Early Human Impact and Heathland Development on the Lizard Peninsula

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Our knowledge of the vegetational history of the Lizard Peninsula is limited and questions around the pre-anthropogenic landscape and the origins of the *Erica vagans* dominated heathland have persisted. To address this, palynological analyses of sediments from two sites on the Lizard Peninsula have been conducted and are reported here. The older of the two archives, with a basal date of 7580±160 ^{14}C cal yr BP, is from the edge of the current heathland of Goonhilly Downs. The basal deposits indicate a dense tree covering dominated by pine with high levels of Pteropsida spores. Over the following *c*. 3000 years pine is replaced by broadleaf trees, principally oak and hazel. Between about 4000 and 2000 years BP there is an abrupt change in the pollen record to one indicative of an open landscape dominated by grasses. Large (>40 μm) Poaceae pollen also appears frequently and Ericaceae pollen expands rapidly. Between about 2000 years and 200 years BP there are only minor changes in the pollen record, the sharp decline of the Ericaceae being the most significant. The second site is at the centre of Goonhilly Downs with a basal date of 4151±254 ^{14}C cal yr BP. Between about 4000 and 3000 years BP the pollen indicates a mixed landscape of oak/hazel woodland and grassland with some possible evidence of both arable and pastoral agriculture. Between about 3000 and 600 years BP, there is an abrupt fall in the tree and shrub pollen, and a rapid rise in the Ericaceae pollen dominated by the endemic *Erica vagans.* Although there is evidence of a hiatus in both these archives, they provide substantive evidence of a pre-anthropogenic landscape of closed canopy forest cover, initially dominated by pine, followed by an open, anthropogenic landscape. This open landscape extended from the edge to the centre of the current heathland of Goonhilly Downs but at some stage >600 years BP the landscape of the Downs reverted to its current status as an Ericaceae dominated heathland. Consideration is given to the conditions that resulted in the establishment and maintenance of the heathlands and the status of *Erica vagans* within them. Farming then continued on the southern edge of the Downs to the present.

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Introduction

The Lizard Peninsula is the southernmost region of the British Isles. Unlike the rugged granitic landscape of much of the rest of Cornwall it consists of a gently sloping Pliocene wave-cut marine platform rising to about 110 m OD. Its geology is unique to the southwest resulting from a tectonic event during the late Carboniferous when a fragment of oceanic crust was faulted against Devonian sediments. The result was an Upper Devonian ophiolite complex consisting largely of the ultra-basic serpentine rock with a smaller area of gabbro to the east. The combination of the mild climate and the unusual geology make this one of the most important botanical areas of the British Isles and it is designated under the EC Habitats Directive as a Special Area of Conservation (JNCC, 2011).

At the time of inception of this study the environmental history and palaeoecology of the peninsula was informed by two pollen diagrams from the coastal areas to the west (French, 1996; Tinsley, 1999) and fragmentary evidence from buried peat and palaeosols from the plateau (Staines, 1977; Crabtree reported in Bell, 1984; Smith, 1984; Balaam, 1984; Straker, 1996). French (*op. cit.*) analysed a 7.5 m core from Gunwalloe on the western coast of the Peninsula which he estimated dated back to a pre-clearance phase in the Neolithic or Bronze Age. The second diagram was constructed by Tinsley (1999) from a 2.5 m core from Porthleven, 6 km to the north. This had a basal radiocarbon date of 3900 cal yr BP. Both archives provide evidence of initial dense tree cover in the coastal valleys followed by clearance phases that finally result in the near treeless habitat associated with the Peninsula today. Both the diagrams indicated that cereal growing was taking place throughout the time period represented, even before major clearance, increasing towards the most recent period. The fragmentary evidence from the Lizard plateau indicates a relatively open Bronze Age environment with a persistent cliff top heath community and traces of *Erica vagans* pollen.

The nature of the pre-anthropogenic vegetation was not addressed by these data nor was there a clear picture of the vegetation of the plateau. To address this gap in our knowledge of the palaeoecology of the Lizard three sites on the plateau have been investigated. The first of these pollen archives, a core from a sediment filled mill pond on the edge of Goonhilly Downs, provides evidence of predominantly anthropogenic vegetational changes over the most recent 800 years (Garbett *et al.*, 2016). The remaining two cores provide a much longer record with the oldest sediments dated at about 7500 years BP. These latter pollen archives provide the basis for this report, the longer of the two extending back to the pre-anthropogenic landscape.

The Study Sites

Palynological evidence from two sites on the Lizard Peninsula is described here. The sites are located by their National Grid References.

Hendra

The Hendra mire (SW 711175) is situated approximately 1.2 km south of the southern edge of Goonhilly Downs and is currently the largest area of heathland on the peninsula. The mire is approximately 110 m by 60 m and lies in a shallow valley adjacent to a stream along its northeast edge. It is located on the serpentine with a small area of granite gneiss to the north beyond the stream. It lies at 54 m above OD, approximately 500 m due south of Erisey Barton farm and 500 m due east of Hendra farm. It can be accessed from Friar's Lane (see Fig. 1). The earliest reference to the site found is on the 1878–1879 OS map where it is referred to as a 'willow bed'. The primary formation of this feature is uncertain, but it may be periglacial in origin; it has subsequently been bypassed by the stream leaving an abandoned terrace with alluvial overbank or channel infill sedimentation.

There is little evidence for flowing water on the surface suggesting that the most recently accumulated organic material has grown above the level of the stream to the north. The permanent presence of surface water, however, and the nature of the surface vegetation dominated by *Phragmites australis* (the common reed) indicate that the mire surface has not risen above the winter water table. *Salix cinerea* spp. *oleifolia* (grey willow), *Iris pseudacorus* (yellow flag iris) and other species typical of freshwater habitats are also present amongst the *P. australis* particularly around the edge of the feature. It has a sediment depth of up to 1.8 m, the top 10–15 cm consisting of highly humified organic detritus underlain by fibrous, highly organic mud. The basal 20–30 cm consists of an organic bluish grey clay becoming increasingly minerogenic with depth.

Croft Pascoe

The Croft Pascoe feature, 95 m above OD, is situated just to the east of the centre of Goonhilly Downs and adjacent to the Croft Pascoe copse. The high point of the Goonhilly serpentine plateau of 110 m OD is at Goonhilly Earth Station approximately 2 km to the NW. It consists of a damp linear feature of unknown origin, approximately 550 m in length and identifiable for 400 m of this by a strip of *Phragmites australis.* It commences in an area of *Salix* carr next to the road that links the B3293 with Kuggar (SW 730192) and falls from 95 m OD at this northern end to 89 m OD at the sampling site approximately 400 m to the SSW (SW 729190). For the remaining 250 m the feature bifurcates into increasingly narrow radiating channels only clearly visible from above (see Fig. 1) with *Schoenus nigricans* (black bog-rush) replacing *P. australis* as the dominant plant species.

The width of the channel varies unevenly as does the depth of the sediment. For the northern half of the channel the width varies from 20 m at its widest to 8 m at its narrowest. The sediment depth variation is between 20 cm and 55 cm but at 300 m from the origin of the feature the channel widens to 25 m with a sediment depth as much as 86 cm. It is from this section of the feature that the Croft Pascoe core was taken. The top 40 cm of the sediment at the sampling point consists of a dense, moderately humified *Phragmites* peat. At 40 cm the degree of humification increases with the sediment becoming increasingly minerogenic with depth.

Field and Analytical Techniques

The two sites were sampled in the spring of 2006. A Russian corer was used to extract overlapping core sections which were wrapped in cling film and aluminium foil and stored in labelled sections of plastic guttering. Samples were taken from the cores of both sites for ^{14}C dating. The first samples were sent to the University of Waikato Radiocarbon Dating Laboratory, New Zealand, for conventional radiometric dating. Subsequent samples were sent to the ^{14}CHRONO laboratory of Queens University, Belfast for AMS ^{14}C dating. In many cases the absence in the samples of macro fragments of wood, charcoal or similar carbon containing materials contemporaneous with the surrounding sediment necessitated the use of bulk organic material for the dating. Root material was removed but some would have contributed to the ^{14}C date so they must be considered minimum dates. The ^{14}C ages were calibrated using the OxCal online facility v4.3 (Bronk Ramsey, 2009, 2020).

The cores were sampled for palynological investigation by slicing them into 1 cm segments and storing them at 5°C in labelled plastic bags. These samples were then selected as required and prepared for counting. To calculate the palynomorph numbers per gram of sediment tablets of *Lycopodium* spores were added to each sample and the *Lycopodium* exotic spore count used to determine absolute frequencies (Stockmarr, 1971). The samples were then prepared by means of standard acetolysis and hydrogen fluoride treatments (*e.g.*, Moore *et al.,* 1991). These procedures remove most of the non-pollen matrix from the sediment and the resultant concentrated pollen samples were mounted in silicone oil for pollen and spore identification and counting. Identification was facilitated by the use of keys for example within Moore *et al.* (*op. cit.*), the 'PalDat' online palynological data base and a small reference collection. Ericaceae (heath) pollen were separated into species, including the very distinctive pollen of the endemic *Erica vagans* (Cornish heath), using the keys of Oldfield (1959). The identification of possible cereal grains (Poaceae $>40\mu$m) was informed by the work of Andersen (1979), Küster (1988) and Beug (2004). Charcoal fragments were counted independently of pollen and spores at approximately 5 cm intervals. Two size categories were chosen, 10–50 μm and $>50\ \mu$m.

Figure 1. *Hendra Mire is accessed from the footpath off Friar's Lane, 3.5 km SE of Mullion village (NGR SW 711175). The mire lies to the right of the footpath in the wooded area. (Photo: Google Earth © Infoterra Ltd and Bluesky.)*

Table 1. *Samples sent for carbon dating with uncalibrated and calibrated date – years BP (and BC/AD).*

Lab. Code	SITE	DEPTH/ cm	MATERIAL	MASS/g	uncalibrated ^{14}C date yrs. BP	cal. yrs. BP (2σ range: 95.4%)	calibrated yrs. BP (BC/AD)
UBA-9710	Hendra	120	organic sediment	1.0	6554±30	7553-7424	7580±160 (5630 BC)
UBA-12422		99	organic sediment	0.165	4513±27	5301-5051	5176±125 (3226 BC)
UBA-21186		92	seed case/bulk material	0.034	3945±45	4521-4248	4384±137 (2433 BC)
UBA-9711		85	organic sediment	2.6	2200±22	2310-2149	2230±80 (280 BC)
UBA-20270		79	wood/bulk material	0.055	1767±40	1813-1570	1692±122 (258 AD)
UBA-18248		71	organic sediment	0.034	1313±37	1298-1180	1239±59 (711 AD)
WK19886	Croft Pascoe	78-87	organic sediment	25.6 +23.4	3746±76	4405-3897	4151±254 (2201 BC)
UBA-12423		61	wood/leaf fragments	0.01	2648±24	2791-2742	2767±24 (817 BC)
UBA-18247		54	wood/ sediment	0.022	530±24	625-512	569±57 (1381 AD)

Hendra

The main Hendra 120 cm sediment core was taken from the deepest point of the mire found during the early stages of the investigation. Subsequently a more thorough survey discovered an area where the corer penetrated 185 cm but this much deeper sediment was not included in the palynological investigation. Six samples taken from the main Hendra sediment core were AMS ^{14}C dated at Queens University, Belfast. The sample details and the uncalibrated and calibrated ^{14}C dates are shown in Table 1. A total of 30 levels were selected for pollen and spore counts from 10 cm to the base of the core at 120 cm. All the samples were counted to between 132 and 442 total land pollen grains, with the spore and abundant Cyperaceae count not included in this main sum. The average count was 344 terrestrial pollen grains per level. Initially samples were prepared and counted at every 5 cm interval but when counting had to be abandoned due to poor pollen preservation the adjacent sample was counted. Pollen preservation over the top 20 cm was very poor with only two samples being counted. At critical parts of the diagram intermediate samples were counted to increase resolution.

Croft Pascoe

The sampling point for this linear feature was approximately 300 m from its origins in the *Salix* carr at a point where the channel widens out to approximately 25 m and the sediment deepens to almost a meter. Three samples were taken for conventional radiometric or AMS ^{14}C dating. Details of these are given in Table 1. A total of 19 levels were counted from 39 cm to the base of the core at 85 cm. All the samples were counted to between 385 and 514 land pollen grains with an average count of 435 grains per level. As with the Hendra core, samples were taken at 5 cm intervals where possible but adjacent samples were counted when pollen preservation at the 5 cm interval was poor. As the pollen diagram emerged intermediate samples at regions of change were taken with a resolution of 1 cm at critical points.

The Pollen Diagrams

The percentage pollen diagrams were constructed using the C2 software as described by Juggins (2010) with the total land pollen count (TLP) taken as 100%, spores excluded. The sediment description column uses the Troels-Smith (1955) convention and the diagrams have been divided into local pollen assemblage zones based upon changes in the representation of key taxa. A key to the sediment descriptors and the colour coding of the taxa in given in Figures 3 and 4.

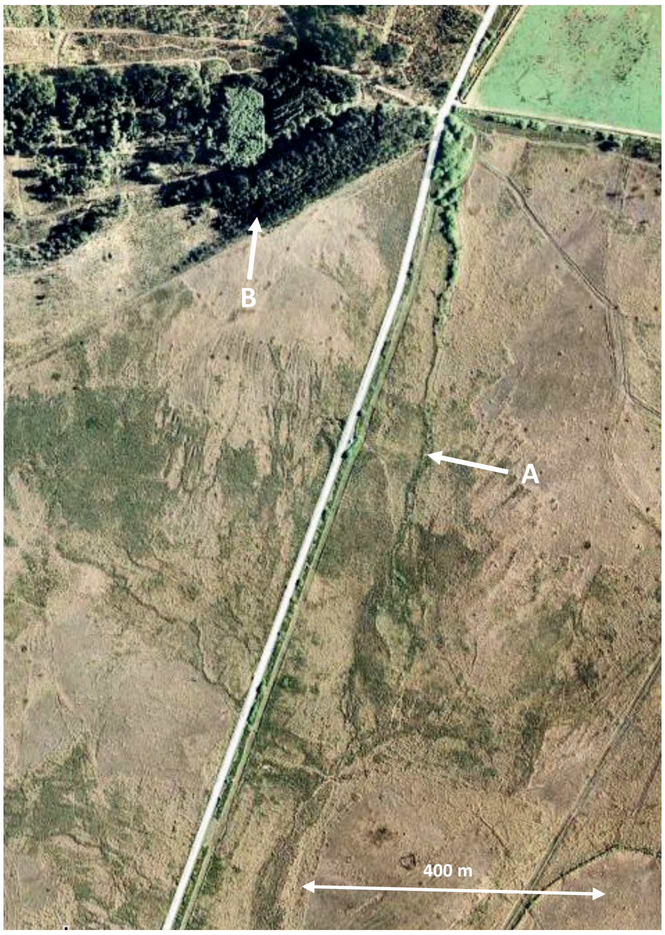
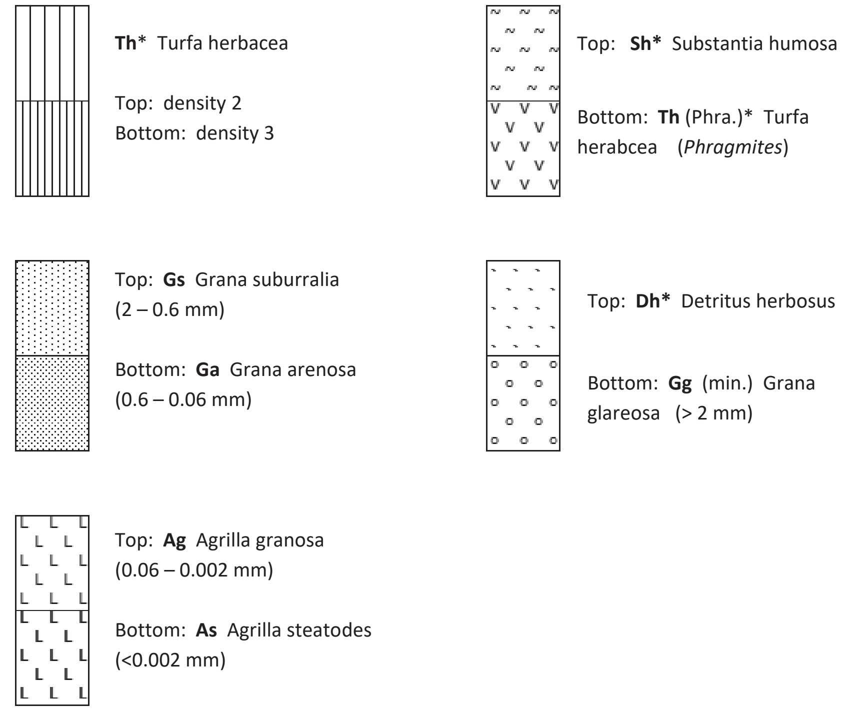


Figure 2. *The Croft Pascoe core was extracted from a linear feature that runs alongside the road between the B3293 and Kuggar. Access to the sampling point (A) is from a small layby approximately 400 m south of the Croft Pascoe Forest (B). (Photo: Google Earth © Infoterra Ltd and Bluesky.)*



Sediment Description abbreviations (from Birks and Birks, 1980 pp.42-43)

Th* **Turfa herbacea** Roots, intertwined rootlets, rhizomes, of herbaceous plants ± stems, leaves connected with these
Sh **Substantia humosa** Completely disintegrated organic substances and precipitated humic acids
Dh* **Detritus herbosus** Fragments of herbaceous plants >2 mm
Gs **G. suburralia** Coarse sand
Ga **Grana arenosa** Fine sand
Gg **G. glareosa** Gravel
Ag **A. granosa** Silt
As **Agrilla steatodes** Clay

* sediment elements that can be humified

Figure 3. *Representations of sediment types used in the pollen diagrams Figure 5 and Figure 8.*

Adapted from Troels-Smith (1955).

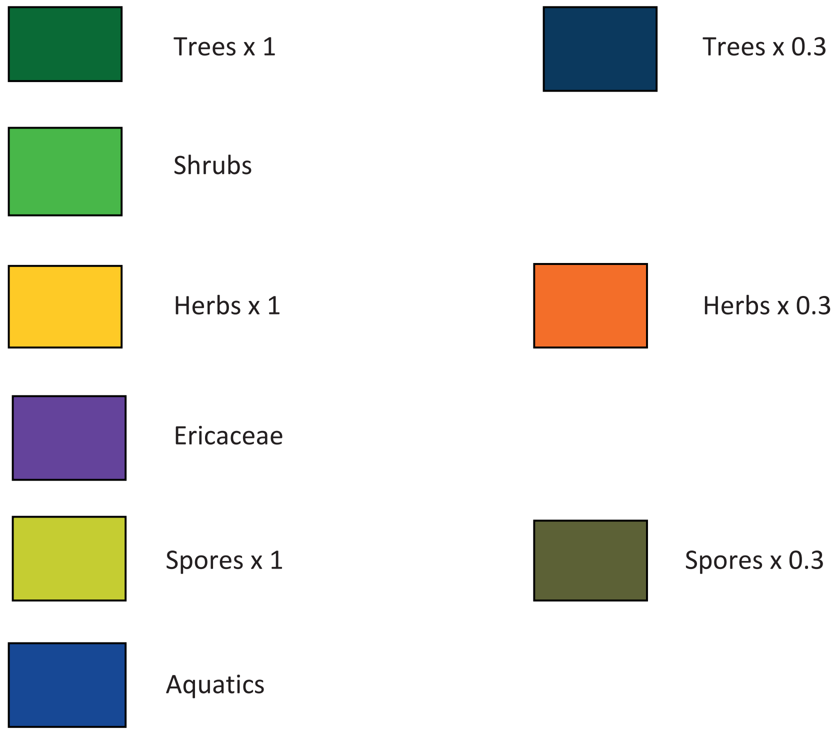
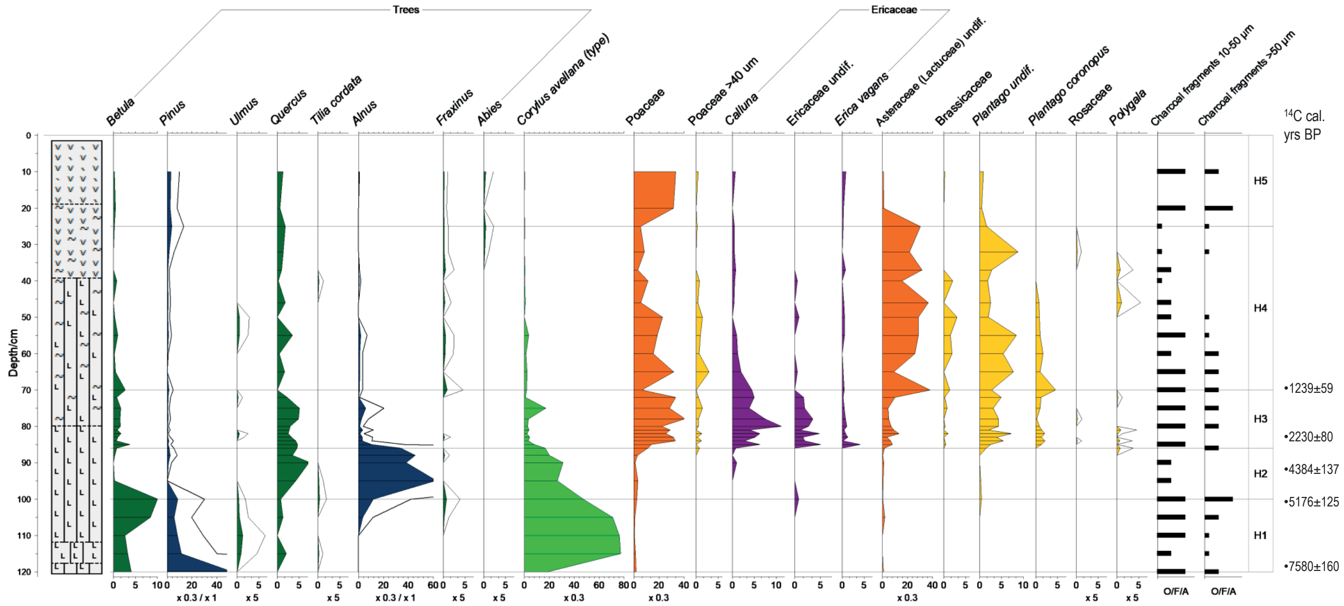


Figure 4. *Colour coding used in pollen diagrams.*

Hendra – description

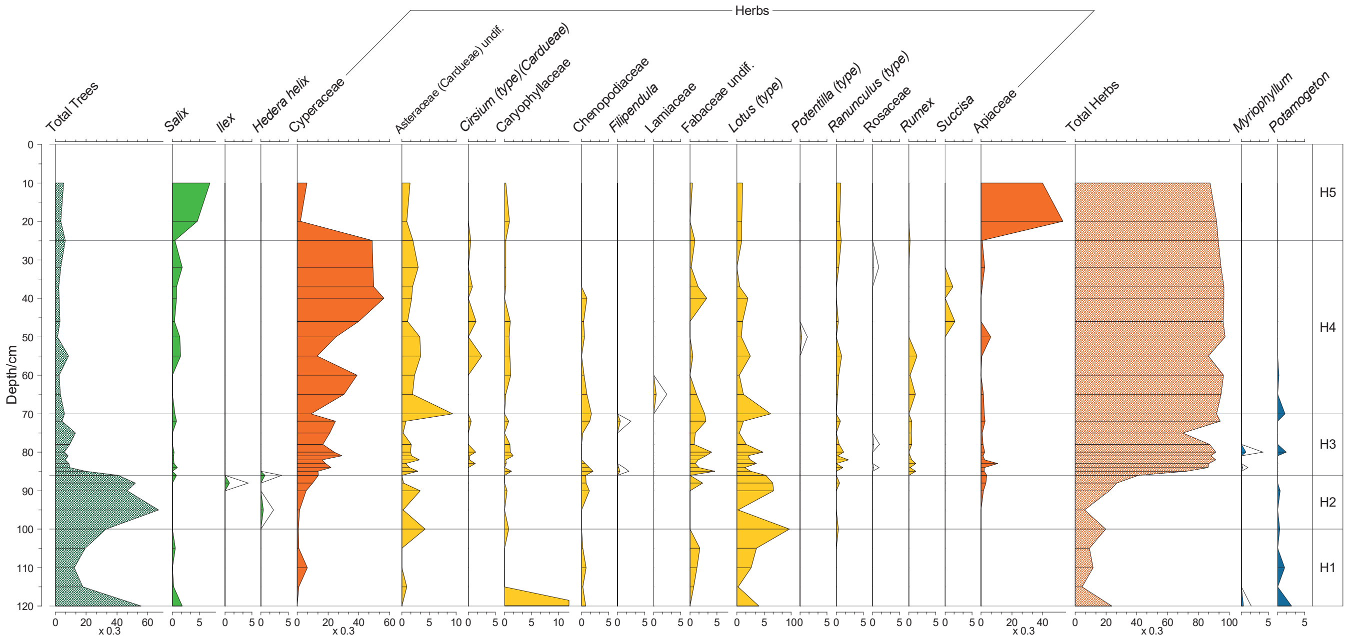
The key trees, shrubs, herbs, charcoal, ^{14}C dates and sediment descriptor are shown in Figure 5, the remaining shrubs and herbs, and aquatics in Figure 6 and the spores, indeterminate grains and pollen concentrations in Figure 7. The scarcity of aquatic pollen suggest that there was only occasional permanent open water during the build-up of sediment in the basin. This supports the explanation outlined above that the sediment built up as a result of flooding episodes in which the adjacent stream overflowed onto the basin, an abandoned terrace, bringing with it mineral and organic particles from the catchment area 1 km to the northwest. Much of the palynomorph assemblage can therefore be considered as allochthonous in origin, transported by the stream from the higher ground to the north. The autochthonous element from the vegetation surrounding the mire would have made an increasing contribution to the pollen rain as the forest was cleared.

The diagram has been divided visually into five pollen assemblage zones, H1 to H5, based upon the changing proportions of the tree, shrub and herbaceous pollen, and spores.



TLP = 100%

Figure 5. *Hendra: Trees,* Corylus, *selected herbs, charcoal and C^{14} dates.*



TLP = 100%

Figure 6. *Hendra: Remaining shrubs and herbs, and aquatics.*

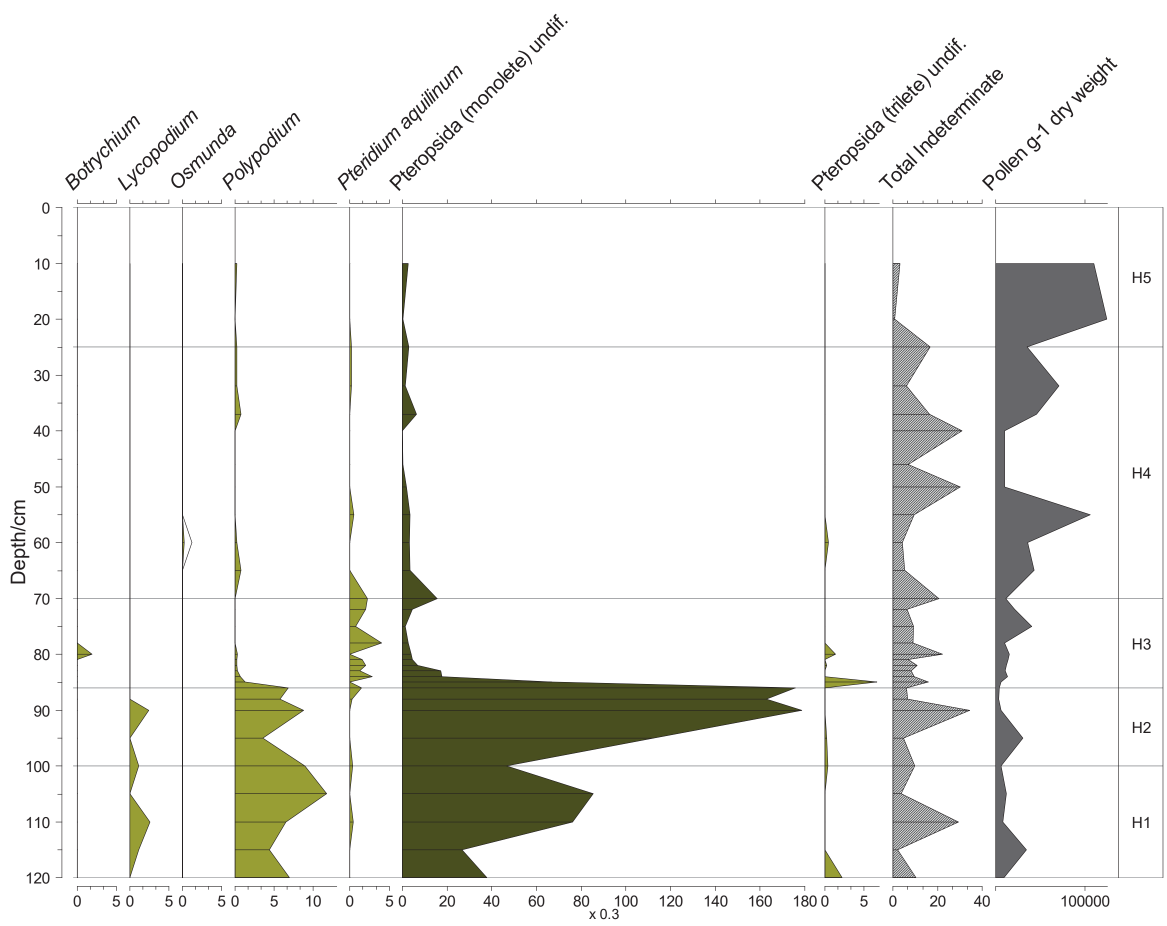


Figure 7. *Hendra: Spores, indeterminate and number of pollen g^{-1} dry weight*

H1 (120–100 cm): The ^{14}C calibrated dates for this zone are 7580±164 to 5176±125 cal yr BP, a period of *c.* 2300 years represented by 20 cm of sediment. At its base the pollen assemblage is dominated by *Pinus sylvestris* (Scots pine) with some *Betula* (birch), together representing 60% of the total land pollen (TLP). Much of the remaining 40% is made up with Caryophyllaceae and *Corylus avellana* (hazel) type pollen. The representation of *Pinus* drops rapidly with decreasing sediment depth, the difference being made up by sharply increasing levels of *Corylus* pollen with some *Quercus* (oak) and *Ulmus* (elm). *Betula* pollen increases rapidly, to higher levels at the top of the zone than it had reached at the base. Throughout the zone there are high counts of Pteropsida spores reaching up to 80% of TLP, abundant small (10–50 μm) charcoal fragments and occasional to abundant large fragments (>50 μm),

H2 (100–85 cm): The ^{14}C calibrated dates for this zone are 5176±125 to 2230±80 cal yr BP indicating *c.* 3000 years represented in 15 cm of sediment. The most significant change here is the rapid rise in *Alnus glutinosa* (alder) pollen up to 60% of the TLP associated with a rise in the *Quercus* pollen, steep falls in *Betula* and *Pinus* and a fall in *Ulmus* pollen from a low base. There is a small rise in Poaceae pollen and Ericaceae, Apiaceae, *Ranunculus* and *Plantago* pollen appear for the first time. The *Polypodium* spore count remains high and the monolete Pteropsida spore count rises to almost 180% of TLP. There are frequent small charcoal fragments but no large fragments in this zone.

H3 (85–70 cm): The ^{14}C dates for this zone are 2230±80 to 1239±59 (at 71 cm) cal yr BP, a period of *c.* 1000 years represented in 14 cm of sediment. The changes in the pollen assemblage here are many and profound. The most distinctive is the rapid fall in *Alnus* pollen from 40% to 5% of the TLP with *Corylus* also decreasing markedly but *Betula* and *Quercus* remaining steady. The overall reduction in tree pollen is absorbed by increases in the pollen of herbaceous species. Poaceae and Cyperaceae (grass and sedge) pollen both increase considerably with smaller but significant increases in Asteraceae and Ericaceae. Also forming a new and significant part of the assemblage are *Plantago* (plantain), Brassicae and Rosaceae pollen. Of possibly greater significance though is the increase in large cereal type pollen (Poaceae >40μ) and the maintenance of this through to the top of the zone. Spores of *Polypodium* and monolete Pteropsida drop rapidly at the start of the zone whilst *Pteridium* (bracken) form a continuous curve for the first time. There are abundant small charcoal fragments throughout the zone, and frequent large fragments.

H4 (70–32 cm): The base of this zone is marked by a drop in the *Quercus* and Ericaceae pollen. This is absorbed largely by increases in the Asteraceae and Cyperaceae pollen. *Pteridium* spores disappear at this zone boundary as do some of the remaining herbaceous pollen taxa. There is also a sharp but temporary decrease in grass and cereal type (Poaceae >40 μ), and sedge pollen. There is no ^{14}C date for the upper limit of this zone but it is marked by falls in sedge, Asteraceae (Lactuceae), *Plantago* and cereal type pollen and the first appearance of the exotic conifer *Abies* (fir) pollen. The occurrence of small charcoal fragments fluctuates between occasional and abundant throughout but the larger fragments are confined largely to the bottom third of this zone with very few above.

H5 (32–0 cm): At the base of this final zone there is a marked rise in Poaceae, Apiaceae and *Salix* pollen and a small rise in *Pinus* pollen. *Abies* pollen continues from the top of zone H4. Small charcoal fragments are abundant throughout this zone, and large fragments abundant to occasional.

Hendra – interpretation

The pollen assemblage of Zone **H1** appears to be the product of a heavily forested area, initially by pine with some birch and later by oak, elm, alder and hazel. The very rapid fall of the *Pinus* pollen count from almost 50% of TLP at the base of the diagram suggests the possibility that it may have been shown to be an even larger proportion of the TLP had the sediments been deeper. At 7500 years BP this *Pinus* fall is roughly synchronous with other areas of the British Isles (*e.g*., Bennett, 1984) but it persists alongside birch and hazel until about 5200 years BP, considerably later than elsewhere. Groves *et al.* (2012) note the unusually long persistence of pine at Conford in Hampshire until 6050 years BP attributing this to low soil fertility and frequent fires. The high Pteropsida spore count, including the largely epiphytic *Polypodium* fern, reinforces the interpretation of the environment as a forest, with fern spores contributing almost all the trunk space non-tree palynomorphs. The rapid expansion of the *Corylus* (type) pollen at the expense of pine, however, would suggest a somewhat open forest in which hazel was able to establish and thrive. The abundant small and later large charcoal fragments may be the sign of some forest disturbance, possibly anthropogenic with the opening of the forest canopy by Mesolithic people. Similar charcoal peaks from the pollen records of the submerged forest in St Mary's Road, Isles of Scilly have been identified from between about 7695 and 5784 years BP (Charman *et al.*, 2016, p. 200). These have been attributed to Mesolithic people opening the canopy to attract game with new browse, and to encourage edible plants such as hazel and bramble. The presence of Mesolithic people in Scilly, possibly seasonally, has been confirmed by the finding of two Early Mesolithic microliths (Dennis *et al.*, 2013) on St Martin's. A Mesolithic presence on the Lizard Peninsula has been well established (*e.g*., Berridge and Roberts, 1986) so it is very likely that the pollen assemblage at the base of the Hendra core has a significant anthropogenic element. The large increase in *Corylus* (type) pollen as the pine declined would support this interpretation.

The only significant presence of pollen from herbaceous species in this zone are the high Caryophyllaceae count of 12% of TLP at 120 cm and the rising *Lotus* (type) count up to 10% of TLP. These can best be explained as resulting from localised populations near the vicinity of the mire, possibly *Stellaria spp.* (stitchwort) and *Lotus pedunculatus.*

The major feature of Zone **H2** is the rapid rise of *Alnus* pollen, up to 60% of TLP, coincident with the fall in the pollen of all other tree species except oak. The fall in the elm pollen at Hendra at 5200 years BP is coincident with the elm decline of *c.* 5000 years BP across much of the British Isles. On Dartmoor, approximately 150 km to the east of the Lizard, Fyfe and Woodbridge (2012) analysed four pollen archives all showing the decline of the elm between about 5300 and 5700 years BP so matching the putative elm decline at Hendra quite closely. On Scilly there is 'some suggestion' of an elm decline in the pollen archive from Porth Mellon on St. Mary's (Charman *et al.*, 2016, p. 205) dated at *c*. 3795 years BP, considerably later than on the mainland and coincident with the discovery of a calf's tooth dated 3740 years BP (Ratcliffe and Straker, 1996, p. 34). This suggests that the reduction in elm pollen here was linked to Neolithic clearances and pastoral agriculture. Fyfe *et al.* (2008) place the Neolithic clearance of upland Dartmoor at about 5500 years BP while the first signs of land clearance for agriculture on Scilly are one thousand years later at 4400 years BP. The alder spike at the elm decline on Hendra masks any clear evidence of Neolithic land clearance but the first appearance of Poaceae, Ericaceae, Asteraceae, *Ranunculus* and *Plantago* pollen at this horizon would indicate the emergence of an agricultural landscape at the time of the decline in elm on the Lizard. This sequence of events across the southwest of the British Isles tends to lend support to an anthropogenic contribution to the explanation of the elm decline: see Garbett (1981).

The rise of *Alnus* at the expense of *Pinus* is a feature of pollen diagrams throughout the British Isles, usually about 2000 years earlier than this, and it has been speculated that alder was replacing pine on water logged valley bottom soils (Bennett, 1984). The alder domination of the pollen rain persists for about 3000 years but it is likely to be a relatively local feature. Bennett and Birks (1990) reviewed 92 ^{14}C dated sites throughout the British Isles, many showing an appearance and rapid rise of alder pollen as in the Hendra diagram. They noted that these sites were not simply time transgressive but had a 'patchy' distribution both in space and time. The initial establishment of the alder at Hendra may well have been as a result of the rising of the water table as described by McVean (1956). This may have been a regional event; Charman (2010) suggests 'muted' evidence for a wetter period in Britain about 4200 year BP and the rapid rise of Pteropsida spores to a peak of 180% of TLP during this zone also points to an increasingly wet environment. However, the lack of a similar alder rise at the Croft Pascoe site just 2.5 km to the SE although alder pollen is present (Fig. 7) adds weight to the interpretation that the alder rise at Hendra is a local event. The rise in the *Alnus* pollen representation coincides with a rise in *Quercus* pollen from 1% to 6% of the TLP and a fall in the *Corylus* (type) pollen from 70% to 20%. Both pollen frequencies would be supressed by the abundant alder pollen which suggests that if the *Alnus* rise in zone **H2** is a local feature an oak/hazel forest may well have been present in the drier areas beyond the Hendra site.

The abrupt change in the pollen and spore assemblage between Zones **H2** and **H3** is possibly the result of an unconformity in the sediment. The six ^{14}C dates available indicate a slight slowing of the accumulation rate between 92 cm and 85 cm (113 years cm^{-1} to 308 years cm^{-1}) and a sharp increase between 85 cm and 79 cm (308 years cm^{-1} to 90 years cm^{-1}). This could be explained by a loss of sediment between 92 cm and 85 cm. The sediment description shows a change from a sandy clay below the possible unconformity to a highly humified clay above although the change occurs 5 cm above the H2/H3 boundary. Although the evidence for an unconformity is quite strong the possibility that this section of the diagram represents a low resolution temporarily contiguous pollen archive cannot be ruled out.

Zone **H3** appears to represent an environment dominated by anthropogenic activity. The palynomorph assemblage suggests that much of the oak/alder/hazel woodland has been cleared and replaced by grasses and sedges. The appearance of cereal type pollen and increases in *Plantago* and *Ranunculus* supports this interpretation. Ericaceae pollen, especially *Calluna*, also increases abruptly at this horizon, the local contribution from the opened-up vicinity of the mire possibly augmented by pollen transport from the plateau to the north. The increase of both large and small charcoal fragments throughout this zone supports the view that this is an anthropogenic heathland.

The herbaceous pollen of zone **H3** suggest a range of habitat types. In addition to the *Plantago*, cereal and Ericaceous pollen the assemblage includes the pollen of *Sanguisorba* and *Polygala* spp. plants typical of meadows, heathland and open woodland. The appearance of *Pteridium aquilinum* spores is also significant pointing to land management practices such as burning.

Zone **H4** shows a fall or disappearance of pollen from many of the species of **H3** and a rise in the Asteraceae, Brassicae and *Plantago* pollen. There is also a further fall in tree pollen particularly *Quercus*. This is consistent with the much more disturbed habitat associated with an increased human population and consequent rise in agricultural activity, both pastoral and arable.

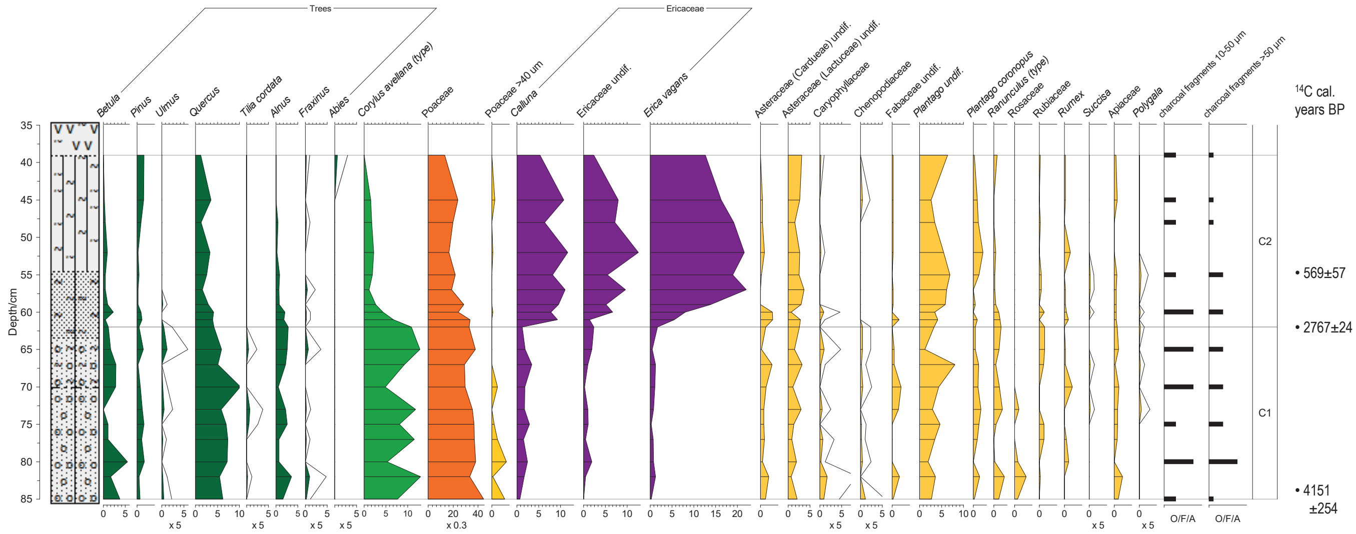
Zone **H5** appears to represent a reduction in agricultural activity, particularly arable, with the reduction of cereal type pollen, the pollen of the weed species Asteraceae and *Plantago* and the synchronous rise in (small) Poaceae pollen. The increase in Apiaceae and *Salix* pollen and the large fall in Cyperaceae pollen appear to represent changes on and around the mire, possibly linked to increasing wetness. The small rise in *Pinus* pollen and the presence of *Abies* pollen is most probably linked to the establishment of forest plantations on the peninsula in the 19th and 20th centuries. These are indicated by historical references of the period to have commenced from the late 1830s (*e.g.*, Pett 1998, pp. 58–59; Phillips 1967, p. 14). This rise in the pollen of coniferous species is also present at the top of the Erisey Barton diagram (Garbett *et al.,* 2016) and the Croft Pascoe diagram (Fig. 7). The high incidence of charcoal fragments in zone **H5** most probably reflects the heathland management practices of the 19th and 20th centuries.

Croft Pascoe – description

A percentage pollen diagram of the lower 46 cm of the 85 cm core from the Croft Pascoe site has been constructed using the total land pollen count (TLP) as 100%, excluding terrestrial spores. Figure 8 shows trees, *Corylus*, selected herbs and charcoal, Figure 9 the remaining shrubs and herbs, and the aquatics, Figure 10 the spores, indeterminates and the pollen g^{-1} dry weight. The diagram has been divided into two local pollen assemblage zones, **C1** 85-62 cm and **C2** 62-39 cm. The division is based upon a decline in the proportion of tree and shrub pollen of 25% to 5% of TLP and a synchronous rapid rise in the Ericaceae pollen from 7% to 45% of TLP.

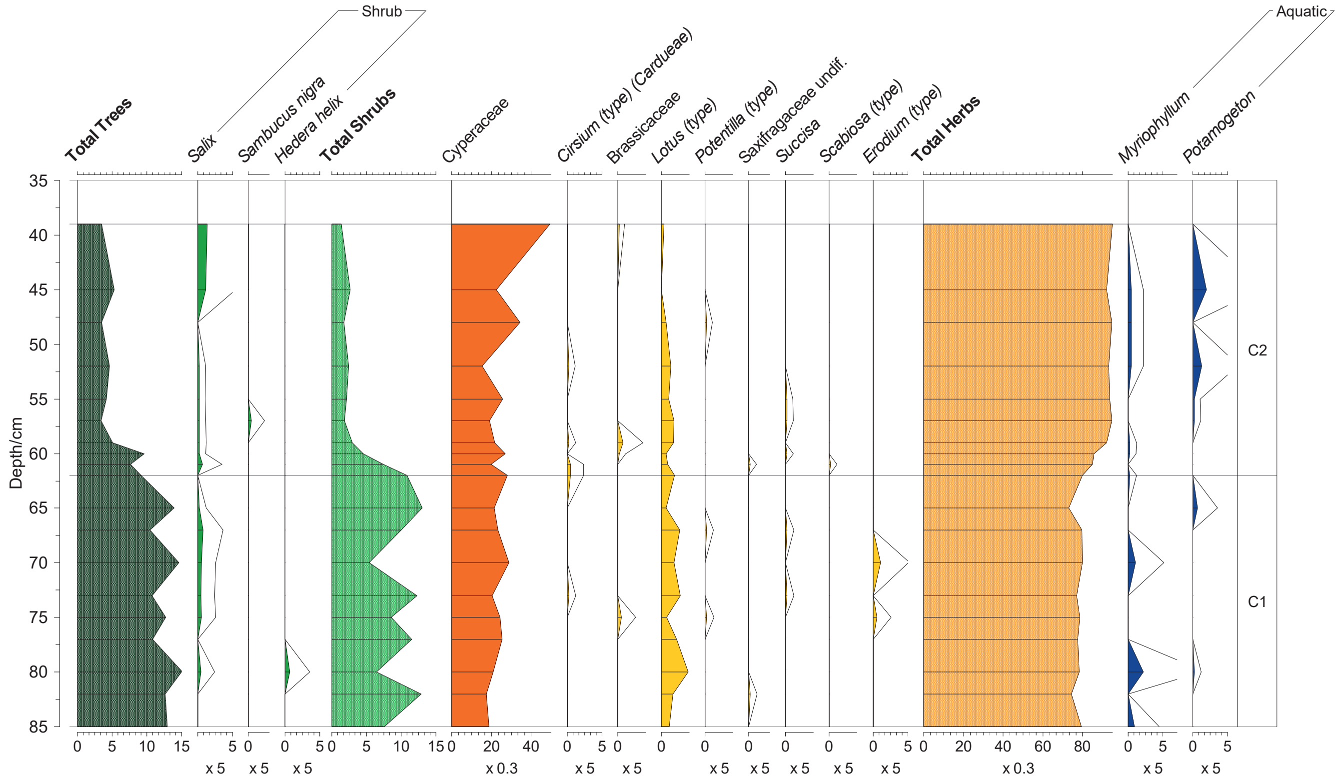
C1 (85–62 cm): The ^{14}C calibrated ages for this zone are 4151±254 cal yr BP (conventional radiometric dating) to 2767±24 cal yr BP (AMS dating). This covers a period of approximately 1400 years during which the tree pollen contributes 13% to 15% of the TLP, principally *Quercus,* followed by *Betula* and *Alnus* and with a consistent low background representation from *Pinus, Ulmus, Tilia* and *Fraxinus.* The *Corylus* (type) pollen fluctuates between 6% and 13% of TLP,

The herbaceous pollen is dominated by Poaceae at 30%



TLP = 100%

Figure 8. *Croft Pascoe: Trees,* Corylus, *selected herbs and charcoal.*



TLP = 100%

Figure 9. *Croft Pascoe: Remaining shrubs and herbs, and aquatics.*

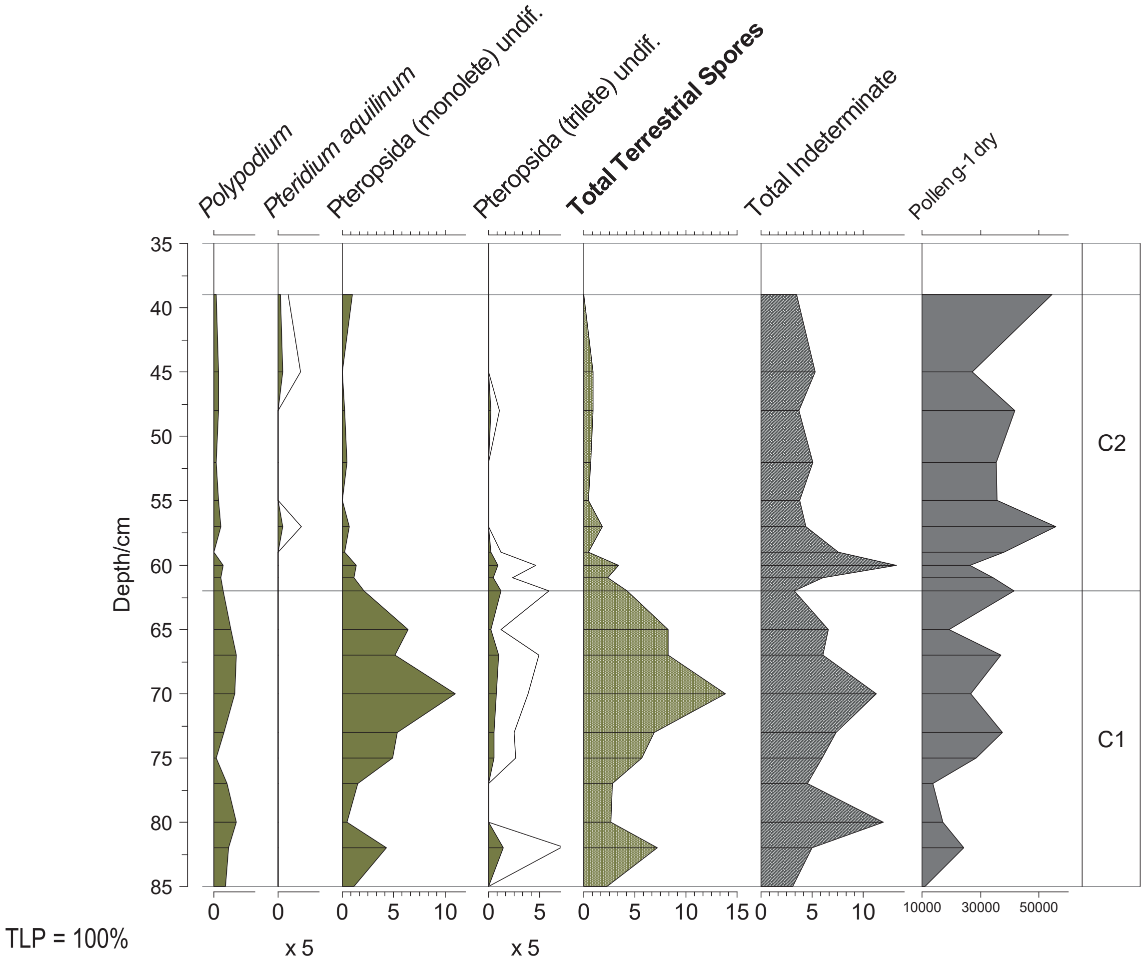


Figure 10. *Croft Pascoe: Spores, indeterminate and number of pollen grains g^{-1} dry weight.*

to 45% and Cyperaceae at 18% to 26% of TLP. The remainder is made up from Ericaceae and Asteraceae species, *Plantago* and *Ranunculus*, all taxa at less than 4% with *Plantago* rising to 7% towards the end of this period. Of particular interest is the appearance of large (>40μm) Poaceae grains at up to 3% of TLP form 85 cm to 70 cm. The disappearance of these grains at 70 cm coincides with a significant increase in the Pteropsida spores. Charcoal grains, both large and small, are frequent or abundant throughout this zone.

C2 (62–39 cm): Across the **C1**/**C2** boundary the depositional environment changes from a minerogenic one of coarse sand and gravel to an increasingly organic and humified one. Zone **C2** starts at the ^{14}C calibrated age of 2767±24 cal yr BP. However, at 54 cm the ^{14}C date is 569±57 cal yr BP suggesting a hiatus in the depositional record. This possibility is reinforced by the large changes is the pollen and spore frequencies at this boundary. Between 67 cm and 57 cm the tree and shrub pollen reduces from 20% to 5% of TLP and the Ericaceae pollen rises from 6% to 43%. The pollen frequencies of four herbaceous taxa fall at this boundary, Asteraceae (Cardueae), Caryophyllaceae, Chenopodiaceae and Ranunculaceae. The pollen of Asteraceae (Lactuceae) and *Plantago* remain at a largely constant percentage of the TLP. There is a small rise in the percentage of *Pinus* pollen at the top of this zone, and the first appearance of pollen of the exotic conifer *Abies*. The occurrence of charcoal fragments drops in zone **C2** compared to that of **C1**.

Croft Pascoe – interpretation

The pollen assemblage of zone **C1** suggests a relatively open landscape with the tree and shrub pollen contributing 19% to 27% of the TLP. This may represent pollen transport from a forested area downslope or from copses and boundary features closer to the sample site. The Cyperaceae and Poaceae percentage will be due in part to the pollen contribution from the surface flora of the linear feature itself, but with the Poaceae pollen count as high as 45% of the TLP it is likely that there is a significant contribution from the surrounding plateau.

The herbaceous pollen assemblage of zone **C1** persists for approximately 1400 years. The compelling interpretation is of an open, anthropogenic Bronze Age landscape supporting both arable and pastoral farming practices. Key to this interpretation is the presence of >40μ Poaceae grains tentatively identified as cereal grains of the *Hordeum* genus based upon the dimensions of the grain itself and those of its pore and annulus, using the criteria of Andersen (1979). It may be significant that Smith (1984) in his analysis of Bronze Age soil from the area also found cereal type and *Erica vagans* pollen but speculated that they may have been washed down from the modern soil. The relatively high incidence of charcoal fragments in zone **C1** also points to some form of anthropogenic land management.

There is good archaeological evidence for a substantial Bronze Age presence in the region. Johnson (1980) and Smith (1987) describe burial mounds on Goonhilly Downs although little evidence of settlement was found. On Scilly the early Bronze Age landscape (from *c.* 4450 BP) is dominated by 'entrance graves' indicating a significant human presence. By the late Bronze Age (from *c.* 3450 BP) it is characterised as a 'domesticated islandscape' with extensive evidence of settlement and mixed subsistence agriculture (Charman *et al.*, 2016, pp. 206–214). The increase in the Pteropsida spores at the top of zone **C1** could be linked to a cooler, wetter climate that would have resulted in the abandonment of arable farming on the Lizard. Charman (2010) notes evidence for just such a change in climate between 2700 and 2500 BP.

The **C1**/**C2** zonal boundary is marked by falls in tree pollen and large rises in Ericaceae pollen, especially *Erica vagans* which accounts for more than half the increase of the total heather pollen. Falls in herbaceous species associated with anthropogenic habitats particularly wasteland and footpaths; Asteraceae (carduae), Caryophyllaceae, Chenopodiaceae and Ranunculaceae, point to a reduction in the human activity (Behre, 1981) as does the fall in charcoal fragments. The slight reduction in Poaceae at this horizon is most probably an artefact of the steep rise in Ericaceae pollen. The zone C2 pollen assemblage is consistent with a largely open heathland with some pastoral activity occurring but little or no arable farming. The dominance of *E. vagans* pollen in the heathland flora matches the distribution of Ericaceae pollen in the medieval to modern times at Erisey Barton on the southern edge of Goonhilly Downs (Garbett *et al.,* 2016). The apparent hiatus indicated by the ^{14}C dates suggests that sediment representing about 2000 years of deposition has been lost so the zone **C2** pollen assemblage represents an anthropogenic medieval to 19th century landscape. The missing 2000 years of pollen archive may well have been the result of the 'Turbaries', peat and turf digging activity identified by Halliday (1959) and Hopkins (1983) from contemporary accounts.

The final sample from zone **C2** shows a slight increase in *Pinus* pollen and also the first appearance of the exotic conifer *Abies* pollen. This is persuasive evidence that the top 40 cm of the Croft Pascoe sediment was deposited within the last 200 years. The comparatively rapid sediment accumulation throughout zone **C2** may indicate a very different depositional environment to zone **C1**, possibly linked to the current high incidence of *Phragmites* along the length of the feature.

Conclusions

The two sites investigated here provide a record of the changing landscape of the Lizard Peninsula plateau over at least 7500 years. It appears that the pre-anthropogenic landscape, possibly of the whole of the plateau but more convincingly of its lower slopes, was initially dominated by a birch/pine forest. Whatever the extent of the forest this investigation provides evidence that, at the least, a significant part of the Lizard Peninsula plateau was forested until about 5000 years BP. The dominant species were birch and pine replaced later by oak, hazel and locally abundant alder. The initial fall in *Pinus* pollen at 7500 years BP is near synchronous with many other sites on the British Isles but it persists alongside birch and hazel for much longer than in most other areas.

By *c*. 4000 years BP the landscape exhibited noticeable heterogeneity. The top of the plateau, the current Goonhilly Downs, was an open landscape occupied by Bronze Age farmers, possibly after the clearance of forests, but the lower slopes were still heavily wooded. At about 3000 years BP, at the earliest, the plateau appears to have been abandoned by the farmers and by *c*. 2230 years BP at the latest Bronze or Iron Age farmers had cleared the lower slopes. There is no evidence of a return to arable farming on the top of the plateau but there is evidence of increasing intensity of agriculture on the lower slopes during the early Middle Ages, (410 to 1066 AD). Garbett *et al.* (2016) show that at Erisey Barton, just 1.2 km due north of the Hendra site, arable farming expanded on these lower slopes moving up to the edge of the current area of heathland by the late Middle Ages then retreating downslope during the 19th century. Both Hendra and Croft Pascoe diagrams provide evidence for the importance of human intervention in the establishment and maintenance of the heathland, supporting the view that lowland heathland is a cultural landscape (Grove *et al.*, 2012).

The presence of *Erica vagans* in the pre-anthropogenic forest pollen assemblage in the Hendra sediments (Garbett, 2012, p.141) and its tentative identification in 14000 year old sediments at Carnmenellis north of the Lizard Peninsula (Forster *et al.,* 2011) argues against an anthropogenic introduction of this species. The abundance of *E. vagans* on the summit of the peninsula over at least the past 500 years and its scarcity in the pre-anthropogenic landscape is best explained as a result of its competitive superiority over *Calluna, Erica tetralix* and *Erica cineria* in disturbed low nutrient soils following agricultural exploitation.

The evidence presented here for the presence of a pine and birch dominated forest in the early pre-anthropogenic landscape of the Peninsula and for possible Bronze Age arable farming on the high point of the plateau has not been previously available. The palynological analysis of the deeper sediments of the Hendra mire, discovered towards the end of the original period of study (Garbett, 2012, p.75) would provide an important contribution to the picture that has emerged from the shallower sediments. The large Poaceae grains from the Croft Pascoe site, tentatively identified as *Hordeum* spp. and so a possible indicator of arable agriculture on the site, need to be confirmed by further investigation.

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