

# Dendrochronology, Documents and the Timber Trade: New Evidence for the Building History of Stirling Castle, Scotland

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*DENDROCHRONOLOGICAL analysis of structural timbers from Stirling Castle has produced exact felling dates for building phases within the Castle complex. This analysis has also provided evidence for the source of the timbers, demonstrating that throughout the 16th century much of the timber was imported from the region of eastern Denmark/southern Sweden. This paper presents a brief building history of the Castle, followed by the dendrochronological evidence. Finally, the historical context for the timber trade between Scotland and Scandinavia is discussed.*

The principal buildings of Stirling Castle represent the most complete and least altered complex of buildings erected for the Stewart court in Scotland.<sup>1</sup> Dating chiefly from the reigns of James IV (1488–1513), James V (1513–42) and James VI (1566–1625) they offer a striking picture of the setting for royal life in the later Middle Ages and earlier Renaissance period. The main components are grouped around a roughly square enclosure, the Inner Close, on the highest point of the castle rock (Fig. 1). On the W. side of the Close is the residence built for James IV, known as the King's Old Building, while the Great Hall built for the same king is on the E. side; James V's quadrangular Palace is on the S. side, and the Chapel Royal built for James VI is on the N. side. A fifth element is the defensive Forework built by James IV, which runs across the main line of approach to the castle from the SW.

Following James VI's succession to the English throne as James I in 1603, the royal use of the buildings declined and, although there were major repairs and redecorations around the time of the 'homecomings' of James VI in 1617 and of Charles I in 1633, the buildings were inevitably adapted to serve more mundane military uses in the course of the 17th, 18th and 19th centuries. The threat of Jacobite risings between the flight of James VII and II in 1688 and the death of Cardinal York in 1807 was the catalyst for some of those changes. However, it was a need for permanent barrack accommodation, starting during the French Wars in the late 18th century, which led to the greatest changes, and these will be

<sup>1</sup> *Stirlingshire: an Inventory of the Ancient Monuments*, (179–223 (Edinburgh, 1963); R. Fawcett, *Stirling Castle* (London, 1995).

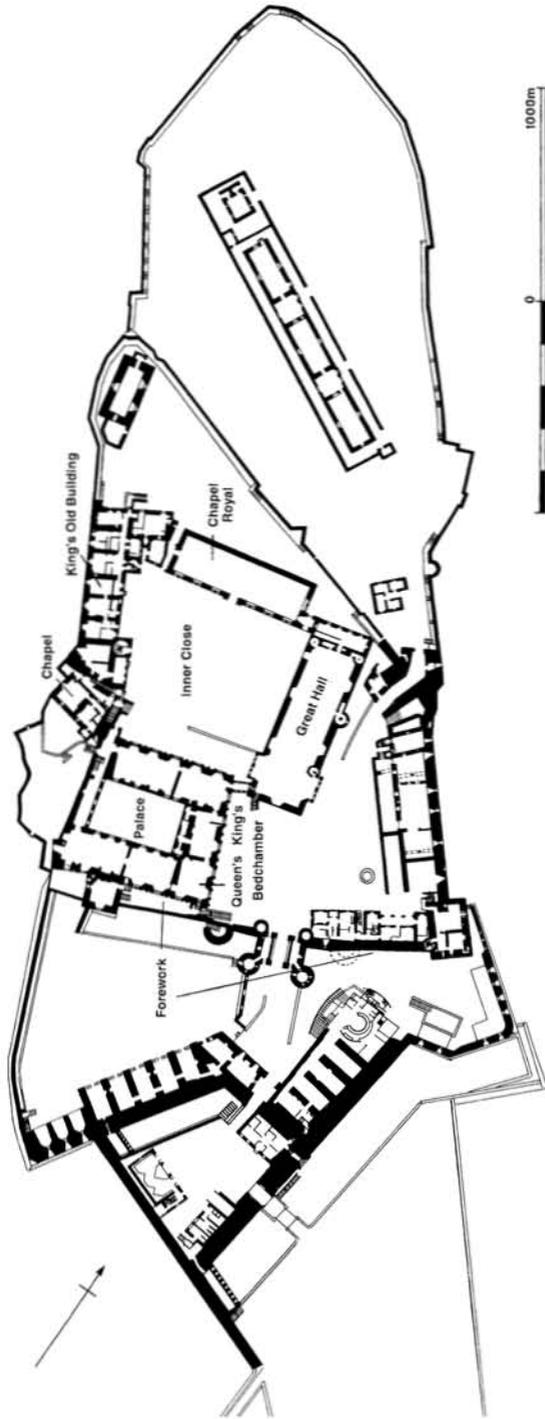


FIG. 1

Plan of Stirling Castle in its present state showing those buildings mentioned in the text.  
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summarized below in the brief accounts of the documentary evidence for the buildings.

A move towards a more historically appropriate treatment of the castle's buildings was initiated following the personal intervention of Edward VII in 1906, as a result of which care of the castle was transferred from the War Office to the Office of Works (the predecessor of Historic Scotland).<sup>2</sup> In the 1930s work began on the restoration of the Chapel Royal.<sup>3</sup> After the war, in 1946 it was suggested that the Great Hall should be restored as a memorial to the fallen (not the first time it had been suggested the Hall should be restored) and during the 1950s further works were carried out on the chapel.<sup>4</sup> It was only when the castle ceased to function as a permanent military depot in 1964 that it became possible to consider reversing some of the more damaging alterations to the main buildings. Since then the King's Old Building has been stabilized and adapted for use as a museum and regimental headquarters of the Argyll and Sutherland Highlanders. The Palace has been repaired and cleared of a number of late insertions with the eventual intention of presenting the two royal lodgings as they would have been in the 16th century. However, the most far-reaching works have been on the Great Hall and Chapel Royal and these are described below.

## THE DOCUMENTARY EVIDENCE FOR THE DATING OF THE BUILDINGS

Timber samples were taken from three of the buildings around the Inner Close: the Great Hall, the Palace and the Chapel Royal, and the known evidence for the dating of these buildings is summarized briefly here.

### THE GREAT HALL

The Great Hall was almost certainly largely a work of James IV, despite a long-standing tradition that it was built for James III (1460–88).<sup>5</sup> It was nearing completion in the first years of the 16th century, since there are references to work at the wall-head in 1501 and to plastering of the walls in 1503.<sup>6</sup> Similarities of the moulded details with those of the King's Old Building support a period of construction in the years around 1500, since the latter is now thought to be the 'King's House' constructed by the master mason Walter Merlioun in 1496.<sup>7</sup>

The Hall was modified on several occasions. A sunken area originally below an open pentice roof along its W. side, towards the Inner Close, was vaulted over at courtyard level, and a two-storey lean-to service corridor was added at the N.

<sup>2</sup> SRO, MW.1.909, Scottish Record Office official file, *Stirling Castle: Transfer of maintenance from War Office to Office of Works*.

<sup>3</sup> SRO, MW.1.98, Scottish Record Office official file, *Stirling Castle: Restoration of Chapel Royal*.

<sup>4</sup> SRO, DD. 27.4099, Scottish Record Office official file, *Stirling Castle: Proposals for restoration of Great Hall*.

<sup>5</sup> R. Lindsay of Pitcottie, *The historie and cronicles of Scotland . . . to the ane thousande fyve hundreith thrie scoir fyftein zeir*, 1, 200 (Edinburgh, 1899–1911).

<sup>6</sup> *Accounts of the Lord High Treasurer of Scotland* II, 82, 381 (Edinburgh, 1877–).

<sup>7</sup> *Treasurers Accounts*, op. cit. note 6, 1, 277, 306; R. Fawcett, 'Stirling Castle: the King's Old Building and the late medieval royal planning', *Château Gaillard* XIV, (1990), 175–93.

end of the Hall; this corridor connected with kitchens which were possibly formed on the upper floor of the adjacent North Gate in 1511–12.<sup>8</sup> A new access was provided from the King's Own Hall of the Palace across a bridge to the dais at the S. end of the hall, presumably at the time that the Palace was built in the 1530s, '40s and '50s. A door inserted near the middle of the W. wall may, on the indications of its mouldings, have been cut for the festivities associated with the baptism of Prince Henry in 1594. By the time of a survey drawn up in 1719 a fully enclosed corridor had been formed along the W. wall, above the vaulted-over area, and there may have been a partial inserted floor within the main body of the hall.<sup>9</sup> But the most far-reaching modification was the insertion of five cross walls and two additional floors, together with the replacement of the roof and the cutting of new windows, in order to create barrack accommodation. The precise date of this work is unknown, though it is probably carried out around the same time that the New Barracks were built in Edinburgh Castle, between 1796 and 1799. A drawing for this conversion in the collection of Historic Scotland has what appears to be the signature of John Sanders, who was appointed architect to the Barrack Department of the War Office in 1794.<sup>10</sup> Since 1964 the inserted walls and floors have been removed, the original windows reinstated and the hammer-beam roof replaced to the form indicated by surveys of 1719 and 1741; restoration is expected to be completed by the millennium.<sup>11</sup>

#### THE PALACE

The Palace was built for James V, incorporating fragments of buildings which already stood on the site; James's initials are within the external tympana of the principal floor windows. The incentive to build a new royal residence, with paired lodgings for the king and his queen, was James V's two successive marriages to French ladies. He was given as his first wife Madeleine de Valois, the daughter of King François I of France, in the course of a visit to that country in 1536–37; she did not long survive the return to Scotland, and in 1538 he married Mary of Guise-Lorraine, daughter of the Duke of Guise and widow of the Duke of Longueville. It is likely that the design of the palace was drawn up by one of the French masons known to have been in James's service, though the guiding hand behind the organization was Sir James Hamilton of Finnart. Finnart is said to have entered the castle in 1538, and in the following year he was created Principal Master of Works throughout the kingdom.<sup>12</sup> Also in 1539, Finnart had various properties granted or confirmed in partial recompense for his work on the palaces of Stirling and Linlithgow.<sup>13</sup>

<sup>8</sup> *Treasurers Accounts*, op. cit. note 6, IV, 281.

<sup>9</sup> National Library of Scotland, Board of Ordnance Drawings (NLS BO).

<sup>10</sup> H. Colvin, *A Biographical Dictionary of British Architects 1600–1840*, 714 (London, 1978).

<sup>11</sup> NLS BO, op. cit. in note 9, Z.2.18 and 22b.

<sup>12</sup> *Accounts of the Masters of Works*, I, 227 (Edinburgh, 1957–); *Registrum Secreti Sigilli Regum Scotorum*, II no. 3144 (Edinburgh, 1908–).

<sup>13</sup> *Registrum Magnie Sigilli Regum Scotorum*, III no. 2021 (Edinburgh, 1882–1914).

Building was possibly interrupted by Finnart's fall from grace and execution in 1540, and it is doubtful that so major an operation was complete by the king's own death in 1542. Extensive works for the Queen Dowager on her Chamber and Hall within the Palace in 1558–59 could indicate that the building was only then being fitted out once the fabric had been completed.<sup>14</sup> Possible support for this may be drawn from a tradition that a missing dormer gable, which is said to have been inscribed with the date 1557, came from the Palace.<sup>15</sup>

The Palace suffered fewer later modifications than the other buildings around the Inner Close. However, much of its W. quarter has been lost apart from the inner section containing the corridor which connects the Outer Halls of the two royal lodgings. The range as a whole was in a parlous state in 1625, when its foundations were said to have partly fallen over the cliff.<sup>16</sup> The upper floor was modified to serve as the lodging of the Hereditary Governors of the castle, the Earls of Mar, and it was probably the sixth earl who had the external forestair built, and who installed a number of bolection-moulded fireplaces and doorcases at that level. A decline of interest in the historic qualities of the building is shown by the way that the superb coffered ceiling of the King's Own Hall, with the figurative roundels known as the 'Stirling Heads', was simply dismantled after part of it fell in 1777.<sup>17</sup> Later alterations included the creation of an officers' dining hall above the Queen's Outer Hall, the construction of a kitchen block against the outer W. wall and of an octagonal latrine block within the courtyard (both of the latter have since been removed). Also dating from the military use was the insertion of sash windows throughout and the cutting of an arch to interconnect the two bedchambers, though the latter has now been reduced to a doorway.

#### THE CHAPEL ROYAL

The Chapel Royal has the longest documented history of any building within the castle. The first certain reference to the castle relates to the endowment of a chapel within it by Alexander I, probably at a date between 1107 and 1115, and later references make clear that there were at least two Chapels within the castle, one possibly dedicated to St Michael and the other to St Mary, though the two dedications were later combined in a single building.<sup>18</sup> One Chapel was being rebuilt in 1412 for James I, while major works were carried out on the roof of one for James III between 1467 and 1469.<sup>19</sup> Even more work was carried out for James IV, who established the magnificently endowed and furnished Chapel Royal of Scotland here in the years around 1500.<sup>20</sup> The predecessors of the present Chapel Royal were probably on the same site as the existing building, on the N. side of the Inner Close, albeit on a more correctly aligned orientation, and excavations

<sup>14</sup> *Works Accounts*, op. cit. note 12, 1, 294–96.

<sup>15</sup> D. MacGibbon and T. Ross, *The Castellated and Domestic Architecture of Scotland*, 1, 475 (Edinburgh, 1887–92).

<sup>16</sup> *Register of the Privy Council of Scotland*, xiii, 705– (Edinburgh, 1877–).

<sup>17</sup> J. Graham, *Lacunar Strevelinense*, 4–5 (Edinburgh, 1817).

<sup>18</sup> *Regesta Regum Scottorum I*, no. 50; Geoffrey Barrow, *The Acts of Malcolm IV* (Edinburgh, 1960).

<sup>19</sup> *The Exchequer Rolls of Scotland*, iv, 164 (Edinburgh, 1878–1908); *Exchequer Rolls* vii 449, 544, 660.

<sup>20</sup> R. Rogers, *History of the Chapel Royal of Scotland* (Edinburgh, 1882).

(currently in course of being written up) have located traces of two earlier buildings below its walls. The other Chapel was almost certainly within the much-remodelled structure at the south-west corner of the Inner Close, behind the stair to the upper floor of the Palace, a building which later served as a kitchen first for the Governor's Lodging and thereafter for the army. Recent excavations have located a number of burials within this building, while earlier excavations revealed that it originally extended further east and was truncated when construction of the Palace was started. This Chapel may already have passed into reduced use by the earlier years of the 16th century, and was possibly the 'ald kyrk' on which the mason John Yorkstoun was working in 1504–05.<sup>21</sup>

It is tempting to suspect that, if he had not been killed at Flodden, James IV may have intended to rebuild the Chapel Royal as part of his larger plans for the Inner Close, particularly since the predecessor of the present building appears to have partly obscured the entrance to the Great Hall. However, his works were probably limited to modifications of the building he inherited, and by 1583 a report makes clear that a new roof had become an urgent necessity, since the king could not stay within it when it rained. It was suggested in 1583 that the Chapel should be rebuilt on a new alignment, and this idea was taken up afresh when it was decided that a new Chapel should be built for the baptism of Prince Henry in 1594. The accounts for the rebuilding of the Chapel have not survived, though it is said that it cost £100,000 Scots; it was certainly ready in time for the baptism on 30 August.<sup>22</sup>

Further minor works were probably carried out in advance of James VI's homecoming in 1617, and there was a major scheme of redecoration by the painter, Valentine Jenkin, in 1628–29 in advance of Charles I's visit of 1633.<sup>23</sup> After that, however, royal interest in the Chapel declined. There were repairs to the roof in 1708, and as early as 1708–09 there was a proposal to insert floors and stairs to allow it to be used as an armoury, though this was probably not acted upon.<sup>24</sup> Nevertheless, various alterations followed, and in 1887 it was said that it had recently been given a new roof. By 1911 the building contained a school and dining hall on the lower floor with stores for arms and clothing on an inserted upper floor.<sup>25</sup> Proposals for the restoration of the Chapel were drawn up by the Ministry of Works in 1934, and these were approved by the Ancient Monuments Board for Scotland in 1935. Work on the removal of floors and partitions started soon afterwards but the outbreak of war then prevented further work being carried out until the 1950s. The Chapel has now been re-roofed with a modern polygonal wagon ceiling following the profile of the original, an operation completed in 1996, and it has been furnished to allow its use for worship as well as for other functions.

<sup>21</sup> *Treasurers Accounts*, op. cit. in note 6, III, 82.

<sup>22</sup> A. Nisbet, *A System of Heraldry*, 151 (Edinburgh, 1816).

<sup>23</sup> *Works Accounts*, op. cit. in note 12, II, 256.

<sup>24</sup> Public Record Office, War Office Papers (PRO WO) 55/345 244; NLS BO, op. cit. in note 9, Z2/17.

<sup>25</sup> SRO, MW., op. cit. in note 3.

## DENDROCHRONOLOGICAL ANALYSIS

Prior to the dendrochronological work at Stirling Castle almost all the work on medieval tree-ring chronologies in Scotland had been undertaken by Professor Baillie of Queen's University, Belfast. In building the first Scottish tree-ring chronology he used timbers from the towerhouse of Castle of Park, Wigtownshire, the choir stall from Lincluden College, Dumfriesshire, roof timbers from Glasgow Cathedral and timbers from the bridge foundations at Caerlaverock Castle, Dumfriesshire, to extend the chronology back beyond the sequences of living trees to A.D. 946.<sup>26</sup> All the material used in the SCOTLAND chronology came from south-central Scotland but analysis of timbers from medieval deposits excavated at the High Street, Perth, extended the scope of the chronology further north.<sup>27</sup> The successful analysis of timbers from as far north as Darnaway Castle, Morayshire, indicated that Scotland might form a unified tree-ring region despite its disparate topography.<sup>28</sup>

While work on two small assemblages from Midhope Castle, Midlothian, and Queen Mary's House, St Andrews, produced long chronologies, they failed to date against the SCOTLAND chronology, raising the possibility that imported timber had been used.<sup>29</sup> This was confirmed when both chronologies were successfully dated against GDANSK-POMERANIA, a chronology from northern Poland.<sup>30</sup> The statistical correlations were strong enough to suggest a Baltic source, although not necessarily a Polish one. The development of an extensive network of locally derived oak chronologies from all over Europe means that it is now possible, given the right conditions, to source timber, an approach which has recently been dubbed 'dendroprovenancing' and which has produced some remarkable results.<sup>31</sup> The assumption behind this approach is that the site chronology will correlate best with chronologies from the region where the timber had grown. Correlation of a chronology from barrel staves found in the Gallowgate, Aberdeen, with GDANSK-POMERANIA produced such a strong correlation ( $t = 13.65$ ) that a source in northern Poland was irrefutable.<sup>32</sup> It was thus becoming clear that we might expect to find imported timber amongst medieval assemblages.

## THE MATERIAL

During the course of five sampling visits to the castle some 32 oak (*Quercus* sp.) timbers and 12 Scots pine (*Pinus sylvestris*) timbers were sampled (Table 1). The

<sup>26</sup> M. G. L. Baillie, 'An oak chronology for south central Scotland', *Tree-Ring Bulletin*, 37 (1977), 33-44.

<sup>27</sup> M. G. L. Baillie 'Appendix A — The dendrochronology', in N. Bogdan, *Perth High St Excavations 1975-1978* (SUAT Monograph, in press).

<sup>28</sup> G. Stell and M. Baillie, 'The Great Hall and roof of Darnaway Castle, Moray', 162-86, in W. D. H. Sellar (ed.), *Moray: province and people* (Edinburgh, 1993).

<sup>29</sup> M. G. L. Baillie, *A Slice through Time: Dendrochronology and Precision Dating*, 132 (London, 1995).

<sup>30</sup> T. Wazny, *Aufbau und Anwendung der Dendrochronologie für Eichenholz in Polen*, (Univ. Hamburg, unpubl. PhD thesis, 1990).

<sup>31</sup> N. Bonde and J. S. Jensen, 'The dating of a Hanseatic cog-ship in Denmark', 103-22, in O. Olsen, J. Skamby Madsen, and F. Rieck (eds.), *Shipshape: Essays for Ole Crumlin-Pedersen* (Roskilde, 1995).

<sup>32</sup> B. A. Crone 'The wood, including the dendrochronological analysis of the barrel', in A. S. Cameron and J. A. Stones, *Aberdeen: an in-depth view of the city's past* (Soc. Antiq. Scot. Monog. Ser.) (Edinburgh, forthcoming).

majority of the timbers were still *in situ* when they were sampled although it was clear that many had been re-used and were now in secondary positions. In particular, a group of timbers which had been used as lintels during the 18th-century re-modelling of the Castle buildings displayed the redundant mortice- and peg-holes clearly indicative of a previous function. In this case it was felt that establishing a date for the timbers might help in identifying likely provenances when considered along with other evidence. Two very large baulks, 300 × 220 mm and 340 × 215 mm in cross-section, which had been removed from the Chapel Royal, were sampled from this group (suffixed CR), along with seven timbers of smaller scantling (130 × 170 mm on average) which had been removed from the Great Hall (suffixed GH). This group of timbers was sampled by sawing slices off the ends.

Timbers in the ceilings of the King's and Queen's Bedchambers within the Palace were sampled by coring from a moveable scaffolding platform. In the Queen's Bedchamber nine of the main joists (suffixed QBMJ) were cored. In the King's Bedchamber all five of the diagonally set principal beams (suffixed KBMJ) were cored, together with six of the floor joists (suffixed KBSJ) and one of the diagonal braces (suffixed KBD). In all, 21 cores were removed.

The stubs of eighteen large pine timbers, embedded in the wall tops of the Great Hall, were removed during the current building work. Of these, twelve were selected for dendrochronological analysis and sampled by removing a slice off one end. Two squared oak baulks, thought to be *in situ* in their original positions within the Great Hall, were also sampled; one from the southern gable end of the roof (GHCORE1) and the other from the scarcement of the north wall (GHNW1).

#### METHODOLOGY

The cores were mounted in lengths of angle moulding and were prepared for measurement by paring flat their surfaces using a Stanley knife followed by a fine sanding. The surfaces of the slices were prepared by sanding using progressively finer grades of sandpaper until the ring-pattern was clear. The ring-pattern was then enhanced by rubbing powdered chalk into the polished surface, a procedure which highlights both the large springwood pores and the smaller latewood pores. The samples were measured on a Henson measuring table and the measured ring-widths were logged on to a PC using a data-capture program, TREERING.<sup>33</sup> Cross-matching and chronology construction were undertaken using DENDRO, supported by visual cross-matching.<sup>34</sup>

#### RESULTS

##### *Oak*

The tree-ring data are presented in Table 1 and the chronological relationships of the dated timbers are illustrated in Fig. 2. During the course of the analyses five

<sup>33</sup> D. McNeill, *TREERING software* (Edinburgh, 1992).

<sup>34</sup> I. G. Tyers, *Dendrochronology programs* (London, 1990).

TABLE 1  
DENDROCHRONOLOGICAL SAMPLES OF OAK FROM STIRLING CASTLE

Sample No.	No. of rings	Sap wood	Bark	Conv Code*	Calendrical date	Felling date or range
GREAT HALL						
GHV	132	—	—	C1	1386-1517	—
GHVI	157	15	Y	C1	1382-1538	1538
GHVII	132	H/S	—	B1-C1	1440-1571	1580-1594
GHXIII	151	—	—	C1	1408-1558	—
GHXVI	113	17	S/B	C1	undated	—
GHXVII	129	—	—	B1-C1	1441-1569	—
GHXIX	171	—	—	B1-C1	1390-1560	—
GHCORE <sub>1</sub>	52	—	—	A1	undated	—
GHNW <sub>1</sub>	111	—	—	C1	undated	—
QUEENS BEDCHAMBER						
QBMJ <sub>1</sub>	135	H/S?	—	B1	1386-1520	1529-1543
QBMJ <sub>2</sub>	75	H/S?	—	A1	1386-1460	1469-1483
QBMJ <sub>3</sub>	135	H/S?	—	A1	1374-1508	1517-1531
QBMJ <sub>4</sub>	97	H/S?	—	A1	1382-1478	1487-1501
QBMJ <sub>5</sub>	147	H/S?	—	A1	1363-1509	1518-1532
QBMJ <sub>6</sub>	140	15	Y	A1	1399-1538	1538
QBMJ <sub>7</sub>	137	H/S?	—	A1	1378-1514	1523-1537
QBMJ <sub>8</sub>	155	17	S/B	A1	1384-1538	1538
QBMJ <sub>9</sub>	135	H/S?	—	A1	1355-1489	1498-1512
KINGS BEDCHAMBER						
KBMJ <sub>1</sub>	86	H/S?	—	A1	1404-1489	1499-1544
KBMJ <sub>2</sub>	59	—	—	A1	undated	—
KBMJ <sub>3</sub>	81	2	—	A1	1413-1492	1500-1545
KBMJ <sub>4</sub>	82	H/S?	—	A1	1402-1483	1493-1538
KBMJ <sub>5</sub>	85	H/S?	—	A1	1402-1486	1496-1541
KBSJ <sub>1</sub>	75	H/S?	—	A1	undated	—
KBSJ <sub>2</sub>	95	—	—	A1	1391-1485	—
KBSJ <sub>3</sub>	138	25	S/B	A1	1363-1500	1500
KBSJ <sub>4</sub>	63	—	—	A1	undated	—
KBSJ <sub>5</sub>	53	19	S/B	A1	undated	—
KBSJ <sub>6</sub>	85	H/S?	—	A1	1407-1491	1500-1514
KBD <sub>1</sub>	76	—	—	A1	undated	—
CHAPEL ROYAL						
CRI	342	—	—	A1	1065-1406	—
CRII	195	—	—	A1	1055-1249	—

\* For conversion codes see B. A. Crone and J. W. Barber, 'Analytical techniques for the investigation of non-artefactual wood from prehistoric and medieval sites', *Proc. Soc. Antiq. Scot.*, 111 (1981), 510-15.

individual site chronologies were constructed, GRTHALL, BEDMAST<sub>1</sub>, KINGBED<sub>2\_3</sub>, KINGBED and CHAPELRO, and these are described below.

*The Great Hall:* GRTHALL consists of sequences from six of the baulks re-used as lintels in the Great Hall and is 190 years in length. Comparisons with the native British chronologies did not produce results and the only strong correlation was with MIDHOPE ( $t = 7.01$ ) at A.D. 1381-1571, indicating a Baltic source. At least two felling episodes are visible within the chronology. The bark was still present on

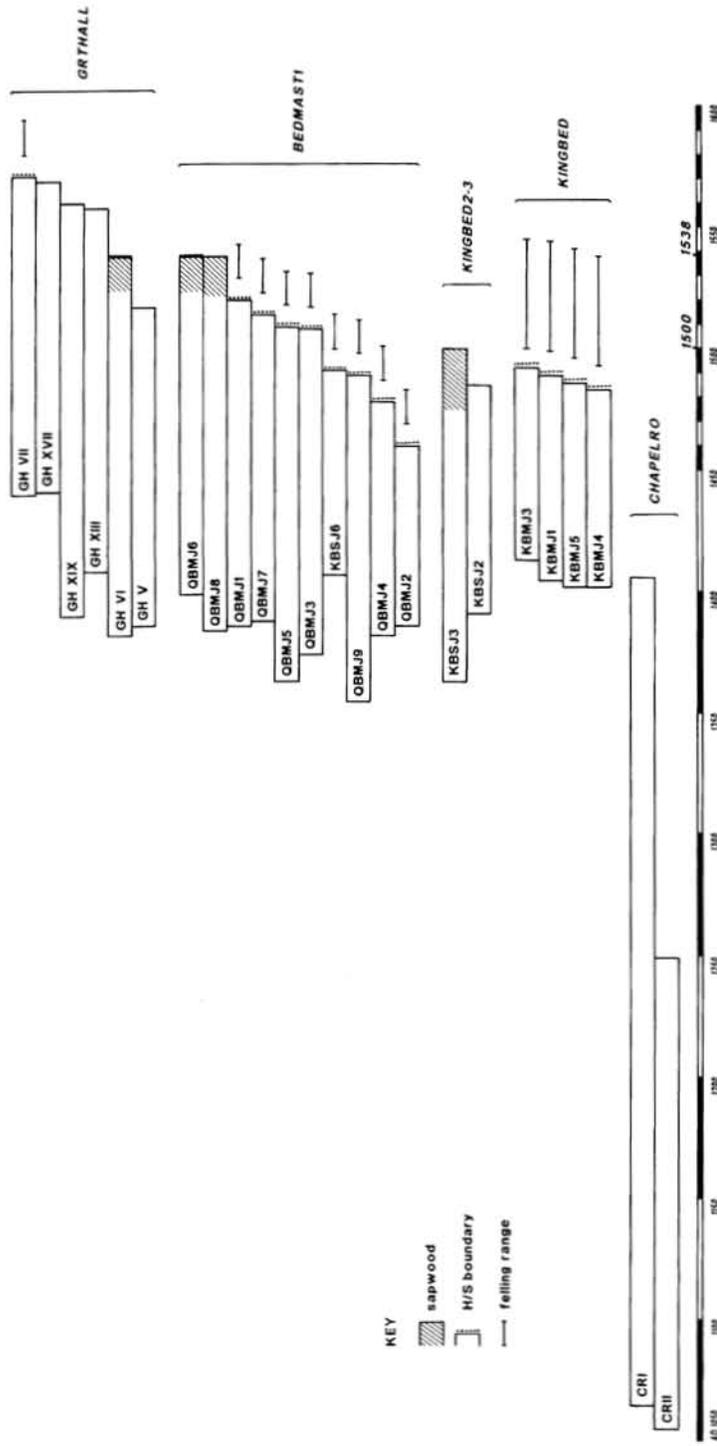


FIG. 2  
Bar diagram showing the chronological relationships between the dated sequences from Stirling Castle.

GH VI so the outermost year of that sequence, A.D. 1538, is the year in which the tree was felled. GH V may also belong to this phase of building. The other four timbers in the chronology were felled much later but, in the absence of bark edge on any of them, an exact felling date is not possible. However, the outermost year of GH VII is on the heartwood/sapwood (H/S) boundary so it is possible to add a sapwood range, thereby providing a date range within which the tree was probably felled. Sapwood ranges for oak vary across Europe, reducing in number from west to east. Thus, in Britain a range of 10–55 years is used while in Poland only 9–23 years is applied.<sup>35</sup> As the timbers in GRTHALL are probably Baltic in origin, the Polish estimate has been used, giving a felling range between A.D. 1580–1594.

*The Palace:* BEDMAST<sub>1</sub> is 184 years in length and consists of all nine sequences from the Queen's Bedchamber together with one of the sequences from the King's Bedchamber. The chronology correlated well with MIDHOPE ( $t = 8.26$ ) and with GRTHALL ( $t = 11.3$ ) at A.D. 1355–1538, again indicating a probable source in the Baltic. There is one clear felling episode within BEDMAST<sub>1</sub>. QBMJ6 and QBMJ8 retain the bark and sub-bark surface, respectively, so the outermost year-ring on both sequences, A.D. 1538, is the last year in which wood was laid down before the tree was felled. The latewood is present in this outer ring so the tree could have been felled either late in 1538, at the end of the growing season, or early in 1539, before the onset of the new growing season. All the other timbers used in the chronology retained the curvature characteristic of the boundary between the heartwood and sapwood meaning that the outer ring of those sequences should fall on or very near the last heartwood ring. It is therefore possible to add a sapwood range on to the outermost ring of each sequence. Again, given the probable Baltic source, the Polish estimate has been used. With this felling range it seems likely that QBMJ<sub>1</sub>, QBMJ<sub>7</sub>, QBMJ<sub>5</sub> and QBMJ<sub>3</sub> were part of the A.D. 1538/9 felling phase but it is more difficult to ascribe the four remaining timbers in BEDMAST<sub>1</sub> to a felling phase. It is possible that the position of the H/S boundary is incorrect and that many heartwood rings have been lost. However the timbers were, with one exception, boxed heart baulks and did not appear to have been heavily trimmed. To have been felled in A.D. 1538/9 QBMJ<sub>9</sub>, QBMJ<sub>4</sub>, QBMJ<sub>2</sub> and KBSJ<sub>6</sub> would have had to have lost 49, 60, 78 and 47 rings respectively. The other possibility is that these timbers represent an earlier phase, or phases, of felling activity and were re-used in the A.D. 1538/9 building phase. QBMJ<sub>9</sub>, QBMJ<sub>4</sub> and KBSJ<sub>6</sub> could conceivably have been felled together sometime between A.D. 1487 and A.D. 1514 but, if the H/S boundary on QBMJ<sub>2</sub> has been correctly identified, it must belong to an even earlier felling phase. The argument against this interpretation is the fact that the timbers are morphologically very similar and there is no detectable evidence for re-use in the form of redundant mortice-holes, peg-holes etc. Stockpiling is possible but it seems unlikely that timber would have

<sup>35</sup> J. Hillam, R. A. Morgan and I. Tyers, 'Sapwood estimates and the dating of short ring sequences', 165–85, in R. G. W. Ward (ed.), *Applications of Tree-ring Studies: Current Research in Dendrochronology and Related Subjects* (Brit. Archaeol. Rep. Internat. Ser. 333) (Oxford, 1987); T. Wazny and D. Eckstein, 'The dendrochronological signal of oak (*Quercus* spp.) in Poland', *Dendrochronologia*, 9 (1991), 35–49.

been stockpiled for nearly half-a-century, particularly given the medieval carpenter's preference for working green oak.<sup>36</sup>

The samples from the King's Bedchamber formed a more disparate assemblage and two chronologies were constructed, neither of which matched with the other. The evidence of KINGBED<sub>2\_3</sub> may elucidate the question of the possible early felling date in BEDMAST<sub>1</sub>. This chronology consists of only two sequences, KBSJ<sub>2</sub> and KBSJ<sub>3</sub>, and is 138 years long. It correlates with BEDMAST<sub>1</sub> ( $t = 5.32$ ), MIDHOPE ( $t = 4.73$ ) and GRTHALL ( $t = 3.99$ ), all chronologies of Baltic provenance, giving the outermost year a date of A.D. 1500. As the sub-bark surface survived on KBSJ<sub>3</sub>, the tree was felled either late in A.D. 1500 or early in A.D. 1501. It is, therefore, possible that this is the date of the earlier felling phase in BEDMAST<sub>1</sub>. Furthermore, all of the secondary joists in the King's Bedchamber displayed redundant mortice- and peg-holes, indicating the re-use of old structural timbers. If a disparate variety of sources was used in the ceiling this may explain the lack of correlation between the remaining secondary joists.

The second chronology, KINGBED, is 91 years in length and consists of four of the five principal beams in the ceiling. It correlated well only with the Scottish master curve, SCOTLAND, ( $t = 5.28$ ) at A.D. 1402–1492, indicating that native timber was probably used. Consequently, the British Isles sapwood estimate of 10–55 rings was applied to calculate the felling range. All retained the H/S boundary and the addition of the sapwood estimate gave a broad felling range within the first four decades of the 16th century. The timber could, therefore, have formed part of either the A.D. 1500/1 or the A.D. 1538/9 felling phases. However, the sapwood estimate used is based on mature trees of over 100 years and, as all four sequences came from relatively young timbers (see Table 1), it is quite likely that, in this case, this is an over-estimate and fewer sapwood rings were present.<sup>37</sup> On the balance of probabilities, therefore, it is suggested that all the timbers in the ceiling of the King's bedchamber were felled in A.D. 1500/1.

*The Chapel Royal:* CHAPELRO consists of the two sequences from the Chapel Royal which matched very well together ( $t = 9.52$ ) and formed a chronology 352 years in length. It correlated extremely well with the chronology from Darnaway, Morayshire, ( $t = 10.67$ ) at A.D. 1055–A.D. 1406, and to a lesser extent with the Scottish master, SCOTLAND ( $t = 4.35$ ). Neither of the two timbers within CHAPELRO retained the H/S boundary so the date of the outermost surviving ring, A.D. 1406, provides only a terminus post quem for the felling of the timber. However, medieval carpenters were very economical in trimming baulks, often squaring them so that the waney edge remained at the corners, and given the size and age of CRI, it seems unlikely that many rings have been trimmed off. If the British Isles sapwood range is added to the outermost year of CRI a felling date sometime between A.D. 1416 and A.D. 1461 is indicated. Given that a few heartwood rings may also be missing the most accurate statement that can be made

<sup>36</sup> L. F. Salzman, *Building in England down to 1540*, 237 (Oxford, 1952).

<sup>37</sup> Hillam *et al.*, *op. cit.* in note 35, 172.

about the date of the CRI is that it was probably felled in the latter half of the 15th century. There are 157 year-rings between the end-years of CRI and CRII. Given the argument for economy of trimming outlined above, it seems unlikely that so great a number of year-rings was trimmed off CRII. The large discrepancy between the end-years suggests, therefore, that CRII represents an earlier phase of building sometime after the late 13th century. Although the two timbers were found as lintels within the Chapel Royal, they were re-used in that position and their original locations and functions are not known.

### *Pine*

All the pine samples analysed to date have come from the roof of the Great Hall. Apart from two sequences with short, complacent ring-patterns, the age structure of the pine assemblage was remarkably similar, with eight of the twelve sequences falling between 153 and 165 years in length. Such a close concentration of ages in one assemblage often indicates that the timbers were felled from the same stand of woodland. Furthermore, apart from the two complacent sequences, the ring-patterns of the remainder exhibit pronounced growth trends indicating that they all grew in a similar environment. Of the twelve sequences measured, six correlated well with one another and a site master chronology, 194 years in length, was constructed.

SCPINE6 was matched against all existing Scots pine chronologies from Scotland, Sweden and Norway but no significant correlations were found and it currently remains undated. There are a number of likely reasons for the lack of success in dating the pine chronology. The pronounced growth trends exhibited by the ring-patterns have already been mentioned; a strongly localized environmental signal may be obscuring the more general climatic signal which is used to correlate ring-patterns. However, it also remains a possibility that the chronology could not be dated because the timbers come from a period and region not yet covered by any master chronologies. At present the only Scots pine chronologies which have been constructed using native Scottish material are based on living trees and extend no further back than A.D. 1671.<sup>38</sup> A single tree from Ballochbuie may extend as far back as A.D. 1580.<sup>39</sup> Beyond this point we must rely on European pine chronologies. Consequently, if the timbers are early medieval and Scottish in origin there are, at present, no dated master chronologies available for comparison.

### SUMMARY

Of the 32 oak timbers sampled, eight remain undated (Table 1). One of these is the sample taken from the Great Hall roof, GHCORE1. Although it could not be dated it correlated well with KBSJ5, a sequence from one of the secondary joists

<sup>38</sup> M. K. Hughes, 'Dendroclimatology of *Pinus sylvestris* L. in the Scottish Highlands', 91-106, in R. G. W. Ward (ed.), *Applications of tree-ring studies: Current Research in Dendrochronology and Related Subjects* (Brit. Archaeol. Rep. Internat. Ser. 333) (Oxford, 1987).

<sup>39</sup> N. Loader, *The Stable Isotope Dendroclimatology of *Pinus sylvestris* from Northern Britain*, 315 (Univ Cambridge, unpubl PhD thesis, 1995).

in the King's Bedchamber. Most of the timber used in the King's Bedchamber was comparable in estimated age to GHCORE<sub>1</sub> and this fact, together with the strong similarity between the growth patterns of the two matching sequences, suggests a source in the same woodland. It is therefore possible that the Great Hall timber was felled at the same time as that used in the King's Bedchamber, i.e. sometime in the early decades of the 16th century, but this can remain no more than a supposition.

The construction of the chronologies has revealed two exact felling dates, at A.D. 1500/1 and A.D. 1538/9, as well as phases of felling activity in the late 13th century, mid 15th century and the late 16th century. It has also provided evidence that at least two distinct sources of timber were used in the construction of the Castle buildings: native Scottish material in the CHAPELRO and KINGBED chronologies, and Baltic material in the GRTHALL, BEDMAST and KINGBED<sub>2\_3</sub> chronologies. Correlations between the Scottish 'Baltic' chronologies were strong (Table 2) and so they were combined to form a chronology, SCOTBALT, 307 years in length.

## DISCUSSION

### THE SIGNIFICANCE OF THE DENDROCHRONOLOGICAL RESULTS FOR THE FULLER UNDERSTANDING OF THE BUILDINGS

The felling dates established for a number of the oak timbers taken from the ceilings of the two bedchambers of the Palace are particularly interesting, since the majority support the date for a commencement of work in about 1538 which is suggested by the limited documentation. However, the 'early' felling ranges for some of the ceiling timbers, i.e. KBSJ<sub>6</sub>, QBMJ<sub>9</sub>, QBMJ<sub>4</sub>, QBMJ<sub>2</sub> and KBSJ<sub>2</sub>, suggest that these are more likely to have come initially from works carried out for James IV. It seems likely, for example, that a Queen's Lodging which James is known to have been adapting for his new queen in 1504 was at least partly on the site of the Palace and would have been demolished before work commenced, while it is also known from archaeological evidence that one of the castle's Chapels was truncated when the Palace was built (see above); both of these buildings may have released timber for re-use in the Palace.<sup>40</sup>

The *in situ* timbers from the Great Hall which were sampled consisted of GHCORE<sub>1</sub>, which was thought to be the end of a purlin of the original hammer-beam roof embedded in the S. gable, GHNW<sub>1</sub>, which may have been a joist for the loft above the screens' passage, and the twelve horizontal, diagonally set braces of pine which appeared to have been added at wall-head level in a relatively late attempt to stabilize the original roof. Regrettably, it is not possible to date any of these timbers at present. Six of the oak timbers which had been re-used as safe lintels for the windows cut through the walls in the late 18th century were dated but their likely original positions are difficult to determine, since much depends on

<sup>40</sup> *Treasurers Accounts*, op. cit. in note 6, II, 441.

what timber was available at that time; it is, of course, by no means certain that they came from within the castle. Nevertheless, the felling date of 1538 for GHVI corresponds with the dates for timbers from the Palace, while the felling date of 1580–94 for GHVII corresponds with the known building date of the Chapel Royal, although there is currently no way of knowing if works on either of those buildings would have released timber for re-use.

The lack of felling ranges for the two large baulks of oak taken from the Chapel Royal, where they had been re-used as safe lintels, does not encourage detailed speculation about their original position. However, since the previous Chapel Royal had to be demolished to permit construction of the new building in 1594, it is an attractive possibility that timber from the earlier building would have been put to new use. The suggested felling date for CR1 in the second half of the 15th century, for example, could certainly be seen to accord with the re-roofing of the Chapel being carried out for James III in about 1467–69 (see above). It need hardly be stated, however, that there can be no way of knowing whether the 13th-century timber (CRII) also came from the earlier Chapel.

#### EVIDENCE FOR THE TIMBER TRADE

Statistical analysis of the tree-ring data has indicated potential sources for some of the timber used at Stirling. The documentary evidence is presented below and then compared with the evidence from the tree-rings.

##### *The documentary evidence*

There are two sets of records from which information about the supplies of timber for building works at Stirling can be extracted: the Accounts of the Masters of Works (1957–) and the Accounts of the Lord High Treasurer of Scotland (1877–). The former is the more relevant here, as it deals with payments for all types of constructional works at all the Royal buildings, but unfortunately there are substantial gaps in the records where documents have been lost and this is particularly so in relation to Stirling. Furthermore, these records begin in 1529 and 1473 respectively, and therefore do not cover the early periods for which we now have dendrochronological data. There are few detailed references to Stirling but the records, as a whole, do provide general information about the variety of sources and types of timber available to the Royal builders.

‘Scottis tymmer’ is certainly recorded as being used at Stirling although there is no mention of the species and where it was used in the buildings. In the accounts of 1531–32 there are numerous references to timber being brought from Clackmannan to Stirling and in 1535–36 timber was transported to Leith from Lochaber for use in the royal works at Stirling, Holyrood and Falkland.<sup>41</sup> It may seem illogical that timber was brought to Stirling from as far afield as Lochaber, the region north of Fort William, when there were apparently plentiful supplies of timber nearby. In the same years ‘Scotis ayk’ (oak) was shipped from Stirling to

<sup>41</sup> *Works Accounts*, op. cit. in note 12, I, 104, 107, 111; *ibid.* 182.

Leith for use at Holyrood while 'vii gret akyn treis' were felled in the Torwood (near Stirling) for use at Linlithgow.<sup>42</sup> However, the timber brought from Lochaber may have been of a particular species and/or dimensions that could not be easily found elsewhere.

The most frequent reference to timber throughout both sets of accounts is to 'estland burdis', or 'Eastland boards', the common name for timber imported from the Baltic and North Sea. By the early 14th century in England, 'Eastland boards' had become differentiated into 'wainscots', which were usually German oak, and 'righolts', oak from the neighbourhood of Riga in the eastern Baltic.<sup>43</sup> This differentiation does not occur in the Scottish records, although 'wainscots' are mentioned occasionally. A reference to 'Eistland, Swadyn and Reys burdis' for use at Holyrood in the accounts of 1535–36 clearly distinguishes between Swedish timber and Eastland boards, suggesting that the latter came from elsewhere in the Baltic.<sup>44</sup> Otherwise the records are silent on the source of this imported timber. There are several references to Swedish timber, and on one occasion to Swedish oak, and in 1539 one Charles Murray was paid for buying timber in Denmark for use in the work at Stirling.<sup>45</sup> The only direct references to the use of imported timber at Stirling are the 'xxiii wanscot burd' brought from Leith in 1531–32, 'ane dozane estland buirdis' bought for the 'chapell dur' in 1537–38, and 'estland burde' bought in 1541.<sup>46</sup>

#### *The tree-ring evidence*

Although 32 timbers cannot be considered a large sample it is possible to detect trends in the supply of wood to the Castle over time. Up until the mid 13th century the carpenters appear to have had access to very high quality (i.e. slow-grown) native Scottish oak of considerable girth, such as the timber used in the CHAPELRO chronology. The extraordinarily high correlation between CHAPELRO and DARNAWAY in contrast to the relatively weak correlation with the south-central SCOTLAND chronology and the absence of any correlation with the PERTH chronology ( $t = 1.51$ ) prompts the suggestion that the timber used at Stirling came from NE. Scotland, possibly from Darnaway itself where a Royal Forest existed at that time.<sup>47</sup> Scotland does not, as yet, have the dense network of tree-ring chronologies that, elsewhere in the British Isles and mainland Europe, facilitates the confident sourcing of material, but the high correlation ( $t = 9.11$ ) with a chronology recently constructed for Spynie Palace, also in Morayshire, provides further support for a north-eastern source.<sup>48</sup> The documentary sources do not cover this early period but as late as 1507–08 the forests at Darnaway were

<sup>42</sup> Ibid. 189; *ibid.* 126.

<sup>43</sup> Salzman, *op. cit.* in note 36, 246.

<sup>44</sup> *Works Accounts*, *op. cit.* in note 12, I, 181.

<sup>45</sup> Ibid. 219; *Treasurers Accounts*, *op. cit.* in note 6, VII, 159.

<sup>46</sup> *Works Accounts*, *op. cit.* in note 12, I, 108; *ibid.* 228; *Treasurers Accounts*, *op. cit.* note 6, VII, 456.

<sup>47</sup> M. L. Anderson, *A History of Scottish Forestry*, 127 (London, 1967).

<sup>48</sup> Baillie, *op. cit.* in note 29, 130; C. M. Mills, 'Dendrochronology of timbers from Spynie Palace', in Lewis, J., *Excavations at the Episcopal Palace of Spynie, Moray* (Edinburgh, forthcoming).

TABLE 2  
 STATISTICAL RELATIONSHIPS OF THE SCOTTISH 'BALTIC' MATERIAL (*t*-VALUES OVER 2.5)

	GRTHALL	BEDMAST <sub>1</sub>	MIDHOPE	KINGBED <sub>2-3</sub>	
GRTHALL	O				} SCOTBALT
BEDMAST <sub>1</sub>	11.3	O			
MIDHOPE	7.01	8.26	O		
KINGBED <sub>2-3</sub>	3.99	5.32	4.73	O	
W GOTLAND (AD1125-1720)	9.07	10.56	9.03	4.14	10.94
SEALAND (AD1316-1538)	9.85	11.21	8.35	5.34	11.05
SCANIA/BLEKINGE (AD1274-1974)	6.72	12.01	5.43	5.21	6.17
N JUTLAND (AD1287-1818)	5.79	6.43	3.08	2.89	4.02
JUTLAND (109BC-AD1986)	4.96	4.65	/	/	4.30
SCHLESWIG-HOLSTEIN (AD436-1968)	2.52	2.83	/	/	2.89
LUBECK (AD457-1723)	2.73	/	2.63	/	/
GDANSK-POMERANIA (AD996-1985)	2.76	3.88	4.83	2.63	5.73
BALTIC <sub>1</sub> (AD1156-1597)	2.59	/	/	/	/
BALTIC <sub>2</sub> (AD1257-1615)	/	/	2.68	/	2.61

still being exploited.<sup>49</sup> Lochaber is mentioned in the records as a source of timber for Stirling (see above); it is possible that sequences from this region might correlate well with the north-eastern chronologies but this is, as yet, unproven.

By the early 16th century when timber is being sought for the construction of, *inter alia*, the King's and Queen's Bedchambers, old timber had to be re-used and imported timber employed. The character of the late 15th-century native Scottish timber used in the King's Bedchamber may explain why such a variety of sources was necessary. The timbers were young and fast-grown, with between only 53 and 86 rings. If the royal carpenters were having to use such timber, it is possible that native sources of large, mature trees were depleted and, as a result, the woodlands had more open canopies allowing the rapid growth of young trees. However, the documentary records for the same period talk of 'gret akyn treis' being felled in the Torwood, near Stirling — perhaps such timber was reserved for special purposes.<sup>50</sup> There is no chronological overlap between KINGBED and the other native Scottish chronologies, CHAPELRO, DARNAWAY, PERTH and SPYNIE, so it is not possible, at present, to source the material.

<sup>49</sup> *Treasurers Accounts*, op. cit. note 6, iv, 44.

<sup>50</sup> *Works Accounts*, op. cit. in note 12, i, 126.

In contrast, the timber being imported from the Baltic was from relatively slow-grown, mature trees of around 140 years of age and this was used exclusively in the Queen's Bedchamber. As the Great Hall lintels show, timber from this source was used throughout the 16th century. Baltic timber is invariably referred to in the records as boards, implying that it was imported ready prepared as cleft planking rather than as undressed logs or squared baulks. Its uses are often specified, for instance '... to be dures, wyndois and casis for the castel ...' at Edinburgh in 1517 and 'for pannalis sylling' at Holyrood in 1531-32, making it clear that it was used where relatively thin planking was required.<sup>51</sup> It was particularly favoured for doors and screens because it was better seasoned than the local timber and therefore did not warp so easily.<sup>52</sup> However, all of the 'Baltic' timber from Stirling consisted of boxed heart baulks, half-baulks and quarter-baulks so it may not have been coming from the same source as the 'estland burdis' (see above).

In order to pinpoint the source of the timber more closely the individual chronologies from Stirling Castle, together with the Midhope chronology, were cross-matched against a group of oak master chronologies from lands around the Baltic (Table 2). The statistical results show a very significant correlation between the Scottish 'Baltic' material and chronologies from the lands bordering the Kattegat and the Öresund, i.e. southern Sweden (SCANIA/BLEKINGE and W GOTLAND) and eastern Denmark (SEALAND). In contrast, the correlations with chronologies further east in the Baltic are very low (SCHLESWIG-HOLSTEIN, LUBECK, GDANSK-POMERANIA, BALTIC 1 and BALTIC 2). The tree-ring evidence, therefore, points to southern Sweden and/or the Danish island of Sjælland as the source for the imported oak used at Stirling and Midhope.

### *The context*

Scotland had been trading in the Baltic since the late 13th century and its strongest links were with the Hanseatic towns of the eastern Baltic, particularly Danzig and Königsberg, a situation which continued throughout the 16th century.<sup>53</sup> However, as a result of the marriage between James III of Scotland and Margaret, daughter of the Danish king, Christian, in 1468 Denmark and Scotland had been allies, a relationship which was further strengthened by a military treaty in 1492.<sup>54</sup> This treaty included a clause allowing freedom of trading between the two countries and as a consequence Scots began settling and trading in Danish towns such as Aalborg, Copenhagen and Elsinore. During the 15th and 16th centuries the southernmost provinces of modern Sweden, Halland, Skåne and Blekinge, were under Danish rule and Scots also settled in this area, in towns such

<sup>51</sup> *Treasurers Accounts*, op. cit. note 6, v, 118; *Works Accounts*, op. cit. in note 12, 1, 67.

<sup>52</sup> Salzman, op. cit. in note 36, 246.

<sup>53</sup> D. Ditchburn, 'Trade with Northern Europe, 1297-1540', 161-79 in M. Lynch, M. Spearman and G. Stell (eds.), *The Scottish Medieval Town*, (Edinburgh, 1988) esp. p. 166.

<sup>54</sup> D. Ditchburn, 'A note on Scandinavian trade with Scotland in the later Middle Ages', 73-89 in G. G. Simpson (ed.), *Scotland and Scandinavia 800-1800* (Edinburgh, 1990).

as Malmö and Ystad.<sup>55</sup> This then is the context in which the timber-purchasing trip by Charles Murray was commissioned in 1539 (see above). However, when the Sound Toll Registers (the record of duties imposed on shipping passing through the Öresund, the sound between Denmark and Sweden) first begin recording the port of departure in 1557, Danish ports are rarely mentioned as port of departure for west-bound Scottish ships.<sup>56</sup> This suggests that timber was picked up to complete the cargo on the return journey back from the eastern Baltic to Scotland.

During this period Denmark and Sweden were intermittently at war with each other and so the alliance with Denmark was a hindrance to commercial relations between Sweden and Scotland.<sup>57</sup> Despite this, there are records of Swedish timber entering Scotland in the early 16th century, and trade picked up in the mid 16th century when the struggle between the two countries was resolved. The customs book for the Swedish port of Lödöse (near modern Göteborg) in 1546 records sixteen ships bound for Scotland, all loaded with timber.<sup>58</sup> Spruce, oak and a little lime are recorded, the oak being shipped as either boards or 'rough lengths', presumably undressed logs. The boxed heart baulks, half-baulks and quarter-baulks from Stirling could have been converted from such logs.

Given the circumstances outlined above, the imported timber from Stirling and Midhope could have originated in either Denmark or Sweden. As we have seen, both countries are mentioned in the Works and Treasurers Accounts; indeed they are the only countries specifically mentioned. Whichever country it was, the timbers from this region were clearly favoured by the royal builders throughout the 16th century. The strong correlation between GRTHALL and BEDMAST1 indicates that the same, or a very similar, source used in 1538 was still being used some fifty years later in the late 16th century.

## CONCLUSIONS

By providing exact felling dates for timbers within identifiable phases of building activity the dendrochronological work at Stirling Castle has gone some way towards fleshing out the rather sparse documentary record of the building history of the site. A valuable corollary of the work is the socio-economic evidence for the source of the timber used in the buildings. Dendrochronological analysis is increasingly being used to trace the movement of timber throughout Europe in the medieval period.<sup>59</sup> Even in areas where documentary evidence for the trade is more plentiful, in the Sound Toll Registers for instance, tree-ring data are proving useful in verifying those records and, by identifying the final destination of many

<sup>55</sup> J. Dow, 'Skotter in sixteenth century Scania', *Scot Hist Rev*, 44 (1965), 34-51.

<sup>56</sup> T. Riis 'Scottish-Danish relations in the sixteenth century', 82-96 in T.C.Smout (ed.), *Scotland and Europe 1200-1850* (Edinburgh, 1986).

<sup>57</sup> J. Dow, 'Scottish trade with Sweden 1512-80', *Scot Hist Rev*, 48 (1969), 64-79.

<sup>58</sup> *Ibid.* 73.

<sup>59</sup> N. Bonde, 'Dendrochronology and timber trade in northern Europe from the 15th to 17th Century', 53-55 in T. Bartholin, B. Berglund, D. Eckstein and F. Schweingruber, (eds.), *Tree Rings and Environment* (Lundqua Vol. 34, Lund, 1992); T. Wazny, 'Historical timber trade and its implications on dendrochronological dating', 331-33 in T. Bartholin, B. Berglund, D. Eckstein and F. Schweingruber, (eds.), as above.

timber exports, a more accurate picture of the physical extent of the trade is emerging. At Stirling tree-ring analysis has identified such imported timber and, by revealing the variety of sources exploited and the variability in the quality of timber used, has given concrete expression to the rather unspecific documentary references about the supply of timber for the building works.

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