DENDROCHRONOLOGICAL ANALYSIS OF TIMBERS FROM CUDMORE GROVE COUNTRY PARK, ESSEX

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Summary
Five timbers, one from site B and four from site C, were sampled for dendrochronological analysis. Only one of these oak timbers, the one from site B, proved to be suitable for analysis, but unfortunately this could not be dated reliably. A recently dead modern tree, located at the base of the cliff adjacent to site C, was also sampled. It was successfully dated indicating that it died sometime during late spring or early summer AD 2001.

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Introduction

This document is a technical archive report on the dendrochronological analysis of timbers associated with archaeological investigations undertaken on the foreshore at the eastern tip of Mersea Island, Essex (Fig 1). It is beyond the dendrochronological brief to describe the site in detail or to undertake the production of detailed drawings. This analysis is a component part of a multi-disciplinary series of studies on the site and thus the conclusions presented here may be modified in the light of other archaeological or environmental evidence.

Cudmore Grove Country Park is situated at the eastern end of Mersea Island and includes part of the foreshore and the East Mersea Cliffs. A series of substantial wooden structures of unusual construction have been revealed by natural erosion in the mudflats in the intertidal zone. These were surveyed in March AD 2002 (Heppell and Brown 2002a) and, due to the threat of further erosion, an archaeological investigation was deemed necessary prior to the eventual natural destruction of the structures (Heppell and Brown 2002b). The fieldwork was undertaken by Essex County Council Field Archaeology Unit (ECCFAU) during November AD 2002 to March AD 2003 and was funded by English Heritage.

The location of the three sites (site code EMCG02) is indicated in Figure 2. Sites A and B lie on the seaward side of the earthwork remains of a Tudor fort originally constructed in AD 1547. The following descriptions are summarised from (Heppell and Brown 2002b) and Heppell (pers comm). Site A (TM0726615132) consists of two lines of vertical posts, orientated south-west to north-east. Horizontal timbers, with mortices cut into them, lie adjacent to the south-easterly, or seaward, row of posts. Some brushwood is extant between the two lines of timbers and some wattlework survives between the posts. Whilst there were no closely datable finds, comparison with other dated timber structures in the Essex intertidal zone suggests an early post-medieval date as most likely. Site B (TM0729615162) lies about 50 metres north-east of site A. It consists of a group of small posts, possibly forming irregular rows, with two larger uprights some 30 metres north-west. The uprights appear to be associated with a dump deposit containing sixteenth- and seventeenth-century pottery. Site C (TM0658414319) lies about a kilometre to the south-west of sites A and B below the East Mersea cliffs. It consists of an irregular line of posts of variable size which, bearing in mind that the cliffs are in an area of rapid coastal erosion, could feasibly represent an attempt to protect the cliff base. In the vicinity of site C an oak tree has come to rest on the beach. It appears to have dropped vertically onto the foreshore, presumably having been undercut by erosion, as beyond the current cliff face there is an area of standing oak trees.

Dendrochronological analysis was proposed as an integral part of the English Heritage funded archaeological investigation, with the primary aim of providing dating evidence for the wooden structures. It was hoped that this would assist in the understanding of the relationship, if any, of the wooden structures at sites A and B and also with the earthwork fort. The analysis of the structure at site C would potentially contribute to the understanding of the coastal landscape and allow comparison with historic map sources. The analysis of the modern tree was undertaken as this would also have the potential to add to current erosion information. In addition this tree was potentially interesting as it has grown in an exposed location and an unusually eastern location.

Methodology

Professional practice at the Sheffield Dendrochronology Laboratory is described in English Heritage (1998). The following summarises relevant methodological details used for the analysis of the samples from Cudmore Grove Country Park.

Oak is currently the only species used for routine dating purposes in the British Isles, although research on other species is being undertaken (Tyers 1998a; Groves 2000). Timbers with less than 50 annual growth rings are now generally considered unsuitable for analysis, as their ring patterns may not be unique (Hillam *et al* 1987). Thus oak timbers are generally sought which have at least 50 rings and if possible either bark/bark edge or some sapwood surviving (see below).

Cross-sectional slices were taken from those oak timbers deemed most likely to be suitable for dendrochronological analysis. Oak (*Quercus* sp.) is relatively easy to recognise as it is a ring porous species with wide medullary rays running from pith to bark and a flame-like distribution of pores in the latewood (Schweingruber 1990).

The dendrochronological samples were prepared by being frozen for a minimum of 48 hours before their cross-sectional surface was cleaned with a surform plane, scalpels, and razor blades until the annual growth rings were clearly defined. The sequence of growth rings in each sample was measured to an accuracy of 0.01mm using a purpose built travelling stage attached to a microcomputer based measuring system (Tyers 1999). The ring sequences were plotted onto semi-logarithmic graph paper to enable visual comparisons to be made between them. In addition, cross-correlation algorithms (Baillie and Pilcher 1973; Munro 1984) were employed to search for positions where the ring sequences were highly correlated. The Student's *t* test is then used as a significance test on the correlation coefficient. The *t*-values quoted 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 (Baillie 1982, 82-5), provided that high *t*-values are obtained at the same relative or absolute position with a series of independent sequences and that the visual match is satisfactory.

Dating is usually achieved by cross-correlating, or crossmatching, ring sequences within a phase or structure and combining the matching patterns to form a phase or site master curve. This master curve and any remaining unmatched ring sequences are then tested against a range of reference chronologies, using the same matching criteria as above. The position at which all the criteria are met provides the calendar dates for the ring sequences. A master curve is used for absolute dating purposes whenever possible as it enhances the common climatic signal and reduces the background 'noise' resulting from the local growth conditions of individual trees.

The crossdating process provides precise calendar dates only for the rings present in the timber. The nature of the final ring in the sequence determines whether the date of this ring also represents the year the timber died or was felled. Oak consists of inner inert heartwood and an outer band of active sapwood. If the sample ends in the heartwood of the original tree, a *terminus post quem* for the death of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings that are missing. This is the date after which the timber died but the actual year of death may be many decades later depending on the number of outer rings removed during timber conversion. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a death date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. The sapwood estimate applied throughout this report is a minimum of 10 and maximum of 46 rings, where these figures indicate the 95% confidence limits of the range and are applicable to oak trees of all periods from England and Wales (Tyers 1998b). Alternatively, if bark-edge survives, then a death date can be directly obtained from the date of the last surviving ring. In some instances it may be possible to determine the season of death according to whether the ring immediately below the bark is complete or incomplete. However the onset of growth can vary within and between trees and this, combined with the natural variation in actual ring width, means that the determination of death season must be treated cautiously. The delicate nature of sapwood, particularly on waterlogged timbers, increases the likelihood of damage/degradation to the outermost surface of the sample and hence increases the difficulties of positive identification of bark-edge.

Results

Assessment

The assessment visit was undertaken by Ian Tyers on 13 January 2003. On-site identification indicated the presence of both oak (*Quercus* sp.) and elm (*Ulmus* sp.) timbers of which the vast majority were clearly unsuitable for dendrochronological analysis as they contained too few growth rings (Fig 3). The north-westerly line of stakes on site A appeared to be derived from reasonably large, fast grown, young, elm trees whereas those in the south-easterly row appeared to be derived from small but relatively slow growing oaks, although neither the elm nor oak appeared to have any dendrochronological potential. The horizontals appeared to be elm. The small posts on site B appeared to be elm but the larger uprights adjacent to the main group B were oak and contained sufficient numbers of rings for dendrochronological analysis. The irregular row of posts at site C appeared to be a mixture of oak and elm timbers. The elm timbers were again unsuitable but some of the oak posts appeared to have some dendrochronological potential. The fallen modern oak tree near site C clearly had sufficient rings for dendrochronological analysis.

Analysis

Samples from one timber from site B and four from site C were submitted for dendrochronological analysis. Details of the samples are presented in Table 1 and their locations indicated on Figures 4 and 5. Two timbers, **132** and **133**, from site C had too few rings for analysis and their grow rings were distorted. Although the remaining two, **135** and **136**, had approximately 80 and 60 rings respectively these could not be measured due to the presence of periodic bands of very narrow rings in which the ring boundaries could not be accurately distinguished. The timber from site B, **125 (oak)**, contained sufficient rings to warrant analysis. The 81 year ring sequence was compared with a range of dated reference chronologies from England and Wales spanning the last 7000 years. Unfortunately no conclusive results were obtained so the timber remains undated by dendrochronology.

The modern sample contained 92 complete rings (Table 2). This ring sequence was compared with a range of dated reference chronologies constructed from modern woodlands spanning the last couple of centuries. This was dated to the period AD 1909-2000 (Table 3). The outermost ring was incomplete and therefore not measured. It consisted of just the spring vessels indicating that it died during the growing season in either late spring or early summer AD 2001.

Discussion

The analysis has failed to successfully date the ring sequence from site B, sample **125 (oak)**. This is not particularly surprising as single tree sequences have a significantly reduced chance of reliable dating compared to a site master sequence that incorporates data from several different trees.

All four samples from Site C showed disturbed growth either in the form of wedging or erratic growth in the form of periodic bands of very narrow rings. The bands of narrow rings occur approximately every 10-15 years. Growth is initially severely suppressed but this is followed by a period of recovery where the tree virtually reaches its initial growth rate as indicated by the width of the growth rings. The possible causes of sudden growth reduction include anthropogenic, local environmental, and general environmental effects. Causal factors include management regimes or at least some form of human intervention, such as pollarding or shredding, localised defoliation by pests, possible responses to localised flooding, or more generalised environmental effects such as severe weather conditions (eg drought, or long hard winters and late frosts). No definitive answer can be provided from the tree-ring analysis and indeed this assemblage highlights the growing need for research on the effects of anthropogenic and environmental factors on modern trees under known conditions. This would allow better understanding of the responses noted in the ring patterns and the anomalies seen within individual rings of archaeological timbers.

The modern sample was successfully dated and its time of death identified as late spring or early summer AD 2001. The annual growth rings for the preceding two years are very narrow, potentially indicating that the tree was already struggling prior to it actually being undermined to the extent that it fell to the base of the cliff. However without data from adjacent trees on the cliffs it is not possible to categorically state that the outermost narrow rings are the result of stress from undercutting and the resultant disruption. This group of trees does have the potential to provide information relating to the growth of trees in exposed situations which may be relevant to the difficulties encountered during dendrochronological analysis of historic assemblages in East Anglia.

Acknowledgements

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Figure 1: Map showing the location of the site (based upon 1:50,000 Ordnance Survey Landranger 168 with the permission of The Controller of Her Majesty's Stationary Office, © Crown Copyright)

Figure 2: The location of the three sites under archaeological investigation (after Heppell and Brown 2002b)

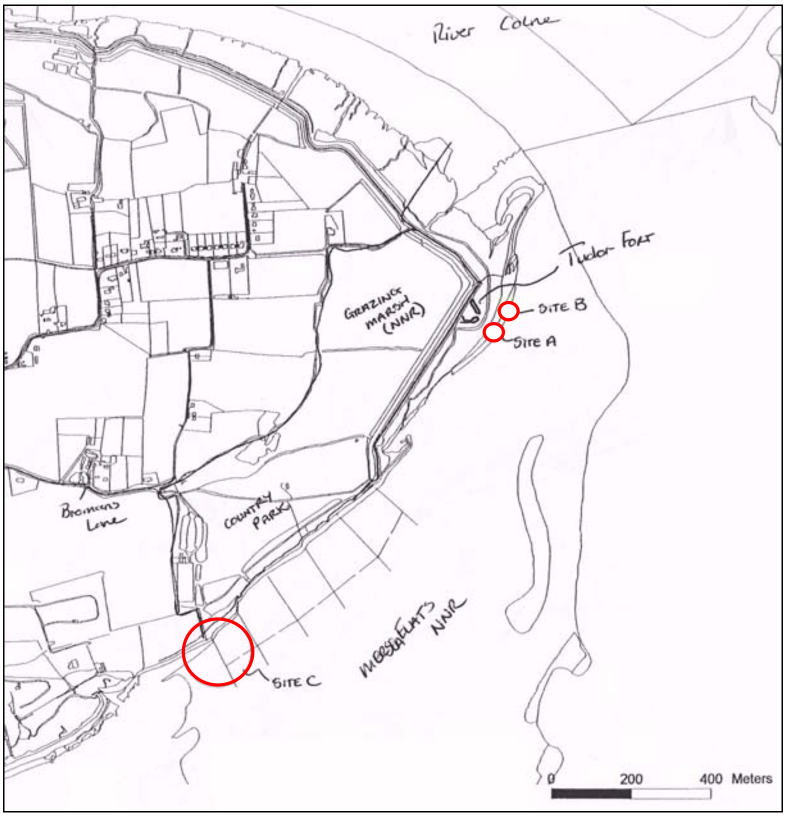

Figure 3: Example of a post derived from a fast grown elm tree with too few rings for dendrochronological analysis (photograph I Tyers)

Figure 4: Site B. The location of the sampled timber (after Heppell pers comm)

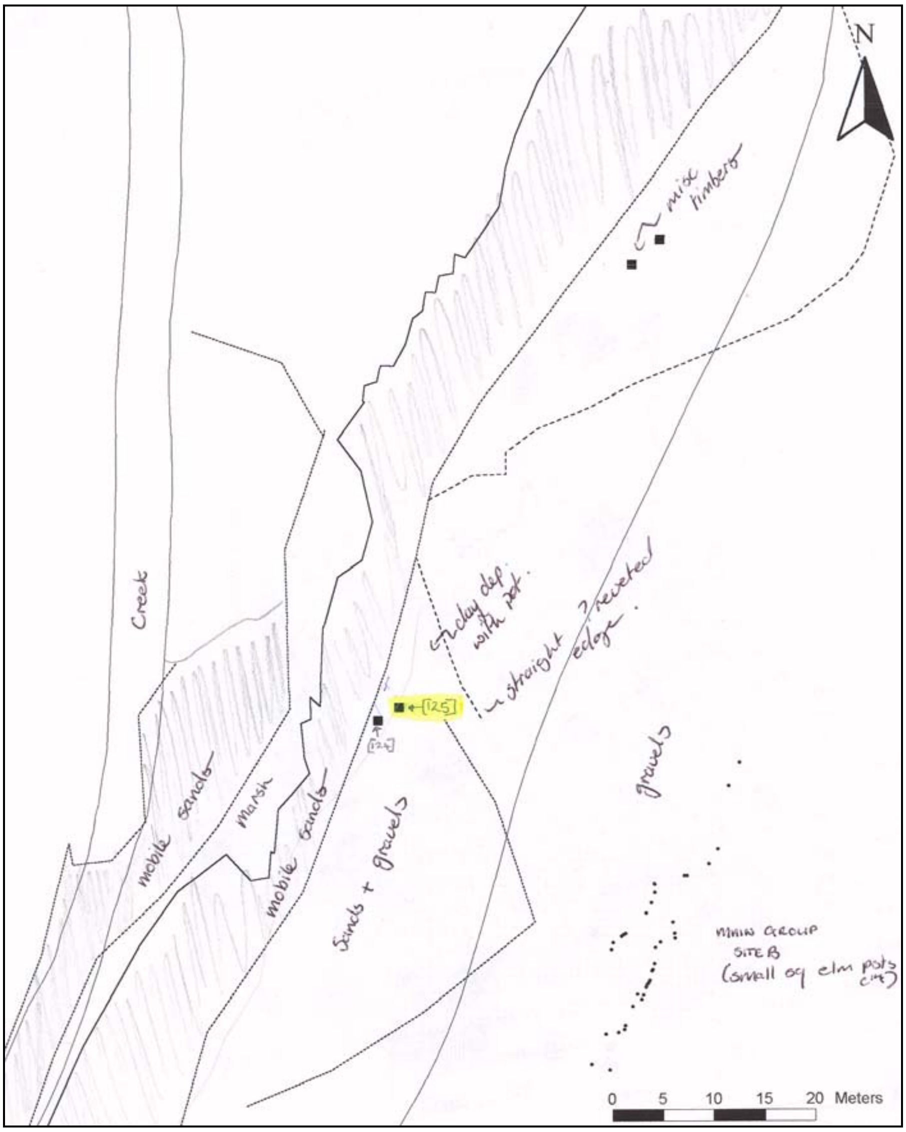

Figure 5: Site C. The location of the sampled timbers (after Heppell pers comm)

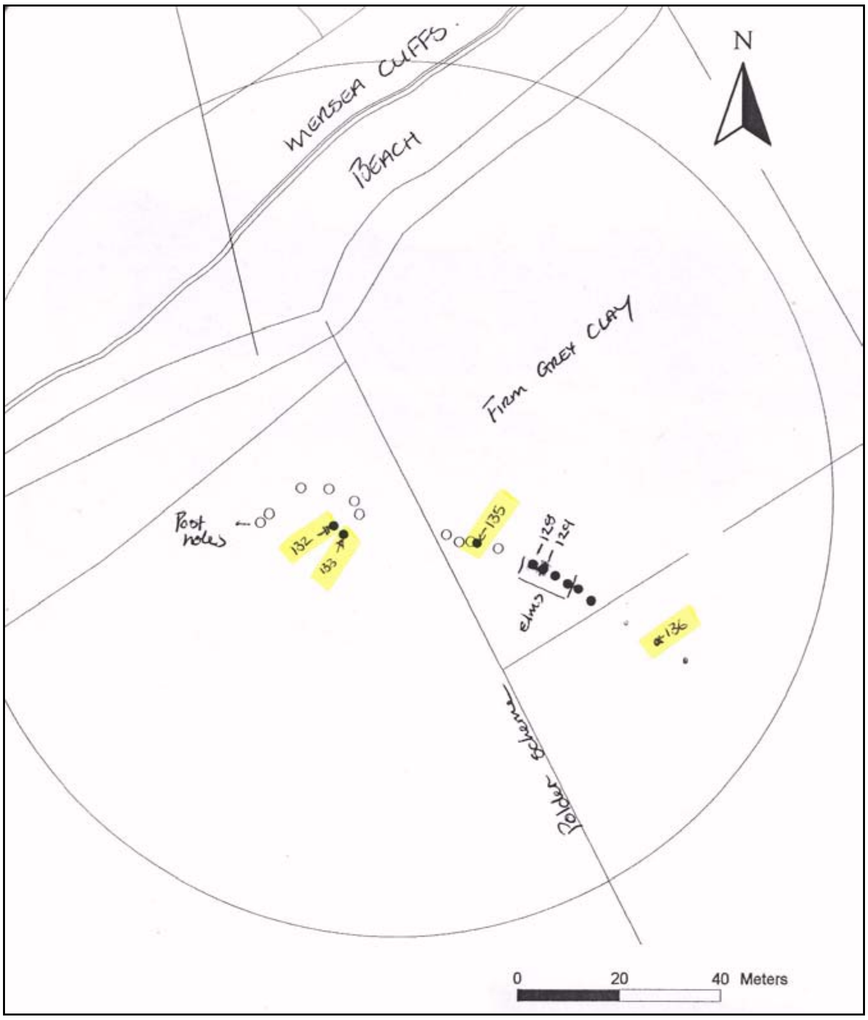

Table 1: Details of the samples submitted for dendrochronological dating

Rings - total number of measured rings including both heartwood and sapwood
Sapwood – number of measured sapwood rings only; hs – heartwood/sapwood boundary; bw – bark edge present with outermost ring complete so died in winter during dormancy; bs – bark edge present with outermost ring incomplete so died in summer during growing season;
ARW – average ring width in millimetres per year
Dimensions – maximum dimensions of the cross-section in millimetres
Cross-section - guide to conversion type

Site	**Sample**	**Wood type**	**Rings**	**Sapwood**	**ARW**	**Dimensions**	**Cross-section**	**Date**
B	125 (oak)	oak	81	?hs	2.25	225 x 160	halved	-
C	132	oak	26	6 +?bw	4.42	230 x 190	whole	-
C	133	oak	22	8 +bs	4.66	205 x 175	whole	-
C	135	oak	c80	16 +?bw	2.88	250 x 230	quartered	-
C	136	oak	c60	-	3.08	185 x 185	quartered	-
C	modern	oak	92	25 +bs	1.46	260 x 260	whole	AD1909-2000

Table 2: The ring width data from the modern sample, dated AD 1909-2000 inclusive

Date	**Ring widths (units of 0.01mm)**									
AD1909									101	200
-	126	234	261	145	234	262	274	242	88	100
-	146	92	81	169	168	118	162	99	114	82
-	181	99	114	83	212	236	218	127	142	168
-	119	103	81	49	138	63	179	65	61	132
AD1951	194	158	262	171	188	169	87	266	183	146
-	192	166	147	216	111	167	214	140	208	209
-	198	137	114	106	186	112	174	158	267	143
-	144	149	185	130	171	139	153	132	93	98
-	111	63	111	126	76	72	72	59	49	45

Table 3: Dating the modern sample AD 1909-2000 inclusive. All reference chronologies are independent

Reference Chronology	**Date of reference chronology**	**t value**
Blickling, Norfolk (Pilcher and Baillie 1980)	AD1717-1979	5.02
Bradfield Wood, Suffolk (Bridge 1983)	AD1833-1980	5.66
Chalkney Wood, Essex (Bridge 1983)	AD1883-1980	6.06
Cobham Hall parkland, Kent (Arnold *et al* 2003)	AD1770-2001	4.72
Danbury/Lingwood Commons, Essex (Tyers pers comm)	AD1862-2001	4.21
Hayley Wood, Cambridgeshire (Bridge 1983)	AD1777-1981	5.08
Hockley Wood, Essex (Bridge 1983)	AD1831-1980	4.95
Old Park Wood, Harefield, London (Bridge and Winchester 2000)	AD1786-1994	4.96
Quendon, Essex (Hillam pers comm)	AD1909-1985	6.20

Sotterly Park, Suffolk (Briffa *et al* 1986)	AD1586-1981	5.76