford (Miles pers comm) | 5.9                           | 102           |

\* these are components of the regional Oxon93 chronology



**Figure 6:** Bar diagram showing the relative positions of overlap of the dated timbers used in the site chronology HillHall 1. The shaded areas represent sapwood



**Figure 7:** Bar diagram showing the relative positions of overlap of the dated timbers from the north-west range used in the site chronology HillHall 2. The shaded areas represent sapwood, h/s = heartwood-sapwood boundary

sapwood for dating. Individual truss drawings were not available and exact locations above tie beam level are not therefore indicated. Good crossmatching was found between seven of these timbers (Table 5) and their series were combined to form a second site chronology Hill Hall 2 (Fig 7), which was subsequently dated (see Table 6).

The two site chronologies, Hill Hall 1 (AD 1425 - 1564) and Hill Hall 2 (AD 1525 - 1681) are given in Table 7.

### **Interpretation and Discussion**

The first point of interest is that many of the timbers which survive in the north range (Figs 1 - 3) are of relatively poor quality, being full of knots, and are not finished to a high degree. The main beam from which sample HHT08 was taken for example, has no chamfers and a rough exterior. Many of the joists have rough rounded edges where the outside of the tree has been left. This seems like rather poor workmanship when compared to nearby properties such as the earlier Gosfield Hall (Bridge 1998c). The nature of the knotty timbers, coupled with the lack of internal matching between the components of this range, suggests that the timber may have come from hedgerow-like environments, possibly from scattered sites, although probably from the local region, given the nature of the crossmatching with reference material. The number of timbers with bands of varying width annual rings, showing sudden changes in the rate of growth, suggests that some lopping of the trees had taken place during their lifetime, though other causes, such as disease, cannot be entirely ruled out. Nevertheless, it was felt that these trees may represent typical growth over a wide area and although they did not crossmatch well statistically, the site master derived from them has been demonstrated to give strong matches against a range of reference chronologies (Table 4). The much earlier date derived for the outermost ring of HHT08 (AD 1546), which had no obvious signs of reuse, suggests that the tree had either been standing dead for many years prior to felling, or that this timber had been stored for many years before being used.

The outer rings of the few timbers with significant sapwood, including a date of AD 1564 for HHT10, suggests the building of this phase was likely to have been within the proposed AD 1568-9 period, which falls within the dendrochronologically derived felling period for the timbers of AD 1564 - 1580. This allows the possible AD 1557-8 date, derived from documentary evidence, to be ruled out.

By contrast, the roof of the north-west wing (Figs 4 and 5), thought to have been built as servants' quarters, at least on the ground floor, has well-finished, refined carpentry. The sapwood appears to have been hacked off rather crudely, though this may well have been done many years later, probably when the wing was remodelled by Blomfield in the early-twentieth century (Drury pers comm). However, the presence of pit saw marks on many of the timbers, indicated that they were likely to be older than Blomfield's time. Many of the principal rafter pairs have made use of very fast-grown oak, and these may have been selected for strength. Many of the floor timbers (Fig 5), including joists and tie beams were cored. Several were found to have a high moisture content and the cores were difficult to extract.

The previous evidence for this wing was less certain, but a date of AD 1576-81 had been suggested (Drury pers comm). The felling range for these timbers of AD 1683 -1701, is now thought more likely to correspond with "great alterations and improvement" between AD 1668 - 1698 (Drury 1983, 100), significantly later than had previously been thought. Only one tie, principal rafters, and collars dated; no evidence was therefore forthcoming about the floor



structure in this wing. The unusual curved principal rafters have been likened to upper crucks, but this much later date further removes this roof from that tradition.

This study has therefore been useful in resolving some of the complexity of the building sequence of the ranges of the house, despite the fact that many timbers were of fast-grown oak and few had sapwood. It has supported an AD 1568-9 date for construction of the north range, though at least one timber has been shown to have been felled a couple of decades earlier. Questions of the building sequence and relationship between the north range and the other main ranges could not be resolved because of the lack of suitable timbers. The date of the roof of the north-west wing places it firmly in a previously unsuspected period, and will be of use in interpreting this part of the building, as well as providing a useful benchmark for comparing other structures in the area. The site chronologies formed will also be of use for dating other structures in the region.

### **Acknowledgements**

I thank Paul Drury for his introduction to the site and supplying numerous drawings. Andy Wittrick (English Heritage) was especially helpful in my work on the north-west wing, giving practical assistance, background information, and drawings.

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**Table 7:** Ring-width data for the two oak site chronologies from Hill Hall, Essex

| Year               | ring widths (0.01mm)                    | no of trees         |
|--------------------|---|---------------------|
| <b>HILL HALL 1</b> |   |                     |
| AD1425             | 187 193 145 178 247 152                 | 1 1 1 1 1 1         |
|                    | 147 190 124 180 251 138 125 121 139 199 | 1 1 1 1 1 1 1 1 1 1 |
|                    | 201 222 312 184 156 129 172 120 165 150 | 1 1 1 1 1 1 1 1 1 1 |
| AD1451             | 164 167 162 183 160 134 121 113 95 71   | 1 1 1 1 1 1 1 1 1 1 |
|                    | 153 156 168 134 227 203 167 199 283 313 | 2 2 2 2 2 2 2 2 2 2 |
|                    | 221 211 190 252 339 200 187 203 336 300 | 2 2 2 2 2 2 2 2 2 2 |
|                    | 267 279 198 213 234 221 240 245 248 279 | 3 3 4 5 5 5 5 5 5 5 |
|                    | 234 234 249 267 249 291 249 172 209 164 | 5 5 5 5 5 5 5 5 5 5 |
| AD1501             | 167 181 170 205 190 194 200 198 232 183 | 6 6 6 6 6 6 6 6 6 6 |
|                    | 197 165 177 192 245 204 161 244 262 189 | 6 6 6 6 6 6 6 6 6 6 |
|                    | 190 229 164 187 150 160 155 154 136 140 | 6 6 6 6 6 6 6 6 6 6 |
|                    | 187 123 140 142 203 168 188 177 200 199 | 6 6 6 6 5 5 5 5 5 5 |
|                    | 195 139 171 134 179 125 106 173 202 144 | 5 5 4 4 4 4 3 3 3 3 |
| AD1551             | 127 110 133 120 136 125 120 131 154 169 | 3 3 3 3 3 3 3 2 2 2 |
|                    | 157 195 57 84                           | 2 2 1 1             |
| <b>HILL HALL 2</b> |   |                     |
| AD1525             | 134 164 155 135 118 93                  | 1 1 1 1 1 1         |
|                    | 177 126 148 173 223 147 182 176 166 95  | 1 1 1 2 2 2 2 2 2 2 |
|                    | 172 100 144 171 192 105 109 163 143 98  | 2 2 2 2 2 2 2 2 2 2 |
| AD1551             | 119 93 154 143 185 109 161 148 97 132   | 2 2 2 2 2 2 2 2 2 2 |
|                    | 101 188 110 83 113 84 73 107 119 125    | 2 2 2 2 2 2 2 2 2 2 |
|                    | 129 145 132 123 159 115 135 107 135 152 | 2 2 2 2 2 2 2 2 2 2 |
|                    | 149 100 93 148 211 159 109 160 88 95    | 2 2 2 3 3 3 3 3 3 3 |
|                    | 97 133 144 220 242 273 276 219 149 148  | 3 3 3 3 3 3 3 3 3 3 |
| AD1601             | 125 106 117 191 135 238 224 206 151 233 | 3 3 3 4 4 4 4 4 4 5 |
|                    | 151 201 226 177 149 152 201 147 138 140 | 5 5 6 6 6 6 6 6 6 6 |
|                    | 181 217 188 179 273 242 233 232 249 200 | 6 7 7 7 7 7 7 7 7 7 |
|                    | 243 237 218 134 138 125 173 194 201 194 | 6 6 6 6 6 6 6 6 6 6 |
|                    | 148 141 166 163 176 201 208 239 174 161 | 6 6 6 6 6 6 6 6 6 5 |
| AD1651             | 145 111 75 100 183 148 167 158 101 116  | 5 5 5 5 5 5 5 5 5 5 |
|                    | 151 134 135 121 111 92 137 169 126 132  | 5 4 4 4 4 4 4 4 4 4 |
|                    | 212 230 269 157 104 42 79 57 59 85      | 3 3 3 2 1 1 1 1 1 1 |
|                    | 107                                     | 1                   |