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(Figures 1–9)

Ancient Forests of the South Devon Coast: 8,000 years of changing vegetation determined by pollen analysis

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Along the South Hams coast, peat remains are the only trace of the formerly abundant woodland. Close to, and on the coastal shelf, sediments have been eroded, re-created and exposed many times during the Quaternary, but most have not been recorded. This paper focuses on lowland peat formed during the last 8,000 years within the coastal lithology of several near-shore south Devon valleys now impounded by coastal barriers. As the outcome of a research project that spanned twelve years, the paper reports findings from nine sites located in Tor Bay, Start Bay, Lannacombe Bay, the Salcombe estuary, Bigbury Bay, and Wembury Bay. In all, some 44 sediment cores were taken and subjected to pollen and macrofossil analysis. Fifteen radiocarbon dates were obtained, thereby establishing a woodland chronology for the region. The previously unrecorded Holocene valley sediments focused upon in this study reveal the changing woodland species communities that existed in settings close to the English Channel in the past. Moreover, it has been possible to identify responses in the woodland communities to environmental changes such as episodes of flooding and the increasing interference in the landscape by early human settlers such as tree clearance and farming. The findings for the South Hams are related to those published by other authors for sites elsewhere in southern England.

INTRODUCTION

Ancient forests, found as tree-covered remnants along the foreshore all around Britain's coast have been a subject of fascination not just for geologists but also for walkers. In Devon, reports were published in the *Transactions of the Devonshire Association* as early as 1866 when William Pengelly revealed the lithology around Torbay's developing Esplanade. Thereafter, in 1869, Pengelly gave details of his field trip to Blackpool Sands. In 1881, the beach sediments of Paignton

and Blackpool were recorded by Hunt. Later, in 1923, Winder concentrated on Thurlestone beach. In north Devon, at Westward Ho!, according to Ellis (1866), records of tree-covered remnants were overshadowed by quantities of flint tools. Together with several finds of fossils, raised beaches had been described in 1868 by Pengelly and the fossil finds were referred to by both Inkerman Rogers in 1908 and Worth in 1934. Pre-Holocene fossils were found in sediments at Sidmouth and also out in the Tor Bay (Hutchinson, 1873; Pengelly, 1865). The tree stumps and peat remnants at Westward Ho! were shown in photographs published by Jenkyn in 1969. Holocene valley sediments formed in the Southwest during the last 8,000 years have been identified in Devon, Cornwall, along the Dorset coast, and beside the Bristol Channel coast in west Somerset (Charman *et al.*, 1996; Healey, 1993; Scourse and Furze 1999; Campbell *et al.*, 1998).

Exposures of 'submerged forests' in south Devon occur regularly during great winter storms. For example, in 1989, quantities of unconsolidated deposits were displaced and a number of coastal valleys of the South Hams were eroded close to the seashore, revealing scraps of ancient woodland on the foreshore. Examples of such tree-covered remnants are found at Blackpool Sands and at Thurlestone, and these have attracted much local interest. Located on the beach around the low spring tide level, such woodland remnants – when devoid of tree remains – are often referred to as patches of 'peat' (Ussher, 1904; 1912; Gregory and Ravenhill, 1971).

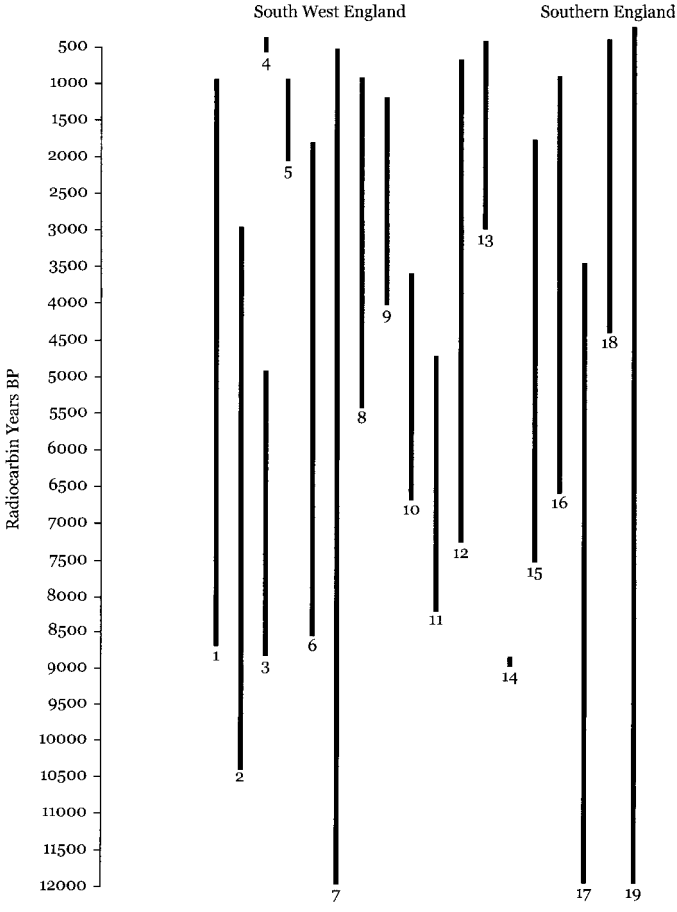
Outcrops found on the beach are remainders of the valley alluvium. Comprising tree stumps rooted in organic debris with a high component of *Sphagnum* (Moss), sedge, rushes or marsh plants, these deposits are very similar to peat. Plant macrofossils from *Corylus* (Hazel), *Quercus* (Oak), with quantities of hazelnuts, acorns and wood, together with barks from the Betulaceae (mainly *Alnus* [Alder] and *Salix* [Willow]), were expected. Such finds have been reported by previous authors such as Pengelly (1865; 1869; 1878) and Ussher (1904). In Start Bay, Mercer (1966) revealed, and Morey (1983) confirmed, that the shingle barrier had moved onshore and was comparatively recent in age, being in place only for about 3,000 years. The sedge peat beneath Slapton Ley is rather younger (Crabtree and Round, 1967). However, Clarke (1970) showed that peat beneath the Skerries was formed 8,110+/−60 radiocarbon years ago, implying that old land surfaces lie beneath the sea. Clearly,

considerable changes occurred around the coast in the Holocene, but a key question addressed in this research was whether the tree-covered remnants could supply any fossil evidence about the character and species composition of the woodland of south Devon, or whether the evidence was now obscured by changes to the land surface.

A broader extension of Holocene woodland species into the Southwest was mooted by Godwin (1975); this was particularly associated by Pennington (1967) with a period, 6,000 years ago (once called the Atlantic period), when the climate was believed to have been most suitable for trees. During that time, peat was readily formed and has been found to contain pollen and seeds of the many tree species covering the countryside. However, the disjointed records for south Devon have always been a little difficult to assemble into an overall picture of the woodland. Recently, a broad extension of the tree species expansion into the Southwest has been proposed from results obtained at Westward Ho! in north Devon by Scaife (1987) which, when compared to the work in this study, show areas of similarity. Figure 1 summarises the periods of time covered by studies of other sites in southern and south western England up to the year 2001.

Inland, three distinct and diverse areas of Holocene 'peat' deposits are recognised in Southwest England. These deposits are (i) deep upland mires: the 'blanket bogs' of *Sphagnum* on Dartmoor, Exmoor and Bodmin, (ii) lowland raised bogs such as the Somerset Levels, and (iii) coastal lagoons, mires and fens. Meare Heath and Shapwick Heath of the Somerset Levels have a unique combination of both coastal deposits and raised bog. On Bodmin Moor and Dartmoor, Brown (1977) and Becket (1981) found most of the moorland sites contained archaeological evidence of human activity which had exerted a significant impact on the history and development of the peat deposits: pastoral and arable farming altered the mid-Holocene sediments, and mining and peat cutting reduced those of the late-Holocene. Of the lowland deposits alongside the Bristol Channel, with its cliffs and rocky ledges, just one coast site, that of Westward Ho!, had retained archaeological relicts (Balaam *et al.*, 1987).

Throughout the Holocene, ancient woodland debris has been torn away from the coast during a continuous process of marine erosion that strips head deposits off the old shore platform; indeed, Orme (1961) concluded that the distance progressed onshore was probably



Woodland Sites

1 Blackabrook (Beckett, 1981)
2 Blacklane Brook (Simmons, 1964)
3 Blackridge Brook (Maguire and Caseldine, 1981)
4 Swanpool (Henon *et al.*, 1999)
5 Prah Sands (French, 1983)
6 Isles of Scilly (Scaife, 1984)
7 Bodmin Moor (Brown 1972; 1977)
8 Marazion Marsh (Healey, 1993)
9 Exmoor (Merrifield and Moor, 1974)
10 Westward Ho! (Balaam *et al.*, 1987)
11 Porlock Marsh (Jennings *et al.*, 1998)
12 Somerset Levels (Hibbert, 1982)
13 Slapton Ley (Crabtree and Round, 1967)
14 Southeast Devon (Clarke, 1970)
15 Thames Estuary (Devoy, 1987)
16 Romney Marsh (Waller *et al.*, 1999)
17 New Forest (Barber and Clarke, 1987)
18 Rimsmoor, Dorset (Waton and Barber, 1987)
19 Isle of Wight (Scaife, 1987)

Figure 1. *Time periods covered by studies of woodland elsewhere in Southwest and Southern England.*

as much as 6 km. The rock basement in Bigbury Bay and Start Bay extends today beneath the sea for some 4–8 km. Nevertheless, during the Holocene the shoreline became recognisably similar to the present-day shoreline. Climatic variation and sea-level change occurred during the early-Holocene while the English Channel developed. There were changes in the vegetation, such as when a drier climate ended mire growth on Bodmin Moor and this, according to Brown (1972), was combined with an adjustment in the altitude of the tree line. Perhaps Holocene woodlands were comparable with those in Devon today, such as Wistmans Wood and St Andrews Wood. Brown (1972) believed that Bodmin Moor was mainly wooded in sheltered valleys or in areas of suitable soil although *Corylus* was not then regarded as a significant species. Subsequently, Gearey *et al.* (2000) have maintained that woodlands of *Quercus* and *Corylus* were widely distributed.

Against the background of the previous research outlined above and given that the lithology of south Devon confirms that the area has deposits of lowland peat that contain Holocene macrofossils and microfossils, the central aim of the research outlined in this paper is to describe the significant changes over time in the region's woodland, the variations that occurred in particular localities, and the degree of comparability of the Devon findings with those found for other woodlands in Southern England. Investigations commenced in 1989, following the great winter storms that year which had displaced and eroded quantities of unconsolidated foreshore deposits and exposed scraps of ancient woodlands on the beaches of the South Hams. In all, the study period lasted for twelve years. The paper therefore reports work that was carried out between 1989 and 2001.

THE STUDY SITES: HISTORY AND CHARACTERISTICS

Because peaty organic debris has been discovered elsewhere in the UK in submerged valleys and behind shingle barriers, a first objective in this research project was to identify similar sites for investigation in south Devon (Fig. 2).[1] The coastal valleys selected for study include Goodrington Valley in Tor Bay [TB], North Hallsands and Blackpool Sands in Start Bay [SB], Lannacombe Bay [LB], North Sands and South Sands in the Salcombe estuary [SH], South Huish and South Milton valleys in Bigbury Bay [BB] and Wembury Bay [WB]. Each valley has a wide, shallow-gradient beach, a back-beach sand ridge or shingle barrier, with low, flat and marshy ground behind. Much

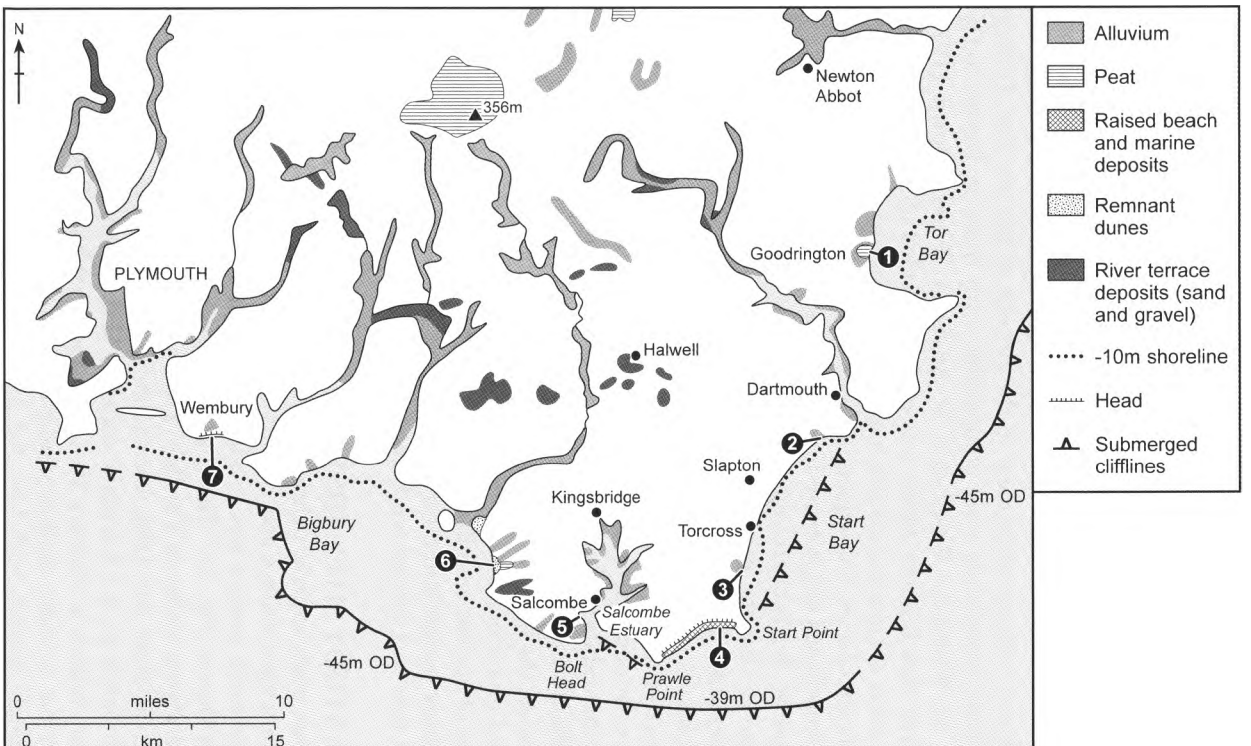


Figure 2. *Locations of the study areas in south Devon: (1) Tor Bay, Goodrington valley; (2) Start Bay, Blackpool Sands; (3) Start Bay, North Hallsands; (4) Lannacombe Bay, Lannacombe valley; (5) Salcombe Estuary, North Sands and South Sands; (6) Bigbury Bay, South Milton and South Huish valleys [Thurlestone Sands]; (7) Wembury Bay, Churchwood valley.*

of the marshy ground has been reclaimed from swamp; some has coastal pasture grazed for hundreds of years, such as that at South Huish and North Sands. A number of small ponds, such as those at Blackpool Sands and North Hallsands, and ditches, particularly at South Huish, are shoreline features of the back-barrier environment. Close to the sea, the lower 100 m of the valleys have somewhat broadened features with former cliff lines and shingle barriers – short in Bigbury Bay, extensive in Start Bay; whilst a terrace feature at about the 15 m contour was most clearly defined at Goodrington.

Quaternary debris rests unconformably on a layer of older stratum: for example, the Permian in Torbay, or the Devonian in Start and Bigbury Bay. The presence and varying thickness of layers of detritus, organic debris, silt, sand and clay reflect local changes of sedimentation as a result of stream capacity and proximity to the sea. Generally, however, at each site, a thin organic layer is overlain by gravels and silts with sediment layers of variable thickness including organic layers of fen or wood peats beneath soil.

Features existing prior to urbanisation were located after referring to OS 1:2500 (6:1) scale First Series maps (1885/6), and Second Series maps (1905–1906) on sheets CXXXV NE (135) together with aerial images and other photographs. More specific descriptions of each of the study sites are now presented.

Tor Bay

To the south of the Paignton area described by Pengelly (1878), an east-facing site in the Goodrington valley (SX889592) was unique in that a lens-shaped, 5m depth of 'peat' had formerly been revealed (Borough Engineer's Report, 1955) inland from the Dartmouth road. Subsequently, during the last fifty years, major modern excavations, together with an infill of at least 4 m depth had taken place and covered all the pasture, whilst creating a lake fronting the Clennon Marsh. An outflow stream, shown on the First Series OS Map, Sheet 22, published in 1809, had been diverted across the Clennon valley. Four Goodrington valley sites in Tor Bay were investigated.

Start Bay

The work of Mercer (1966) and Morey (1983) revealed dominant onshore movements of shingle into a 9 km barrier, with Slapton Ley

established during the last 3,000 years and rather younger sedge peat developed within it (Crabtree and Round, 1967). Ancient woodland was found and recorded in Start Bay at Blackpool Sands (SB1), SX854478 (Fig. 3). The organic deposits contained bark, twigs, leaves, stumps and roots; Pengelly (1869) found abundant *Corylus* nuts close to the present-day quay. Later, Hunt (1881) located a leaf-bed, 0.4 m thick, above a thin layer of sand and a thick layer of clay. More recently, Osmaston (1975) located tree stumps embedded in grey clay

Figure 3. *Remains (stumps) of ancient trees at the Blackpool Sands study site in Start Bay.*

at +1/−1 m OD, normally beneath 1 m of beach gravel, which has also been revealed by stripping and re-distribution of gravel in 1802, 1852, 1869, 1873, 1881, 1903, 1973/4 (Orme, 1974) and also in 1990 during the course of the present author's investigations.

At the southern end of the Start Bay shingle barrier, at North Hallsands (SX818388), 'submerged forest' sediments were found by Morey (1974) and later by Holmes (1995), with a sequence of organic sediment and compressed detritus silt contained in three separate layers of round stones, plus an eroded silt surface with stems of *Phragmites communis* (Common reed) (Morey 1983), and embedded driftwood and grey silty clay (Fig. 4).

To the south of Start Point, Harris's Beach (SX802373) was believed to have submerged organic sediments at the top of the beach, at approximately the high-water mark during 1959 (Orme, 1960). The sediment was classified as dark grey-brown clay containing small twigs of *Quercus* sp.; however, after this date, no ancient forest was found on the beach area, but the Quaternary sediments of head, above relict cliffs from 1.5 m to 4.5 m above high water, are comparable to those at Hallsands (Orme, 1960; Steers, 1981). Two

Figure 4. *Deposits exposed on the beach at the North Hallsands study site in Start Bay.*

Start Bay sites and one in Lannacombe Bay were studied in this research.

Salcombe Harbour

The drowned valley of the Salcombe estuary (SX738384) lies behind a submerged sand barrier, between the outstanding headlands of Bolt Head and Prawle Point. Deeply set between the inset headlands of Sharp Tor and Rickham, the valley is a classic example of a ria that broadens into an estuary with a 5 m tidal range (Orme, 1960). Earlier finds of ancient woodland at low-tide level on shore platforms, behind the sand barrier, just inside the harbour entrance, were not confirmed in Fairweather (1874). However, possible remnants of the ancient woodland may possibly be present in the valley sediments located during this study. Two sites in the Salcombe estuary were included in this research.

Bigbury Bay

The bay features a wave-cut arch with a west-facing beach behind: Thurlestone Sands, which is about 0.8 km long, with a storm beach that rises up to 4 m above the rock platform. There is a relict dune feature, which runs in a north-south direction and rests on Permian breccia behind a tidal inlet along the western end of two valleys: South Milton and South Huish. The valleys are separated by, and set between, adjacent low hills to the north and south, which follow the geology of lower Devonian slates.

In the wide South Huish valley (SX678413), sands and peats rest in part on white gravel; there is grey clay on the southern hill slope. A stream runs along the base of the northern hill slope, its outflow seeping beneath the storm barrier to reach the sea. Three sampling sites were chosen in this valley.

The semi-permanent coastal lagoon, South Milton Ley (SX688422 to SX678428), has fen sediments in its upper reaches, with sand and mud in the lower reaches, becoming organic beneath the stream outflow. The coastal platform is periodically cleared of 1 m of coarse gravel and sand exposed by storms such as in 1866, 1923, 1960, at length during 1989, and again in 1994; it is marked 'Submarine Forest' on OS 6:1 sheets CXXXV NE (135) 1907 (Fig. 5). On the eastern edge of the platform, the detritus fragment included in this study is situated

Figure 5. *Macrofossil woodland evidence at the Thurlestone Sands study site [South Milton and South Huish valleys] in Bigbury Bay.*

in a small floodplain site crossed by the stream issuing from the South Milton Ley. The deposit at SX675415 is on the landward side of the Permian wave-cut arch, in close proximity to the opening of a coastal lagoon, probably formed prior to the emplacement of a sand barrier. Winder (1923) described a section on the north of the platform, whilst Ilbert (1866) and Pengelly (1866) recorded a large area to the west with 'well preserved *Quercus* wood with the tree tops all pointing to the west'. Some macrofossil evidence was found by Orme (1961) in the base of the top-most sediment layer. This evidence comprised leaf stalks, *Corylus* nuts and *Betula* (Birch) bark with no *Pinus* (Pine), a little *Betula*, and *Sphagnum* (Sphagnum moss). Considerable evidence of woodland in the area has now been found within the sediment and

is reflected in the pollen assemblages produced in the course of this investigation. Two sites were investigated at South Milton Ley and at South Huish.

Wembury Bay

The steep valley that opens into the centre of Wembury Bay (SX517485) has Pleistocene relict cliff and clay-rich alluvium with a small stream cutting through reworked head. The samples taken from the core extracted at Wembury reflected local erosion; they were taken from the coastal pasture at the seaward end of the valley behind a south-facing beach. The wide, wave-cut rock platform lies west of the Mewstone Rock and north of the rock valley containing the River Yealm.

METHODS

Sediment Sampling

After making short exploratory surface traverses at each study site, sediment samples were raised by a Edelman Soil Mapping Gouge Auger (70 mm diameter), coring through to the sediment base or bedrock. Cores in 1 m lengths were laid out in shallow plastic troughs, labelled and wrapped in clear polythene to avoid drying out, oxygenation and degradation prior to laboratory study and analysis. The deepest sedimentary sequences from Salcombe and Torbay were subsequently sampled to bedrock by using a Cable Percussion Corer. Coring penetration difficulties were encountered when marine gravel, shingle, clay, water or wood was present. Not all of the deeper sequences were available for study; however, of 439 sediment samples taken at 5 cm intervals, those at 20 cm intervals were used for micro and macrofossil work. The Munsell Colour Chart was used to assess and correlate descriptions of the sediments. As a result, the stratigraphy is presented in Fig. 6(a–e).

Plant Macrofossil Analysis

The seeds or fruits within 58 samples were distinguished following the principles outlined by Dickson (1970) including a simple assessment of the organic content in each sample and its lithology using Troels-Smith (1955) guidelines. Formal and English nomenclature followed Stace

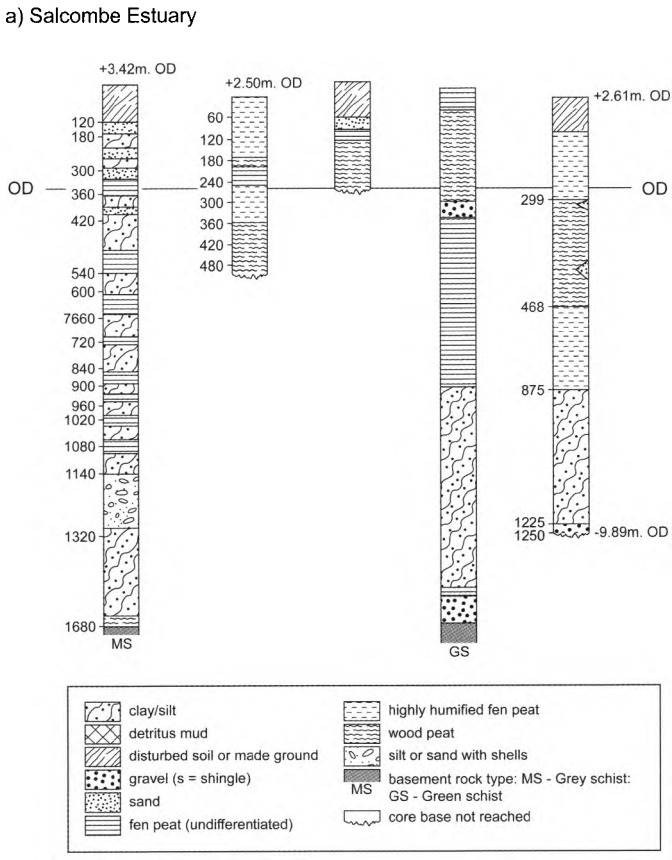


Figure 6. *Stratigraphy of study sites in (a) Salcombe estuary (b) Tor Bay (c) Wembury Bay (d) Bigbury Bay (e) Start Bay.*

(1997), incorporating alternative names recommended by Bennett *et al.* (1994).

Radiocarbon Dating

Age estimates were provided by radiocarbon dates on fifteen basal sediment samples with a further three dates at significant boundaries. Samples were subjected to the standard treatment of conventional radiocarbon dating at the Natural Environment Research Council

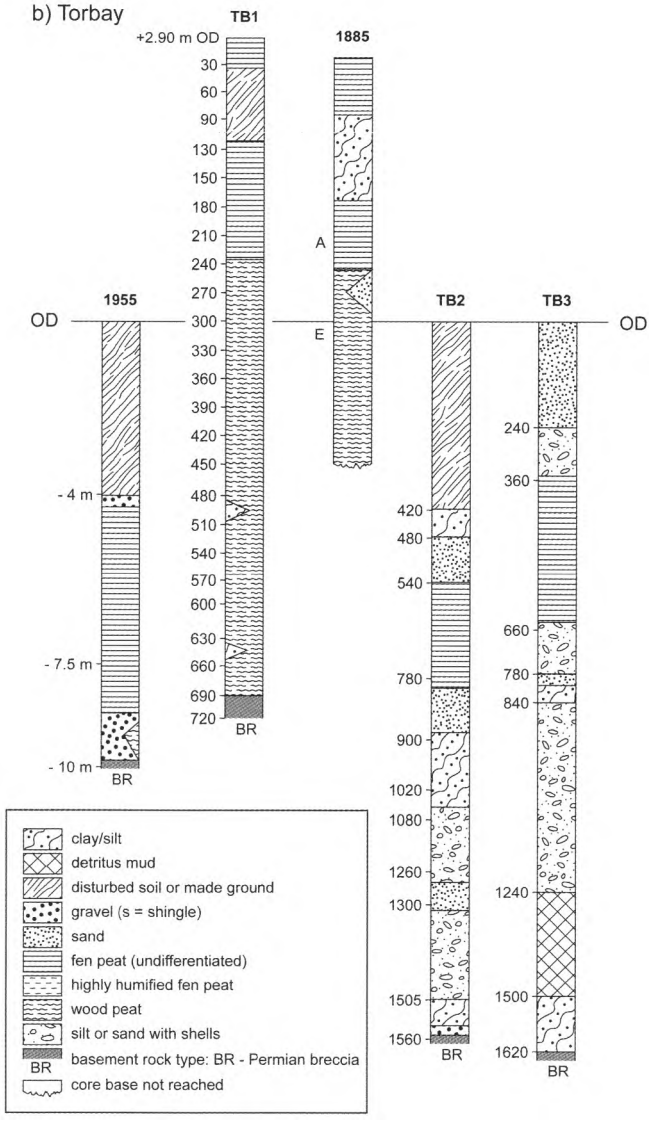


Figure 6. *(Continued).*

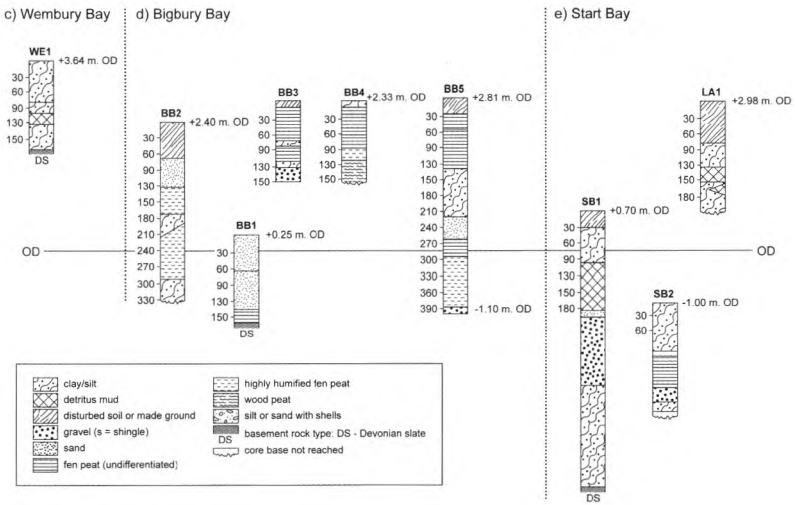


Figure 6. *(Continued).*

[NERC] Radiocarbon Dating Laboratory in East Kilbride. Bulk samples were used for all estimates.

This radiocarbon dating programme enabled a chronology to be established from the basal organic deposit of the available samples including three bio-stratigraphic dates. The results of this analysis are presented in Table 1.

Pollen Analysis

Changes in the woodland around the South Hams during the last 7,500 years are suggested from species changes found in the pollen diagrams. The species commonly found, particularly at Torbay and the Salcombe estuary, were those able to flourish at, or just above, ground-water level and those that thrive in exposed sites as a result of human actions. High quantities of lignins, cellulose, siliceous material, together with carbonates and calcareous sediments, were present in the samples. As a result, each batch was subject to oxidation, acetolysis, followed by HCl and HF treatments at the University of Plymouth School of Geography laboratories following standard procedures. Initial sieve-washings for macrofossil work were prepared and stored in 4–5 per cent ethanol. With the possibility of low pollen in coastal

Table 1: *Calibrated Dates – South Hams Coast*

Location	Sites	Depth (cm)	Radiocarbon Date BP	Calibrated Date BP (2 σ)	CAL BP[1]	CAL AD BC[1]
Wembury Bay [C1]	**Wembury [WE1]**	109	925 ± 50	930–720	518	1440
Bigbury Bay [C2]	**South Milton Ley [BB2]**	119	1280 ± 45	1290–1070	800	1150
	South Milton Ley [BB2]	281	4490 ± 50	5290–4890	4660	2710
	South Huish [BB1]	180	3585 ± 50	4060–3720	3460	1510
	South Huish [BB5]	380	1405 ± 50	1400–1190	935	1015
	South Huish [BB4]	71	750 ± 50	770–570	400	1550
Salcombe Estuary [C3]	**North Sands [SE1]**	455	3830 ± 45	4400–4080	3760	1810
	South Sands [SE4]	1680	7425 ± 50	8320–8020	7840	5890
Lannacombe Bay [C4]	**Lannacombe [LA1]**	180	2260 ± 50	2350–2140	1860	90 AD
Start Bay [C5]	**Blackpool Sands [SB1]**	180	2550 ± 45	2750–2430	2200	250 BC
	Blackpool Sands [SB1]	1000	4345 ± 45	5040–4830	4440	2490
Tor Bay [C6]	**Goodrington [TB2]**	760	5295 ± 45	6190–5940	5640	3690
	Goodrington [TB3]	560	4625 ± 45	5470–5080	4830	2880
	Goodrington [TB1]	707	4160 ± 45	4830–4540	4220	2270
	Goodrington [TB1]	240	2865 ± 40	3110–2860	2680	730

The last two columns follow Stuiver and Braziunas (1993)

sediments, preparation was adapted to maintain a minimum grain count with 206 sample sizes larger than the standard 1 ml.

A Watson Microsystem 70 Microscope (with Kohler illuminator) was used with eyepiece lens at ×10, using ×4/.13 ×10/.30 ×45/.65, for routine counting and oil ×90/, with anisole immersion fluid for critical identifications. Early pollen work was carried out using a Vickers instrument at ×40. The pollen analysis technique was based on the standard method of sample mounting, microscope observation and counting, followed by the preparation of pollen diagrams to show the vegetation successions. Identification of pollen and spores was carried out using the keys published by Faegri and Iversen (1989), Moore Webb and Collinson (1991) and Andrew (1984), together with the Pollen Slide Reference Collection held at the University of Glasgow. In particular, a low susceptibility to corrosion and oxidation of certain pollen grains and spores was found to cause an over-representation of *Polypodium* (Common fern), *Pinus, Tilia* (Lime) and *Alnus*; the latter also distorting the arboreal result.

From the study of an average of 423 pollen grains per slide, a total of thirteen[2] pollen diagrams were compiled and used in the analysis. These diagrams were prepared using the guidelines presented by Birks (1980) and also Bennett (1984), and employing the computer software program Tilia©Grimm (1992). The pollen data were expressed as percentages of total land pollen (TLP). These pollen percentages were then used to designate local pollen assemblage zones where changes in the pollen record reflect local vegetational changes – defined as a point where a significant change appears in major taxa. A summary of the woodland species encountered in the pollen analyses carried out in this research is presented in Table 2. A small selection of the pollen diagrams is included later in this paper.

A CHRONOLOGY OF HOLOCENE WOODLAND COMMUNITIES IN THE SOUTH HAMS

10,000–8,000 Radiocarbon Years BP: the Early Holocene

On the coast, the Holocene taxa were recognised by Pennington (1969) to support a small element of plant refugia, particularly on the south shore of Tor Bay. For Tor Bay, Godwin (1975) included communities recognised as establishing quickly during the climatic amelioration, and Ingrouille (1995) added species attributable to human activity. The lowland climate had already ameliorated

Table 2: *Summary of the woodland species found in thirteen pollen diagrams*

	Quercus	Ulmus	Corylus	Pinus	Fraxinus	Tilia	Betula	Alnus	other
Tor Bay	√	√	√	√	√	√	√		
Blackpool Sands	√	√	√				√	√	
North Hallsands		√	√			√		√	
Lannacombe					√	√	√	√	Picea
Salcombe	√	√	√	√	√			√	Picea, Salix & Sambucus nigra
South Huish	√	√		√	√	√			Juglans
South Milton	√	√		√	√	√	√	√	Fagus, Picea
Wembury	√			√	√			√	Ilex

before 7,425 BP allowing a rapid establishment of open woodland overlapping remnants of Boreal woodland. The *Alnus* and *Corylus* rise occurred before the onset of organic deposits in south Devon at about 8,000 BP.

8,000–7,000 Radiocarbon Years BP *Ulmus-Corylus-Quercus* (Elm-Hazel-Oak)

The early open woodland comprised *Ulmus* at 10 per cent, *Corylus* at 22 per cent, *Quercus* at 15 per cent, and Moss. Local fen or carr in suitable valley environments was supported by values of *Alnus* (at 25 per cent, with peaks to 60 per cent) accompanied by Filicales and aquatics. There was just a trace of *Betula*, but *Pinus* values (of up to 50 per cent) were found locally. The *Corylus* value was highest at the valley entrances of Salcombe Harbour and is thought to represent a remnant of more extensive woodland that existed prior to the transgression (Fig. 7). *Corylus* is known to prefer a dry soil and was found to coincide later with a corresponding absence of *Alnus* in Bigbury Bay.

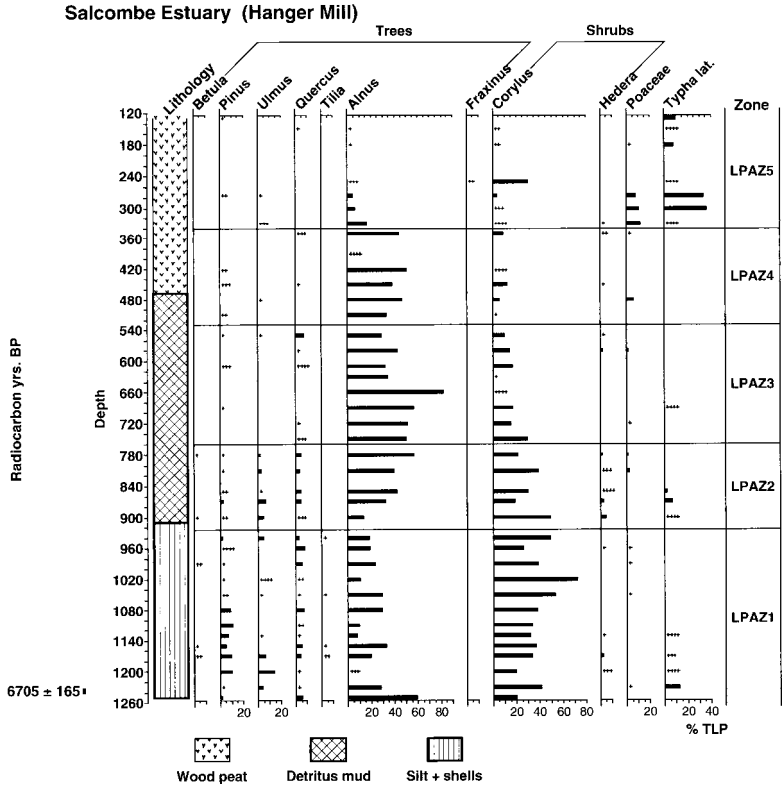


Figure 7. *The pollen diagram indicates that, from 6,705 radiocarbon years BP, the Salcombe site supported a woodland environment dominated by Alder and Hazel. Oak was present and so were limited amounts of Birch. Further evidence of woodland cover is provided by the presence, from time to time, of Hedera (Ivy): a woodland indicator species. A change in the character of the vegetation is evident towards the top of the diagram (at depths in the core less than 3.2 m): woodland species decline and plants common in open grassland environments (Poaceae) become more abundant. However, Hazel was still present, perhaps given the usefulness of its timber, indicating human management of the landscape. The presence of the grains of Typha (Bulrush) suggests the presence of bodies of open freshwater in the area.*

7,000–5,500 Radiocarbon Years BP *Pinus-Corylus-Alnus-Quercus* (Pine-Hazel-Alder-Oak)

After 6,705 BP, and just prior to the *Ulmus* Decline, a woodland high of 50 per cent coincided with a *Pinus* high and very low *Alnus* and *Quercus* values. During this woodland stage, a low *Tilia* value suggested that this tree was also part of the vegetation in fen margins or on suitable hill slope areas. The *Tilia* decline was difficult to determine, as the regional pollen value was low. However, in Bigbury Bay, the decline coincided with a change of sediment at about 5,600 BP from silt-with-shells to detritus-mud. This decline appeared to reflect the onset of organic deposition in the valley and an increase in fluvial sediment. Generally, *Corylus* reached a maximum value of 60 per cent after the *Ulmus* decline and, with *Ulmus* at 15 per cent, considerable open woodland is indicated. Conditions were locally suitable for the inclusion of *Tilia* and the wider distribution of *Hedera* (Ivy), whilst further opening of the canopy was a result of the local lack of *Quercus*. A fairly undisturbed, open environment with the presence of *Succisa* and *Epilobium* (Willowherb) increased in the herb-fen component, and with *Alnus* reaching a maximum of 60 per cent, particularly in the valley areas.

5,500–5,000 Radiocarbon Years BP *Corylus-Alnus-Quercus* (Hazel-Alder-Oak)

By 5,200 BP, extensive woodland (at 85 per cent), particularly in the east of the region in Torbay, existed at the same time as conditions causing humification of organic sediments, poor pollen preservation plus fragments of charcoal. This evidence is consistent with anthropogenic activity and also climatic disturbance. *Betula, Pinus, Ulmus* and *Tilia* were present, but at far lower levels, whereas the value of *Alnus* was increasing. There were also increases in values locally for *Hedera*, *Typha latifolia,* and *Cyperaceae* (Sedge).

5,000–4,500 Radiocarbon Years BP *Betula-Pinus-Ulmus-Corylus* (Birch-Pine-Elm-Hazel)

At the *Ulmus* decline in south Devon, the woodland contained a narrow range of trees including *Fraxinus* (Ash). Poaceae and Cyperaceae were dominant in the damper valleys and locally in close proximity to the coast with Chenopods, *Iris* and *Typha angustifolia* (Bulrush).

Although, in the New Forest area, the *Ulmus* decline is shown to have coincided with an excess of moisture or the removal of grazing animals (Barber, 1987), such a result is also consistent with an increase in overgrown woodland. There appeared to be an indication of damp conditions in south Devon, perhaps similar to the present day, with small coastal mires and lagoons, apart from higher arboreal values. Species indicative of disturbed sites were present such as *Plantago lanceolata* (Plantain), *Asteraceae* (Daisy family), *Ranunculaceae* (Buttercup family), although there were some contrasts, such as the first appearance of *Linum bienne* (a species preferring undisturbed open ground) occurring in Bigbury Bay. Continuing through to 4,600 BP, extensive woodland areas were rich in organic debris and were extensively overgrown by *Rubus fruticosus* (Bramble).

4,500–4,200 Radiocarbon Years BP *Quercus-Corylus*-Filicales-*Pteridium* (Oak-Hazel-Ferns-Bracken)

Locally open woodland with 10 per cent *Quercus* at 10 per cent with Filicales was encountered with *Malva*, *Linum* and Filicales (i.e. *Osmunda*) in open spaces. However, in the Bigbury Bay and South Huish sites, results with low arboreal pollen values suggest clearances as there is no increase in aquatics, whilst spore plants continued to be present, as was *Sphagnum* locally. There was a lower Poaceae (grasses) value and, within poorly drained areas, the damp conditions caused Cyperaceae to reach 85 per cent whilst *Alnus*, which commenced at 55 per cent, subsequently fell away and did not recover throughout the middle and late Holocene. At this point, after the *Ulmus* decline in south Devon, an extensive period of erosion appears to have occurred in Tor Bay.

4,200–4,000 Radiocarbon Years BP *Pinus-Quercus-Corylus-Alnus* (Pine-Oak-Hazel-Alder)

By 4,160 BP, following a continuation of the woodland clearances, *Ulmus* was just 2 per cent, but *Tilia* was quite well represented, and *Pinus* was also present. *Alnus* commenced at 18 per cent but continued to fall to only 5 per cent (Fig. 8). Conditions locally indicate the presence of damp areas, but Cyperaceae also declined to 25 per cent, which suggests a drier climate or perhaps an increase in pastoral activity.

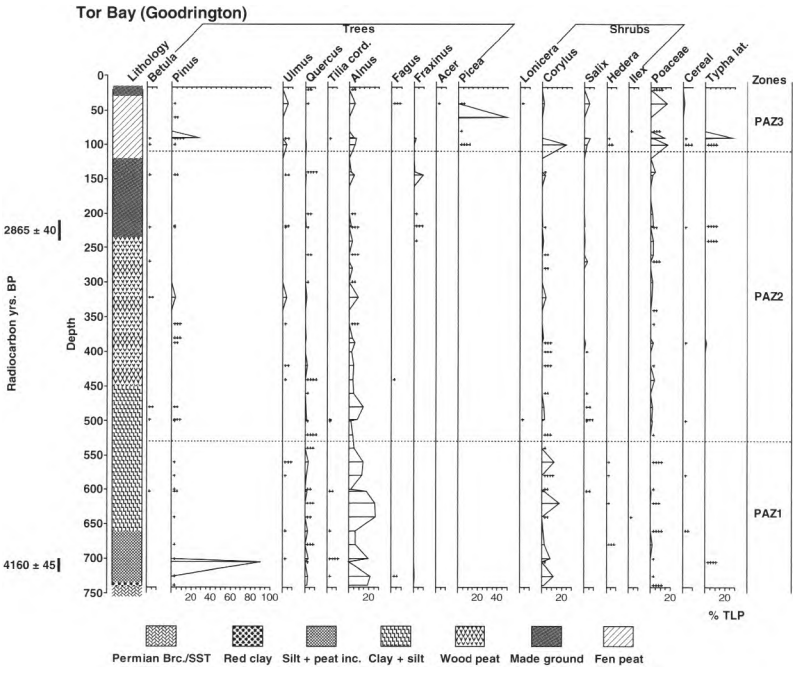


Figure 8. *Two radiocarbon dates are available for this core taken at the Goodrington site in Tor Bay: 4,160 BP and 2,865 BP. The pollen diagram therefore shows the species present at the site during the early to mid-Bronze Age. Evidence of woodland clearance in the landscape is provided by the decline – but not total elimination – of Alder, Hazel and Oak. A steady, but increasing presence of grasses (Poaceae) and some cereal pollen grains suggests arable and pastoral land use.*

3,830 Radiocarbon Years BP

From 3,830 BP, a distinction between damp and dry conditions becomes increasingly emphasised, together with an increase in pastoral activity. There was a further decline in Cyperaceae from 27 per cent to 10 per cent. Tall herb fen increased with *Epilobium*, *Lythrum salicaria* (Purple loosestrife), and*Urtica dioica* (Nettle) with the values maintained subsequently. A slight recovery of the *Alnus* value occurred (to 10 per cent) and this was accompanied by Filicales, for which the value was again high at 80 per cent. *Equisetum*

(Horsetail) was present in badly drained and wetter sites around south Devon such as at South Huish.

3,585 Radiocarbon Years BP *Quercus-Corylus-Poaceae* (Oak-Hazel-grasses)

From about this time the decrease in *Quercus* continued, although it was still locally dominant, such as at Bigbury Bay (Fig. 9), whilst *Fraxinus* appears and traces of *Tilia* remain. This zone continued to show high Cyperaceae, thus suggesting a decline in pastoral activity. Evidence of arable farming activity was provided by high Poaceae and cereal pollen together with a number of clear agricultural and open-ground indicators: for example, the presence of Asteraceae, Campanulaceae, Chenopodiaceae (Goosefoot), *Empetrum nigrum* (Crowberry), *Plantago lanceolata, Lythrum salicaria, Succisa* (Devilsbit scabious) and *Urtica* sp. From this point onwards, *Armeria maritima* (Thrift) was present in the pollen record and this finding is consistent with changes in the proximity of coastal cliffs and the increase in plants tolerant of salt spray.

2,865 Radiocarbon Years BP

The open woodland structure had changed to include isolated stands with just a trace of *Fagus* (Beech) appearing, although *Fraxinus* continued to be high. There was a low pollen count, but an increase of herbaceous taxa is noticeable, particularly those of dry grassland, with Poaceae at 5 per cent, whilst Cyperaceae is locally high at 60 per cent.

2,400–1,350 Radiocarbon Years BP: Late Iron Age to Early Medieval

After 2,260 BP, the open landscape continued to increase towards present-day values but retained pioneer species. Together with herbs typical of more open conditions, there were small woodland areas with *Tilia, Betula* and a trace of *Ulmus*. In the lowland areas, there was a restoration of *Alnus* (to 25 per cent) accompanied locally by areas with swamp conditions and a large number of aquatics including *Hydrocotyle* (Marsh pennywort), *Menyanthes* (Bogbean) and *Typha angustifolia*.

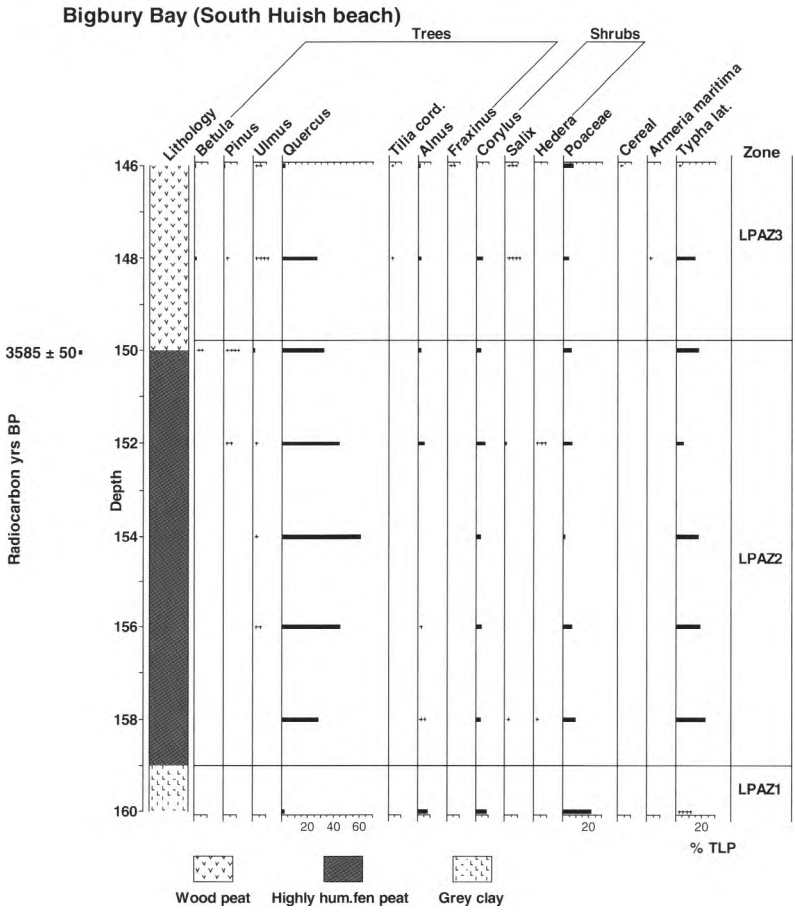


Figure 9. *A radiocarbon date of 3,585 for this core, taken at the South Huish site in Bigbury Bay, shows that at this site, in contrast to other locations where woodland was probably being cleared (certainly its presence was declining) and grasses and cereals were appearing, a woodland environment dominated by Oak (Quercus) existed. The pollen diagram also indicates a minimal presence of Alder, Hazel and Elm. Open areas of freshwater are suggested by the Typha (Bulrush). An absence of cereal pollens and the low representation of grassland species might indicate that, in this area, the Oak woodland itself was used as a resource for livestock or perhaps for hunting.*

From 1,405 BP, open grassland was almost at present-day values with Poaceae high at 30 per cent. Consistent with exposed areas of open ground and maritime conditions, together with *Plantago coronopus* (Buckshorn plantain) and *Artemisia maritimus* (Sea wormwood), the herb species *Anthoceros* (Moss), *Osmunda, Malva, Lythrum* and *Epilobium* were present. Lowland conditions continued to be locally very wet as *Alnus*, commencing at a low level, rose to 25 per cent, and Cyperaceae was well represented at 20 per cent, and *Cladium* (Sedge family) was present. These species indicate areas of extensive open water.

c. 1,350–500 Radiocarbon Years BP: Early Medieval to Early Post-Medieval

From 1,280 BP there was a large increase in Cyperaceae together with a high herb value, including Poaceae, Rubiaceae (Bedstraws), *Rumex* (Dock), *Plantago lanceolata* and *Brassica* (Cabbage). At this point, there was a decline in all the woodland trees, although *Fraxinus* and *Ilex* (Holly) survived among the remnants. The presence of cereal pollens and *Empetrum* suggest further clearance activity and patches of bare ground. In the lowland areas, *Alnus* remained high and was accompanied by *Salix*.

925 Radiocarbon Years BP

By 925 BP, the increasingly open and scattered woodland contained a renewed presence of *Fagus, Fraxinus, Ulmus* and *Ilex* and a continuing but small presence of *Quercus*. Poaceae continued to be well represented (at 30 per cent) but was declining; cereal was present, together with the herbs Apiaceae (Umbellifer family) and *Plantago lanceolata*, and with Asteraceae, which was high at 20 per cent. The open-ground herbs, *Succisa, Polygala* (Milkwort), *Stellaria* (Stitchwort), *Lemna* (Duckweed) and *Malva*, were also present, and Cyperaceae continued to be well represented. The exposed coastal environment by then had *Empetrum nigrum, P. lanceolata, Calluna, Armeria maritima,* and Chenopods.

750 Radiocarbon Years BP

After 750 BP, *Quercus* was established (although it was less abundant than before) in open woodland within a landscape which by then approached that of the present day. Both Poaceae and Cyperaceae

values approached 30 per cent. Areas of exposed bare ground increased with *Plantago lanceolata* at 8 per cent, accompanied by *Centaurea cyanus* (cornflower) and *Anthoceros*. Again, local conditions were very wet and this is indicated by the presence of aquatics, including *Cladium*.

AD 1200 to the Present: the Modern Era

From AD 1200, there was locally an increase in *Osmunda regalis*, whilst the results of purposeful and recorded planting of *Pinus* and *Picea* (Spruce) were noticeable. In the late-Holocene, there is a co-incidence in the appearance of *Picea* with the lesser occurrence of *Quercus* and *Alnus* and the increase of Poaceae. The coincidence of fewer trees with more herbs and an often-higher Cyperaceae value was noticed, together with a recent large increase in *Typha* pollen. Disturbed soil or made ground at the top of most valley alluvium was directly attributable to human land use.

DISCUSSION – THE SOUTH HAMS WOODLAND COMPARED WITH FINDINGS ELSEWHERE

In general terms, for a considerable part of the Holocene, the climate in the coastal zone of south Devon appears to have been mild and windy and the sedimentation rates appear to have been rapid. The adaptation of vegetation to climatic variations, sediment changes and human activities are all manifest in the results of the pollen analysis obtained during this research.

Close to a steep shelf edge, the South Hams may have escaped certain stages in the dynamics of changing sea levels. However, during the last 5,000 years, and most certainly since the present-day coastline was established in the last 3,000 years, the coastal valleys have been subject to seasonal and storm flooding, which over time has certainly both decreased and changed the nature of woodland. As a result, the pollen record for maritime palaeoenvironments contrasts with that for areas with little maritime or salt-marsh vegetation, whereas, in the macrofossils, an increase in salt-tolerant plants was found particularly after 4,000 BP in the late Holocene. As a result, in Start Bay and further to the west, the presence of marsh plants able to cope with periods of sudden flooding followed by rapid and prolonged drying may either be a response to such changes or a reflection of climatic variation.

In this final section of the paper, comparisons are made between the woodland communities identified for the South Hams sites investigated in this research and those described by other researchers elsewhere in southern England. A summary of the 'early Atlantic' mix of woodland species encountered at other sites is presented in Table 3.

Pre-Holocene

In our coastal woodland, from the early Holocene, the low arboreal pollen record is consistent with existing records for maritime Europe (Coope *et al.*, 1987) where forest trees generally accounted for 10–15

Table 3: *Early Atlantic Woodland (percentage representation of tree pollen) at other locations in southern England*

Site	*Betula*	*Quercus*	*Ulmus*	*Alnus*	*Tilia*	*Fraxinus*	*Corylus*
Bodmin	8.5	7	1	3	1	1	28
Blacklane	1.5	14	2	4	1	1	29
Blackabrook	9.5	11	4	2	1	1	25
South Sands	0.5	15	12	25	–	0	24
North Sands	1.5	10	15	45	2	0	40
Somerset	2.5	15	2	65	10	0	20
Porlock	0.5	30	0	48	1	0	10
Westward Ho!	0.5	73	15	0	0	0	23
Isles of Scilly	40.5	30	–	2	–	–	15
Marazion Marsh	1.5	11	1	48	0	1	25
Horsemarsh	1.5	2	3	3	30	–	20
Pannel Bridge	5.5	20	10	35	30	–	30
Brede Bridge	2.5	22	5	32	15	–	25
Cranes Moor	10.5	20	4	3	0	–	42
Church Moor	10.5	30	5	60	0	1	40
Isle of Wight (1)	15.5	70	2	80	1	1	50
Isle of Wight (2)	12.5	50	10	32	0	–	80
Thames Estuary	3.5	40	10	30	2	1	40

Sources: The South Sands and North Sands sites are based on data collected by the author; data for the remainder of the sites is taken from the sources listed in the caption to Fig. 1.

per cent (but ranging up to 30 per cent) of total pollen. From 7,000–6,000 years ago, sheltered coastal valley areas contained open *Quercus-Corylus* woodlands, particularly on the hill slopes with better drainage, with *Fagus* and small or isolated stands of *Pinus* or *Betula*. This kind of community occurred, for example, at the Torbay and the South Milton Ley sites investigated in this study. In valleys prone to flooding, for example at South Milton Ley, very damp and swampy areas expanded rapidly.

Mid-Holocene

Sudden breaks for *Alnus*, occurring around 7,000–6,000 ago, were typical of a 'sudden submergence reflecting wholesale destruction of fen-woods' (Godwin, 1975). However, at the Bigbury Bay site, the evidence suggests the possibility of a decline in water level, perhaps caused by human activity such as the digging of ditches. In addition, the coppicing of the *Alnus* taxa (Scaife, 1987) may help to explain the pattern of sudden breaks in that area of the pollen record. The particular abundance of *Alnus* pollen masks the importance of *Salix* within the drier fens encountered in this study, particularly those in the Tor Bay area. It also masks the extent of dominant trees, *Quercus* and *Corylus*. It is very clear that *Alnus* was rather less significant in south Devon than, for example, in Somerset, where values of 75 per cent to 90 per cent were common.

The possible woodland profile in south Devon, covering two woodland types: *Fraxinus excelsior-Acer campestre-Mercurialis perennis* woodland (Rodwell, 1991); and *Quercus-Pteridium-Rubus* (Rodwell, 1991) appears to cover the range of species identified in this study. Moreover, findings in this research are consistent with those revealed by work from Torbryan Caves (Cartwright, 1996). Although absolute certainty is clouded by the passage of time, within each of the woodland types, the locally important dominant and associate species of today's vegetation appear recognisable throughout the Holocene. A constant representation of open-ground herbs, for example *Plantago*, was included in the profile as locally present in coastal retreat (Pennington, 1969) from enclosing inland woodlands; also possibly masking the expected increase of the open-ground herbs after the commencement of farming activity from the Neolithic onwards (Jenkins, 1902; Belville, 1956–57; Griffith, 1986).

The replacement of *Alnus* with *Quercus* and *Corylus*, and minor *Betula* with *Filicales*, is taken as an indication of the drying out of the peat surface (Long and Innes, 1993). This drying out appears to be a recurrent event in the south Devon coastal area. The presumed adaptation of the plant communities to the process of drying out also occurs at Bigbury Bay. Inland, woodland with a high *Quercus* percentage of the arboreal pollen was observed on Dartmoor at Blacklane Brook in two periods (Simmons *et al.*, 1983). The first period was between about 9,600 BP and 8,000 BP and the second period was from about 7,500 BP to 3,500 BP. *Quercus* was present about 7,400 BP at South Sands in the Salcombe estuary, 4,300 BP at Start Bay, and about 3,500 BP at Bigbury Bay. After these dates, *Quercus* values decreased. Locally, *Quercus* occasionally fell to as little as 15 per cent, but elsewhere it might also be as high at 60 per cent. However, an average value of 22 per cent was found to be significant for *Quercus* on Bodmin Moor (Geary *et al.*, 2000) and at Slapton Ley (Crabtree and Round, 1967). The sites in the South Hams considered in this research that show *Quercus* to have been dominant, were those located alongside part of a fluvial margin environment at North Sands in the Salcombe estuary, at South Huish close to the once more-extensive River Avon in Bigbury Bay, and at Blackpool Sands in Start Bay.

The evidence indicates that an extensive woodland area was present before the early Holocene transgression and this matches the conclusions of Scaife (1984) for the Isles of Scilly. There is a strong indication that Pengelly's deduction was correct: significant amounts of woodland in the south Devon coastal zone were lost to headland and other erosion prior to about 4,000 BP (Pengelly, 1865). However, on the uplands of Bodmin Moor, *Quercus* was believed by Brown (1977) to have favoured the valley sides; a situation where it still occurs today. In response to fluctuations and extreme conditions of rapid run-off or fast evaporation in the Holocene fluvial regime, plants such as *Pinus* and *Betula*, although only locally common, rapidly colonised drier areas, including those now located offshore (Evans, 1990). Exceptions to the apparently dominant *Alnus* carr were found at Westward Ho! (Balaam *et al.*, 1997) and around Mounts Bay where *Salix* carr was a main woodland component (James and Guttman, 1992). The Westward Ho! and Mounts Bay assemblages

correspond with the findings of this study for the Tor Bay area, especially close to the Bay itself.

Although the *Ulmus* decline identified in this research does not appear to be connected with cereal planting in south Devon, it was probably linked to Neolithic pastoral activity. On Dartmoor, it has been noted that the *Ulmus* decline was accompanied by a disruption of the *Alnus* and *Calluna* pollen record (Beckett, 1981). *Ulmus* was recognised in the south Devon woodlands in this study at Bigbury Bay and one of the Tor Bay sites with a value between 4 and 12 per cent. Although the taxon may be under-represented on Dartmoor and on Bodmin Moor, in south Devon there is a sharp decline of *Ulmus* at about 5,000 BP. *Ulmus* requires shelter from exposure, as established for Dartmoor by Beckett (1981). Such conditions are often afforded in south Devon on the better-drained valley slopes. The *Ulmus* decline was shown at South Milton Ley in Bigbury Bay and was followed by a secondary rise that ended at about 4,500 BP. However, a trace of *Ulmus* presence continued here until systematic tree planting took place after about AD 1760. As noted, the cultivation of cereals does not appear in south Devon to have coincided with the *Ulmus* decline. Thus cereal pollen was not found until about 4,100 BP in the Tor Bay samples; 3,600 BP in those for Salcombe; and later still, between 1,400 BP and 1,280 BP, in Bigbury Bay.

Small values suggest a similar problem of under-representation of *Tilia* as was found in Southeast England by Waller (1994) and for Dartmoor by Beckett (1981). Godwin's (1975) *Tilia* decline was also linked with the initial presence of cereals, but dates for a possible *Tilia* decline in south Devon might be as late as between 3,800 BP for South Huish in Bigbury Bay and 3,500 BP at Tor Bay, where a period of fluvial clay silt deposition occurred just before the accumulation of wood peat. These dates compare with the general decline in Southeast England, but both are a little later than the 3,700 BP date for the specific area of the Brede Valley (Waller, 1994). A probable date for the decline was around 4,160 BP.

Unusual dips in the *Corylus* values (Waller, 1993; 2000) are attributed to possible anthropogenic woodland clearance activity on lower slopes. Although not as extensive as the evidence of early charcoal deposits found in Dartmoor contexts by Caseldine and Hatton (1993), in this research an early identification of charcoal, possibly coincident with tree clearances, was found in the Tor Bay

area. The indications are that, after the decrease of open *Quercus* woodland in this maritime area, open plant communities flourished, particularly those of the dry heath and coastal grasslands (Bell and Walker, 1995).

Late-Holocene

Vegetation in this top-most zone was distinct from the earlier zones; it was one of the few zones with clear bio-stratigraphic markers – a consequence of the much increased human activity that characterised the late-Holocene. For south Devon, the upper sections of the pollen diagrams reflect the planting of *Picea, Abies* and *Pinus*, together with the presence of far greater quantities of Poaceae and some cereals. In Dorset, Barber (1987) showed that modern planting commenced as early as 1776, and in Devon, Ivimey Cook (1984) dates purposeful replanting of *Pinus* and *Quercus* from 1826. Modern activity included the draining of fen to form meadow land, and the creation of numerous open fields and heath (Bell and Walker, 1995). Such changes are reflected in the presence of cereal pollen in the samples.

The base of a zone at around 1,800 BP in the south Devon samples corresponds well with the modern zone base found at Wallend Marsh by Waller *et al.* (1999) and coincides with a rapid decline of arboreal taxa and ferns. Although in south Devon, the ferns were able to find many alternative habitats, a decline in these plants is often consistent with woodland reduction or an increase in sedimentation.

HUMAN INFLUENCES ON VEGETATION

The commencement of human influences on vegetation communities probably dates to the Palaeolithic. Occupancy of sites such as Kent's Cavern near Torquay is now known to extend through 400,000 to 100,000 years ago (Charman *et al.*, 1998). In south Devon, human impacts occurred that were similar to those encountered elsewhere in southern England, including upland sites, during the mid-Holocene. Temporary clearance activity dated to the Neolithic coincides with the *Ulmus* Decline and the occurrence of charcoal in Tor Bay samples from 4,160 ± 45 BP (4,220 cal. BP) and may represent small Landnam phases (Iversen, 1941 *in* Bell and Walker, 1995). While this date is later than the evidence of Mesolithic activity in upland Dartmoor that was found by Caseldine and Maguire (1981) to have occurred

from 7,360 ± 65 BP, it supports the suggestions of Pidgeon (1885) and Belville (1956/7) that there was activity in the South Hams area which was used on an irregular or seasonal basis for activities such as for the collecting of flints. The date also compares favourably with Waller's proposal that woodland disturbances commenced during the Mesolithic at about 6,300 BP in Southeast England (Waller, 1994). This idea was subsequently reinforced by finds of charcoal dating from 4,925 ± 80 BP (Waller, 2000). According to Kidson (1971; 1977) and Kidson and Heyworth (1973) woodland around the Somerset Levels contained an abundance of *Corylus* and more prolific *Tilia* and *Ulmus* than that found west of the River Exe.

Finds of Bronze Age sword blades, axe heads, and a torc dating to 1,100 BC from a shipwreck found in Salcombe implies that the Bronze Age was significant for the South Hams with many local settlements (*Kingsbridge Gazette*, 2005). Roman pottery also occurs in later organic horizons in Tor Bay. Although little evidence of Roman occupation in Devon generally exists outside the Exeter area (Fyfe *et al.*, 2004), Tor Bay may bear some similarities to the Thames Basin at Tilbury (Pidgeon, 1885; Devoy, 1987). By Norman times, Domesday Book reveals that the South Hams had many flocks of grazing animals but relatively little woodland – documentary evidence that is supported by the pollen record produced in this research.

CONCLUSION

This paper has reconstructed a detailed chronology of the early Atlantic woodland (from 7,400 BP) of south Devon. Moreover, comparisons have been made between the woodlands identified for the nine South Hams study sites and those described for locations across the south of England. The clear effects of variations of land use have been revealed. Woodland was particularly affected by early agricultural activity, but also by the precipitation changes and differences in water retention in each of the south Devon valleys investigated in this project. Prior to 5,000 BP, agricultural activity that involved the basic management of tree species such as *Corylus* and *Alnus* might possibly account for the many fluctuations in their abundance which cannot all be explained as the result of tidal movements. Throughout the study period, the local woodland changes that occurred across the South Hams area show a diversity of flora and a good soil balance that contrasts with those examples of

poor or water-logged soil and more restricted flora. The presence of many ferns and epiphytic *Polypodium* is consistent with the presence of undisturbed mature woodland and of open woodland on exposed areas and high soil moisture. Changes were visible within the microfossils and sediments suggesting a variety of natural features of swamps, lakes, woodland often with significant *Quercus* and dry grassland.

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NOTES

1. Examples elsewhere in the UK include (1) behind barriers, for example at Borth Bog and Ynsylas, (Nature Conservancy Council 1983) Westward Ho! (Jenkyn, 1908; Balaam *et al.*, 1987) and Blue Anchor Bay (Jennings *et al.*, 1998); (2) in river valleys, Thames (Devoy, 1987) and Forth (Newey, 1966); and (3) in known marshy areas, The Somerset Levels (Hibbert, 1977; 1982) and Romney Marsh (Waller, 1993).
2. Of the thirteen pollen diagrams, three examples are presented and explained later in this paper.

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