# THE SUBMERGED FOREST AT AREA F, GOLDCLIFF EAST

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## INTRODUCTION

Submerged forests have long been known to exist around the coastline of the British Isles (e.g. Cameron 1878; De Rance 1869) with early theories of their presence ranging from subsidence of the coastline (Ashton 1920; Travis 1926) to association with mythical "lost lands" (ie Lyonesse in Cornwall, Johnson and David 1982). It is now generally accepted that their occurrence is representative of woodland killed by rising of the water table or the ingress of saltwater through sea-level rise. These woodlands were then subsequently preserved through burial by later growths of peat, or deposition of clay, silts and sands (Kidson and Heyworth 1973; Caseldine 1990).

Although the presence of these submerged prehistoric woodlands have been observed in a number of studies, rarely have they been recorded and analysed in the detail they deserve. Submerged forests are after all exceptionally well preserved remnants of the *original* woodland offering high palaeoecological resource potential. Earlier studies have attempted to reconstruct these environments on the basis of one main analytical approach, mainly pollen analysis, less commonly wood identification, seeds and beetles. This study attempts to utilise the full range of those resources by using a multiproxy approach to reconstruct part of the extensive submerged forest at Goldcliff East.

## SITE DETAILS

Area F is located on the upper peat shelf at Goldcliff East (Bell *et al* this vol. figure 1) some 250m east of the extended Mesolithic site at Area J and 200m west of the stratigraphic transect sampling site of Smith and Morgan (1989). The main stratigraphic unit of the area is the upper main peat which consists largely of a wood peat (from 5850 ±80BP (CAR-658) to 5360 ±80 BP (CAR-656)) overlain by a reed/sedge peat followed by raised bog (from 5020 ±80 BP (CAR-652) to 3130 ±70 BP (CAR-644)). For further details of the overall stratigraphic sequence see Bell *et al* (2003, table 1). Other work in Area F includes dendrochronological sampling by Nigel Nayling (trees GC39 to GC41) and footprint investigation work in the marine blue grey clay layer 0.7 m below the upper main peat by Rachel Scales.

## METHODS

An area 30 x 5 m was mapped and sampled for wood identification analysis using the method outlined in Timpany (2002). A monolith (50 x 10 cm) was taken for pollen and plant macrofossil analysis from the upper peat and tree GC310 (S8280) was sampled for dendrochronological investigation (see Figure 1 for locations).

### *Pollen analysis*

Samples of 0.5 cm vertical thickness were prepared for pollen analysis after Barber (1976) at sampling intervals of 2 cm and 1 cm where finer detail was required to examine, vegetation change. Spore tablets (Stockmarr 1971) were added to each sample to permit calculation of pollen concentration and of microscopic charcoal using the point-count estimation method devised by Clark (1982). Plant nomenclature and general order follow Stace (1997) and take into account the suggestions of Edwards (1991) and Bennett, Whittington and Edwards (1994). Non-pollen microfossils are indicated by a type number following van Geel (1978, 1986).

## Site F wood identification plan

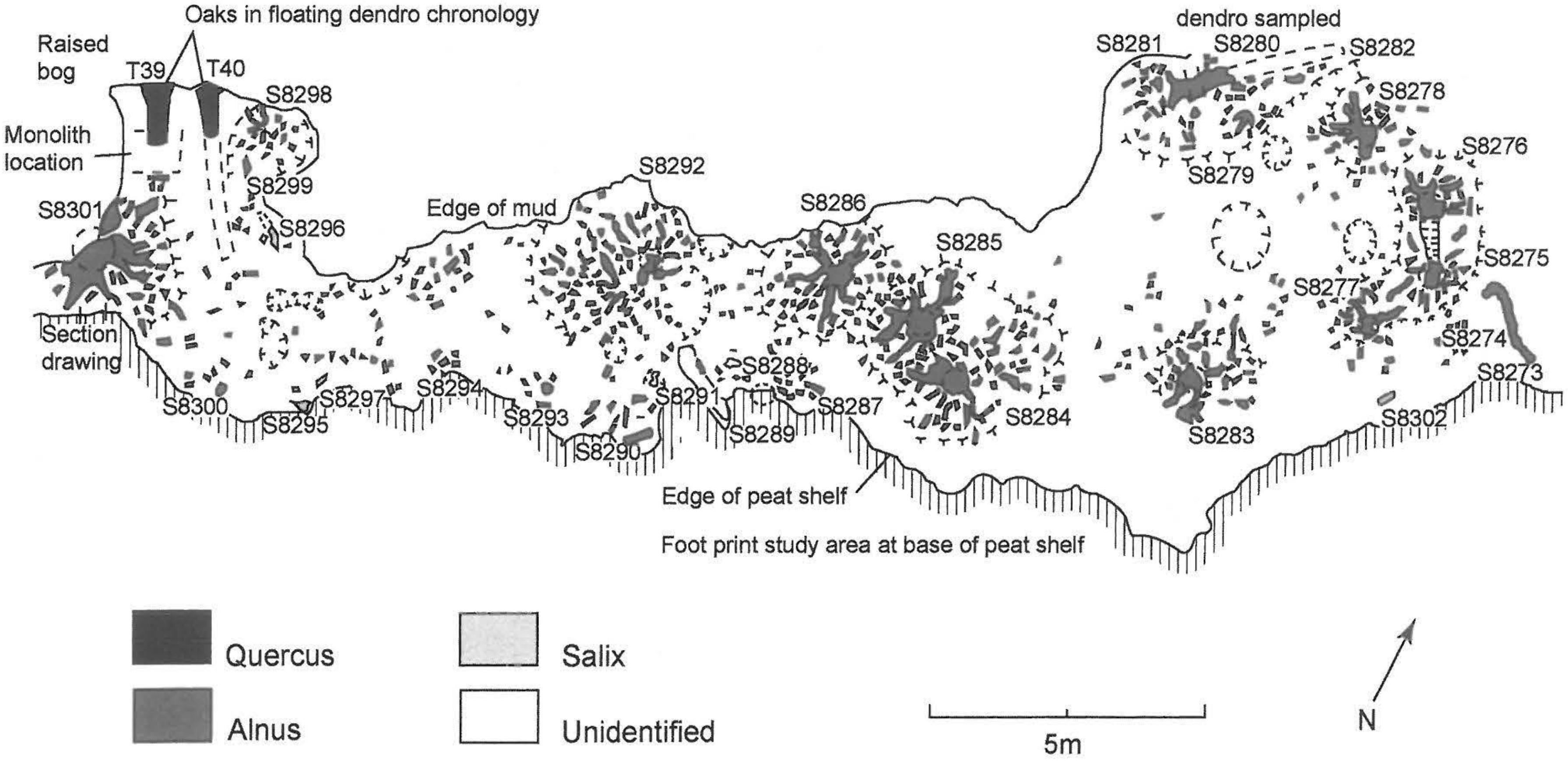

*Figure 1: Plan of Area F including wood identification results.*

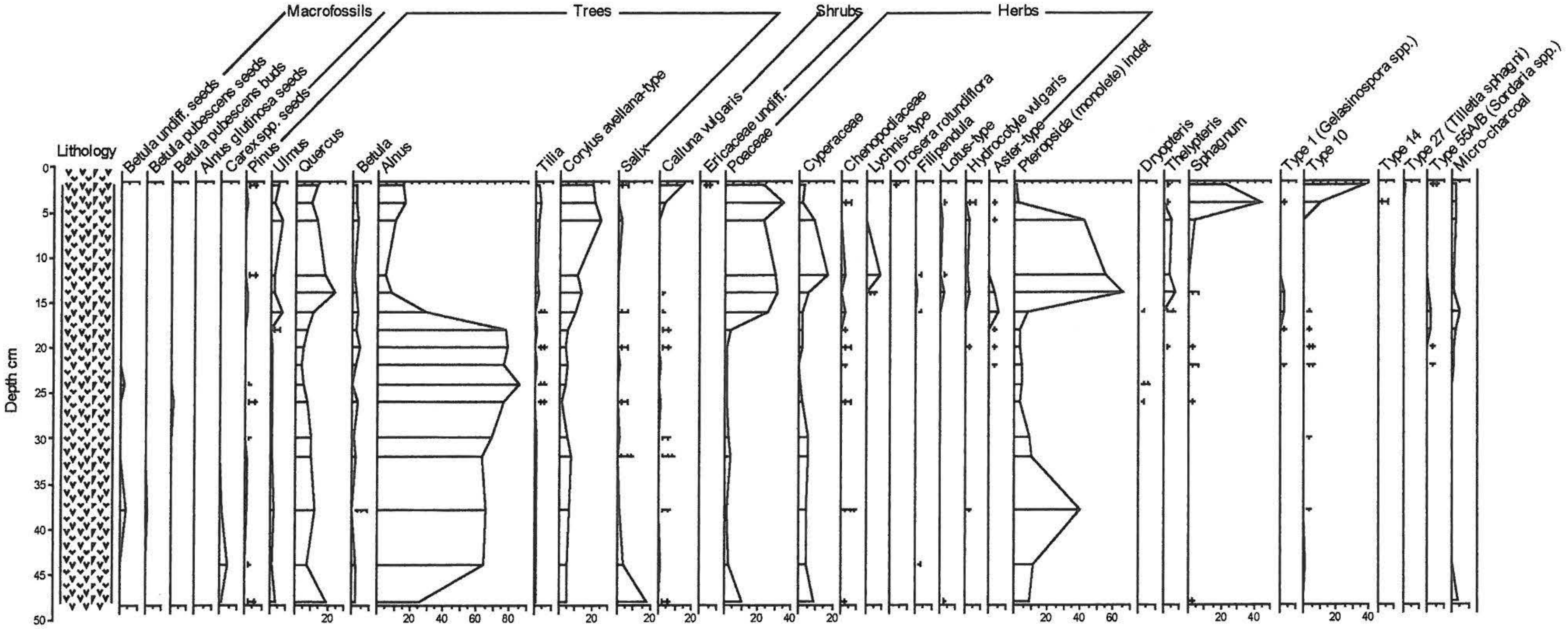

*Figure 2: Selected pollen and plant macrofossil diagram of Area F*

### *Plant macrofossil analysis*

Samples examined were 50 ml sub-samples removed from the same monoliths used for pollen sampling outlined above. Samples were washed through a small stack of sieves with 1 mm and 500µm meshes. The remains were sorted and identified using a Leitz binocular microscope. Identification was by comparison with modern reference material and standard identification texts including Berggren (1969, 1981).

### *Wood analysis*

Samples were thin sliced along radial, tangential and transverse sections using a razor blade and then stained using bleach before being mounted on a slide in glycerol and examined at x100 and x400 when required. Wood sections were identified using features described by Schweingruber (1990).

### *Dendrochronology*

Samples were frozen for a period of at least 24 hours and then cleaned with a Surform plane to make the growth ring boundaries more visible. Ring widths were measured on a travelling stage connected to a microcomputer using the dendrochronological programme TSAP and then plotted as a graph. Three measurements were carried out in differing directions from the pith and then averaged to construct the graph.

## RESULTS

The wood identification results (see Figure 1) show the area was dominated by *Alnus glutinosa* (alder) with *Salix* (willow) and *Quercus* (oak) also present. Within the area there are three oak trunks of diameter 43 x 22.5 cm (GC39), 16 x 17.5 cm (GC40) and 40 x 21.5 cm (GC41), one alder trunk (GC310, see below) and a number of other stumps/root systems of mainly alder where the size and age cannot be directly established from the tree remains.

The pollen and plant macrofossil diagram (Figure 2) shows an environment dominated by alder pollen with values reaching up to 80% TLP. Tree pollen from oak and *Corylus avellana*-type (hazel) is also present with lesser values of *Tilia* (lime), *Betula* (birch), *Pinus* (pine), and *Ulmus* (elm). The plant macrofossils are largely made up of seeds of *Betula* undiff. with lesser numbers of *Carex* (sedges) and *Rubus idaeus* (raspberry) seeds.

Above 16 cm there is an abrupt change in the pollen assemblage with a decline in the amount of alder pollen and an increase in oak, hazel and herbaceous pollen, with Poaceae (grasses) pollen rising to 40% TLP.

The tree ring count for tree GC310 (S8280) shows that it was *c.* 74 years old at time of death (Figure 3) suggesting it grew to a mature age. The lack of any substantial periods of narrow ring growth suggests it grew in an environment with few environmental stresses being placed on the trees. However, at present it is not clear where this tree fits into the chronology of the site other than being part of the *Alnus* carr woodland, therefore its cause of death is unknown.

## INTERPRETATION

High values of *Salix* pollen at the base of the pollen/plant macrofossil diagram (48 cm) together with peaks in Poaceae and Cyperaceae (sedges) pollen together with *Carex* seeds suggest damp wet conditions during the early phase of peat initiation (Stace, 1997). *Alnus* pollen is also present indicating the beginning of carr-woodland development. High pollen values of *Quercus* together with pollen of *Corylus avellana*-type, *Tilia* and *Ulmus* suggest some deciduous woodland possibly on Goldcliff Island or derived from the dryland further inshore. This early environmental picture is of an open landscape of grasses (possibly reedswamp) and sedges with notable sporadic, carr-woodland development on the wetland and some deciduous oak dominated woodland possibly on Goldcliff Island, some 370 m southwest of Area F.

A dramatic rise in *Alnus* pollen follows (44 cm) suggesting a strong increase in the local component of alder likely in the form of an expanse in the now largely alder carr-woodland, which is thought to have resembled the W5 *Alnus-glutinosa-Carex paniculata* woodland (Rodwell 1991a). This rise in *Alnus* pollen is reflected in the wood identifications in the Area F plan which

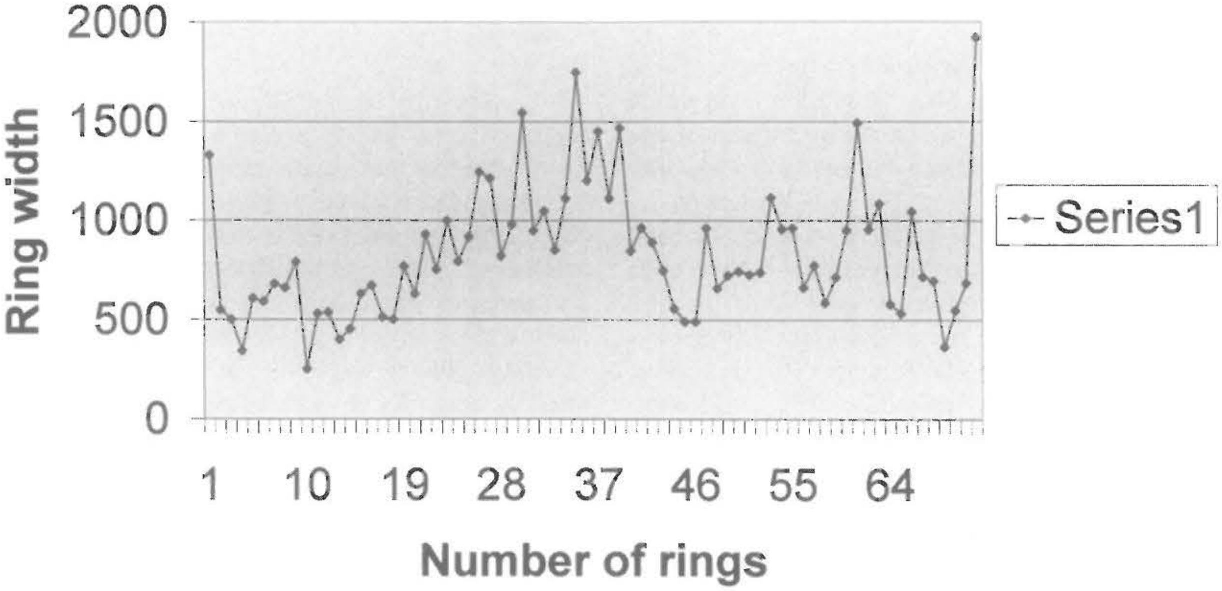

*Figure 3: Tree ring count for GC310 (S8280).*

is dominated by alder wood with substantial remains of alder trunks and stumps. The rise of alder-carr is seen in other pollen diagrams from Goldcliff notably Smith and Morgan (1989) and Caseldine (2000) beginning at around 5850 ±90 BP (CAR-658) and 5720 ±80 (SWAN-235) respectively. *Salix* pollen decreases with the rise in *Alnus* suggesting it has become a less important part of the woodland as the wood identifications also show. Interestingly this dominance of alder is barely witnessed in the plant macrofossil record with only one *Alnus* seed present. The almost continuous curve of *Betula* undiff. (birch) seeds; likely to be *Betula pubescens* (downy birch) from the one intact seed suggests a local presence. However *Betula* wood is absent from the wood plan suggesting these seeds may have been carried by the wind (the seeds are winged) from a birch stand nearby. At Area 4, 400 m to the east, tree remnants of *Betula* have previously been identified (Timpany, 2002).

The decline in Poaceae, Cyperaceae and *Carex* seeds indicates, drier conditions possibly owing to the terrestrialisation of the peat due to the spread of the alder carr-woodland. This would seem to be evident in the wood identification plan of the area with the presence of *Quercus* trunks showing the invasion of oak into the alder carr-woodland probably from Goldcliff Island. The ring count for GC310 suggests trees within this carr-woodland were able to grow to a mature age (in this case 74 years) with few environmental restrictions or anthropogenic impacts up to their time of death.

The pollen and plant macrofossil diagram shows a steep decline in the pollen curve for *Alnus* accompanied by a rise in Poaceae (16 cm), which may reflect an increase, in reeds and the appearance of possible maritime taxa, Chenopodiaceae and *Aster*-type. This suggests the decline in *Alnus* may have been caused by a marine transgression related to a period of rapid sea-level rise at *c.* 5000 BP in South Wales (Scaife and Long, 1995). An increase in sea-level would have caused a rise in the water table causing trees to drown where they stood. A period of marine transgression is the favoured cause of death of the alder carr-woodland in studies by Smith and Morgan (1989; zone GC1-3) and Caseldine (2000; zone GC2099.5). Smith and Morgan note a phase of minerogenic deposition in the stratigraphical sequence at this time. Caseldine also finds evidence of traces of clay within the stratigraphy which may give further indication of this brief marine episode. Radiocarbon dates from these two studies also enable an estimation of the timing of this sea-level rise to between 5360 ±80 BP (CAR-656) and 4900 ±60 BP (CAR-1500). These dates give an average of *c.* 5100 BP a time which correlates well with a period of rapid sea-level rise shown in sea-level curves for the Severn Estuary produced by Scaife (1995) and Haslett *et al* (2000). This phase of sea-level rise would have left a landscape somewhat eerie in nature with dead standing trees the stumps of which can be seen in Figure 1 in a possible *Phragmites* reedswamp environment (suggested by the size of the Poaceae grains, dominantly less than 25 μm). The death of the trees would also have left them vulnerable to strong winds and therefore susceptible to windthrow (Allen 1996, 1998) it is perhaps these fallen trunks which after burial by peat are now visible in Area F. The continued presence of pollen from other tree taxa indicates the survival of deciduous woodland elsewhere.

This phase of marine inundation is followed by an increase in Cyperaceae and other taxa suggestive of the presence of tall herb fen community such as *Lychnis*-type (catchfly), *Lotus*-type (Bird's-foot-trefoils) and *Hydrocotyle vulgaris* (Stace 1997). High values of *Pteropsida* (monolete) indet. (ferns) spores and *Thelypteris* (marsh fern) also indicate a damp, marshy environment. These taxa suggest the colonisation of the reedswamp by S25b *Phragmites australis-Eupatorium cannabinum* tall herb fen, *Carex paniculata* sub-community (Rodwell 1995). A slight rise in *Salix* following the rise in these taxa together with increases in *Alnus* and *Betula* imply these trees may once again have started to grow on the wetland.

A rise in the curves of *Sphagnum* and *Calluna vulgaris* (heather) pollen in the assemblage (4 cm) suggests the development of *Erica-Sphagnum* raised mire communities (Rodwell 1991b) and the start of the raised bog stage at Area F. The occurrence of Type 10, a fungi, which has been related to *Calluna* (appearing to form on the roots), suggests heather was growing locally (van Geel 1986). The development of raised mire is also indicated by the presence of *Drosera rotundiflora* (sundew) pollen (Stace 1997). High values of Poaceae pollen during the time of the increase in raised mire vegetation suggests the presence of *Molina caerulea* growing in seepage zones in the fringes of the raised mire (Rodwell 1991b).

There is some evidence people may have been active in the landscape with an increase in micro-charcoal and the presence of *Gelasinospora* which has been linked to phases of burning (van Geel 1986) at around the rise in sea-level and death of the alder carr-woodland (24 cm upwards). The death of the trees would have meant a more open canopy over the wetland around Area F allowing for an increase in herbaceous taxa possibly attractive to grazing animals. The small rise in Type 55 A/B (*Sordaria* spp.) may indicate the presence of dung and hence animals near the site although this type has also been linked to the presence of decaying wood, notably birch (van Geel *et al* 1981). The increase in micro-charcoal may indicate the burning of some of these dead trees in order to clear an area to aid hunting activities. The presence of identifiable wood micro-charcoal in these levels with visible scalariform plates with often more than 20 bars also suggests that it is the alder trees which were being burnt; other trees with scalariform plates such as birch and hazel having less then 20 bars (Schweingruber 1990). The possibility of lightning strikes being responsible for some of the micro-charcoal should also not be ruled out.

## DISCUSSION

The environmental picture gleaned at the site of succession from swamp to alder-carr woodland into raised bog complements previous studies in the Goldcliff area. Smith and Morgan's (1989) pollen diagram (GC1) from Goldcliff East also records these vegetational changes, from zones GC1-2 through to GC1-4a as does the Caseldine (2000) Monolith 2099 pollen diagram zones GC2099-3 to GC2099-6. This alder-carr dominated wetland landscape is known to have lasted for *c.* 600 years at Goldcliff from radiocarbon dates given in the two aforementioned studies. Just how far this coastal carr-woodland would have stretched along the southern coast of the Severn Estuary is unknown but other findings of pockets of submerged alder carr-woodland such as at Woolaston suggest it may have been fairly extensive.

## CONCLUSION

The multi-proxy approach to the palaeoecological investigation of the submerged forest at Area F has shown the importance of the use of different environmental data sets. Pollen analysis has produced a regional environmental picture, which has also been used to tie in this study with others at Goldcliff, whilst a more local picture has been gleaned through the use of plant macrofossils, wood identifications and dendrochronology. The differences between the regional and local data sets are important as they show environmental changes which occur regionally are not necessarily mirrored by those which occur locally. However the amalgamation of these sources produces a more detailed picture of the nature of these prehistoric coastal woodlands. It is suggested that the submerged forest along the upper peat shelf at Goldcliff East at Area F and beyond was a dominantly alder carr-woodland with oak starting to invade before the rapid rise in sea-level at *c.* 5000 BP shown in sea-level curves for this area, drowned the woodland leaving a reedswamp/tall herb fen environment gradually replaced by raised bog.

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