

THE WEST CORNISH HEATH LANDSCAPE STUDIES IN SOUTHWEST ENGLAND ENVIRONMENTAL STUDIES REPORT

Emily Forster and David Earle Robinson



This report has been prepared for use on the internet and the images within it have been down-sampled to optimise downloading and printing speeds.

Please note that as a result of this down-sampling the images are not of the highest quality and some of the fine detail may be lost. Any person wishing to obtain a high resolution copy of this report should refer to the ordering information on the following page.

Research Department Report Series 53-2011

THE WEST CORNISH HEATH

Landscape Studies in Southwest England

Emily Forster and David Earle Robinson

© English Heritage

ISSN 1749-8775

The Research Department Report Series incorporates reports from all the specialist teams within the English Heritage Research Department: Archaeological Science; Archaeological Archives; Historic Interiors Research and Conservation; Archaeological Projects; Aerial Survey and Investigation; Archaeological Survey and Investigation; Architectural Investigation; Imaging, Graphics and Survey, and the Survey of London. It replaces the former Centre for Archaeology Reports Series, the Archaeological Investigation Report Series and the Architectural Investigation Report Series.

Many of these are interim reports which make available the results of specialist investigations in advance of full publication. They are not usually subject to external refereeing, and their conclusions may sometimes have to be modified in the light of information not available at the time of the investigation. Where no final project report is available, readers are advised to consult the author before citing these reports in any publication. Opinions expressed in Research Department reports are those of the author(s) and are not necessarily those of English Heritage.

Requests for further hard copies, after the initial print run, can be made by emailing:

Res.reports@english-heritage.org.uk

Or by writing to English Heritage, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth PO4 9LD
Please note that a charge will be made to cover printing and postage.

SUMMARY

Five sites in West Cornwall were sampled for pollen analysis and radiocarbon dating in order to investigate the long-term development of vegetation in the region, particularly that of the Cornish heathlands. Pollen data indicate that heathland taxa - notably *Erica ciliaris*-type, which includes *Erica vagans* (Cornish heath) - were present in Cammenellis (Lower Lancoarrow) as early as the late-glacial period, and in West Penwith (Treen Common) from at least the early Neolithic. The data from both sites suggest that *Erica ciliaris*-type was formerly more prevalent than the now ubiquitous *Erica tetralix* (cross-leaved heath).

Keywords - Environmental studies, pollen, landscape, prehistoric

Cover: Sampling at Treen Common *Photograph by Vanessa Straker, English Heritage*

CONTRIBUTORS

Emily Forster and David Earle Robinson carried out the bulk of the research presented here. Zoë Hazell assessed the testate amoebae samples and John Meadows provided the radiocarbon dates and calibrations. All maps and figures were produced by the authors unless otherwise stated.

ACKNOWLEDGEMENTS

Many thanks are due to Gill Campbell and Zoë Hazell for helpful comments on a draft of the text, which greatly improved the report. We are very grateful to Rob Scaife and the University of Southampton for access to pollen reference material, and to Ralph Fyfe, Bent Odgaard and Catherine Langdon for helpful advice regarding *Betula nana* identifications and related statistical analyses. We would also like to extend thanks to the staff of Cornwall County Council's Historic Environment Services, in particular Peter Dudley, for all their help, and to the landowners of the study sites for their cooperation, especially Jon Brookes for permission to take samples on National Trust Land.

ARCHIVE LOCATION

English Heritage, Fort Cumberland, Portsmouth.

DATE OF RESEARCH

2007-10

CONTACT DETAILS

University of Sheffield, Department of Archaeology, Northgate House, West Street, Sheffield, S1 4ET.
Emily Forster Tel: 01142222921. Email: E.E.Forster@sheffield.ac.uk
David Earle Robinson Email: bloch_robinson@hotmail.com

CONTENTS

Introduction	1
Fieldwork and sampling	2
Assessment.....	3
Methodology	3
Pollen identification of critical groups.....	6
Ericaceae	6
Birch (<i>Betula</i> sp).....	7
Results	9
Treen Common	12
Sediment description	12
Pollen.....	14
Lower Lancarrow.....	18
Sediment description.....	19
Pollen	20
Discussion.....	26
Appendix I: Additional figures and tables.....	30
References	38

INTRODUCTION

HEATH (Heathland, Environment, Agriculture, Tourism and Heritage) was a wide-ranging project aiming to improve understanding and inform management of heathland or 'rough ground' in five sub-regional areas of Northwest Europe (www.theheathproject.org.uk), including a landscape of national significance in Southwest England known as the Cornish Heath. In the past, heathland was important for activities such as grazing and furze-cutting, but both its use and its extent in Cornwall have declined dramatically since the late medieval period (Dudley 2011). Although still used for grazing, the interests in and pressures on heathland environments today are generally different to those in the past, with a growing concern for conservation of wildlife and rare habitats and an increase in recreational use.

The part of the HEATH project detailed in this report used palaeoecological and scientific dating methods to elucidate the history of West Cornwall's heathland vegetation, including human exploitation of, and impact upon, the landscape. In addition to exploring the development of the vegetation as a whole, this research focuses specifically on the history of a unique component of the area's heathland flora, *Erica vagans* (Cornish heath)(Figure 1)¹. The preliminary findings of the project were reported in Robinson *et al* (2011); the full results of the palaeoecological analyses are presented here.

Archaeological evidence indicates that there was a human presence in Cornwall as early as the Upper Palaeolithic and that a substantial population probably existed by Neolithic times (Berridge and Roberts 1986). Despite the richness of the prehistoric archaeology and the number and extent of archaeological investigations (see *Cornish Archaeology*, volume 25 (1986) for a summary), surprisingly few pollen studies have been carried out and the understanding of the relationship between human occupation, vegetation and land-use history remains relatively poor. Vanessa Straker's exhaustive review of palaeoenvironmental studies conducted in the region highlights the patchiness of the data both spatially and temporally, with many of the pollen records covering limited time periods or lacking sufficient dating evidence to establish a chronology (see Straker 2011 for a summary).



Figure: 1: *Erica vagans* (Cornish heath)
(A Karwath 2005)

¹The Cornish heathland is also characterised by two species of squill (*Scilla verna* (spring squill) and *S. autumnalis* (autumn squill)), but unfortunately squill was not identified in any of the pollen assemblages (see Discussion).

Evidence for the presence and expansion of heathland in Cornwall is variable and sporadic; although *Scilla*-type (squill) and *Calluna vulgaris* (heather) pollen have been identified in Mesolithic (c 8500-4000 BC) deposits at Porthallow, the Lizard (Tinsley 1999, cited in Straker 2011), it has been suggested that these originate from relict late-glacial floras and may not be representative of the Mesolithic vegetation (Robinson *et al.* 2007). Deposits beneath Bronze Age barrows have yielded evidence for *Calluna* and *Erica* in some parts of the region (eg Balaam 1984; Scaife 1996), indicating that heaths were present at this time and/or earlier. The spread of heath or moorland in the UK is often attributed to activities such as woodland clearance and farming, particularly from the Bronze Age onwards, which are thought to have resulted in leaching and acidification of soils (Limbrey 1975). There is also palaeoecological evidence for a climatic downturn across northwest Europe during the Late Bronze/Early Iron Age (c 1300-700 BC), with the colder, wetter climate promoting growth of peat bogs at this time (see Godwin 1975; Barber 1982; van Geel *et al.* 1996; Amesbury *et al.* 2008; Brown 2008). In order to understand better the development vegetation both spatially and temporally in Southwest Cornwall, particularly with regard to the emergence of heathland environments, peat/sediment samples were collected from several sites in the region and analysed as described below.

FIELDWORK AND SAMPLING

West Cornwall's lengthy history of tin streaming and peat cutting has rendered many apparently promising sites unsuitable for palaeoecological studies on account of removal, truncation or disturbance of the sediments. However, following extensive consultation with Pete Dudley and Pete Herring (of Cornwall County Council's Historic Environment Service) and a wide-ranging programme of fieldwork in West Cornwall, five sampling sites for palaeoecological analyses and dating studies were identified; Lower Lancarrow (NGR SW 69271 37320) and Tregantallan Farm (NGR SW 70998 32146) in Cammenellis, Cam Galver (SW 42386 36153) and Treen Common (NGR SW 44666 36638) in West Penwith and Lizard Downs (NGR SW 69148 14111) on the Lizard peninsula (Figure 2). A series of monoliths was collected from each of the sites with the exception of Tregantallan Farm, where deeper sediments and wet conditions necessitated the use of a Russian corer.

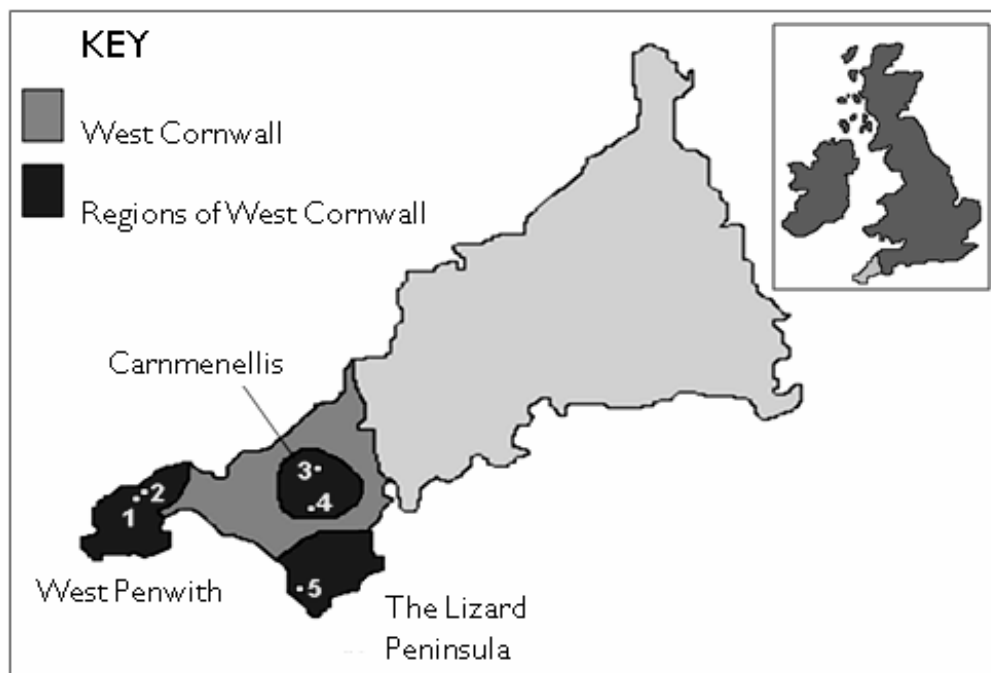


Figure 2: Map of Cornwall showing location of study area and sampling sites. 1) Carn Galver 2) Treen Common 3) Lower Lancarrow 4) Tregantallan Farm 5) Lizard Downs.

ASSESSMENT

The potential of the five individual sediment sequences (relative to the aims of project) was assessed by examining and briefly describing their stratigraphy and composition, analysing a number of widely spaced samples for pollen and testate amoebae and submitting a series of samples for radiocarbon (AMS) dating. The aim was to identify sites with long-term, undisturbed records of vegetation and environmental change, so good preservation of palaeoecological proxies (particularly pollen), stratigraphic integrity and a strong chronology were important criteria for selection. On the basis of the assessment, no further work was carried out on the samples from Carn Galver and Lizard Downs. Preliminary analyses of samples from Treen Common, Tregantallan Farm and Lower Lancarrow indicated that concentrations of testate amoebae were too low to merit full analysis; consequently no further work on this aspect was undertaken.

METHODOLOGY

Preliminary sediment descriptions were carried out on all cores and monoliths in the field using a modified version of Troels-Smith's methodology (1955; Birks 1968a). The sediment profiles from Lower Lancarrow and Treen Common were examined more closely in the laboratory for full description. A Munsell soil chart was used for colour determination (US Soil Conservation Service 2000) and the composition of the deposits was examined in detail in the course of obtaining plant macro-remains for radiocarbon dating (see below). The following attributes were recorded for each sediment unit (after Troels-Smith, 1955 and Birks, 1968) with values ranging from 0-4 where 0 indicates absence of the property and 4 indicates a strong tendency towards the given attribute (eg elasticity of 0 indicates plasticity while a sediment with elasticity of 4 would be very elastic):

- 1) Darkness (*nigror*)
- 2) Degree of stratification (*stratificatio*)
- 3) Elasticity (*elasticitas*)
- 4) Degree of dryness (*siccitas*)
- 5) Calcareousness
- 6) Sharpness of the upper boundary between sediment types/layers (*limes*)
- 7) Humicity (*humositas*)
- 8) Composition

The codes used for composition follow Troels-Smith's system (1955); a brief summary is provided in Table 5, Appendix I. Colour was also recorded (using a Munsell chart), as was the structure of the sediment unit. For *limes* (6) the scores relate to specific depths over which the transition from one sediment unit to another occurs, as follows:

lim. 0 – - – boundary zone 10 mm or more

lim. 1 – diffusas – boundary zone 2 - 10 mm

lim. 2 – conspicuus – boundary zone 1 - 2 mm

lim. 3 – manifestus – boundary zone 0.5 - 1 mm

lim. 4 – acutus – boundary zone less than 0.5 mm

Samples were taken at regular intervals throughout the sediment sequences from Lower Lancarrow and Treen Common for loss on ignition (LOI) analysis, carried out according

to the protocol of Heiri *et al* (2001). Samples with a minimum mass of 4g were dried at 105°C overnight (approximately 12 hours), weighed and returned to the oven for one hour to check for a further change in mass². When the samples were deemed to be dry, they were heated to 550°C in a furnace for three hours to burn off the organic carbon before recording the final mass. The difference in mass after stage one gives the water content of the sediment while that after stage two reveals the approximate organic carbon content (Heiri *et al*. 2001).

Full pollen analysis was carried out at regular intervals on the profiles for Lower Lancarrow, Treen Common and Tregantallan Farm. Samples of 1cm³ were processed by standard procedures of potassium hydroxide digestion, treatment with hydrofluoric acid and acetolysis, followed by mounting in silicone oil (Moore *et al* 1991). Two *Lycopodium* spore tablets (batch 124961, average 12542 grains per tablet) were added to each sample at the start of the preparation procedure to facilitate calculation of absolute pollen concentrations (see Stockmarr 1971).

Pollen identification was carried out at x400 magnification on a Leica DM2500 microscope, by consultation with Moore *et al* (1991) and reference material held by English Heritage, Fort Cumberland, Portsmouth. Where identification was critical, as in the case of large grasses/cereals, ericaceous types, birch grains (from Lower Lancarrow only) and other difficult pollen types or groups, grains were examined at x1000 magnification using oil immersion. Criteria for the identification of cereal types followed Andersen (1979). A minimum of 500 land pollen grains were counted at each level where sufficient pollen was present; where concentrations were very low a minimum count of 300 land pollen grains was achieved. The data were processed in Microsoft Excel, Tilia 2 and TGview (Grimm 1991-3). Pollen percentage data were calculated relative to the total land pollen (TLP); the sum of trees, shrubs, heaths and herbs. Unidentifiable grains, sedges, aquatics and spores were excluded from the pollen sum; percentages of these were calculated relative to the TLP³. Nomenclature follows Bennett (1994).

Preparation of testate amoebae samples followed standard procedures by Charman *et al* (2000), micro-sieving between 15 and 300µm, and adding *Lycopodium* spores (as an exotic) for abundance calculations. Samples were mounted on slides using glycerol, and examined on a high power Leitz Dialux 22 microscope at x400 magnification. Identifications were predominantly made according to Charman *et al*'s (2000) key, but also using Ogden and Hedley (1980). Where identifications were not clear on account of poor preservation, individuals were grouped together in an 'undifferentiated' category. Counting stopped when either 150 tests or 100 *Lycopodium* had been encountered - whichever was reached first.

² If necessary, this would have continued until a stable mass (ie less than a 0.002 g decrease, based on the accuracy of the scales) was reached, but no further reduction in mass was seen in any of the samples after the first additional hour.

³ ie as percentages equivalent to the pollen sum - so where the sum of the TLP was 500, a count of 100 spores would give an equivalent value of 20 per cent)

When available, recognisable, above-ground parts of terrestrial plants (eg *Carex* nutlets, Poaceae/Cyperaceae stems, ericaceous twigs) were picked out for radiocarbon dating. Sampling was carried out with care to avoid contamination. Owing to the paucity of material available in some samples, it was necessary to date bulk sediments (humins and humic acid fractions) and in two instances, root material, which may have been intrusive and therefore younger than the surrounding peat/sediment at that depth (OxA-20313 and SUERC-22566).

Pollen identification of critical groups

Ericaceae

Separation of ericaceous species was an important aspect of this project owing to the need to distinguish between the pollen of *Erica tetralix* (cross-leaved heath) and the much rarer species, *Erica vagans* (Cornish heath). Based on the key of Moore *et al* (1991) and careful examination of examples in the reference collection, it proved possible to ascribe many of the *Erica* grains encountered to either *E. tetralix* or *E. ciliaris*-type, which includes a number of species, including *Erica ciliaris* (Dorset Heath) and *E. vagans*. Grains were examined at $\times 1000$ magnification and typed according to the criteria shown in Figure 3. Where features were indistinct or pollen was obscured, broken or crushed, it was often impossible to determine the species/type. In these cases grains were defined as a) *Erica* undiff. (undifferentiated) for those definitely of *Erica*, or b) Ericaceae undiff., for grains that could not be identified as *Erica* rather than *Calluna* with certainty.

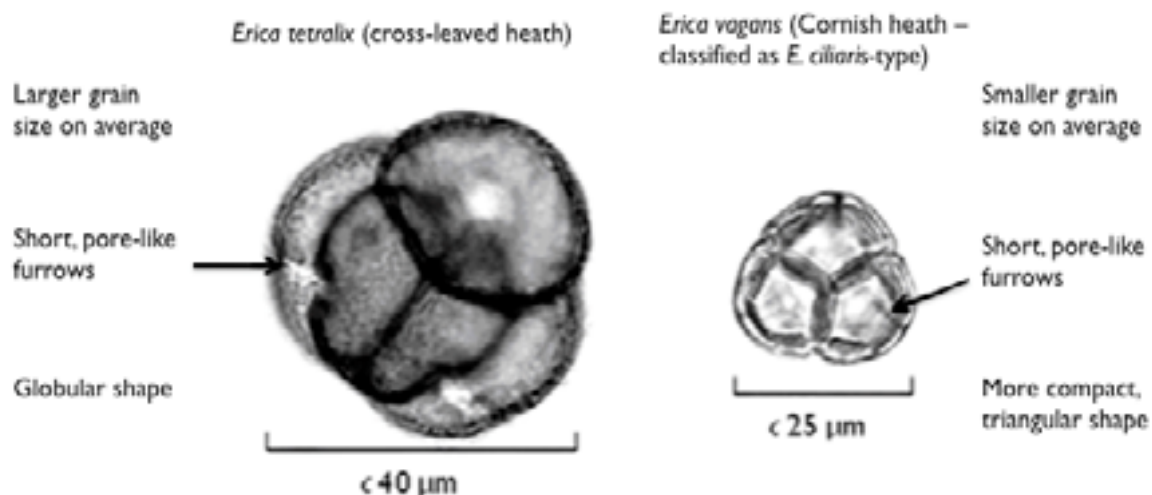


Figure 3: Criteria for separation of *Erica tetralix* and *E. ciliaris*-type pollen (represented here by *E. vagans*). The measurements shown are accurate for the grains pictured, which were prepared using standard procedures and mounted in silicon oil.

***Betula* spp (Birch)**

Radiocarbon dates for the basal part of the Lower Lancarrow sediments indicate that they accumulated in the late-glacial period. Consequently, it was thought likely that some of the *Betula* (birch) pollen in the assemblage originated from dwarf birch (*Betula nana*) rather than tree birches (*B. pubescens* or *B. pendula* in this area (Huntley and Birks 1983)). Pollen grains of *B. pendula* (silver birch), *B. pubescens* (downy birch) and *B. nana* cannot be distinguished easily at $\times 400$ magnification and require careful measurement at $\times 1000$ with oil immersion. Generally, tree birch grains are larger than those of dwarf birch and have deeper pores relative to their size. There have been numerous studies on the separation of *Betula* pollen types using measurements of grain diameter (D), pore depth (P) (Figure 4) and the ratio between these (D/P), based on measurements of modern birch pollen (eg Birks 1968b; Prentice 1981; Mäkelä 1996; 1998; Caseldine 2001; Clegg *et al* 2005; Karlsdóttir *et al* 2007; Karlsdóttir *et al* 2008). Some pollen falls between the types in each of the studies, and the number of grains assigned to a species depends to some extent on the method employed. All *Betula* grains encountered in samples from Lower Lancarrow were photographed using a Leica DFC320 camera (mounted on the microscope) and measured with calibrated imaging software (Leica Application Suite). D and P were recorded for each pore and side of the grain wherever possible, in order to assess variation within individual grains.

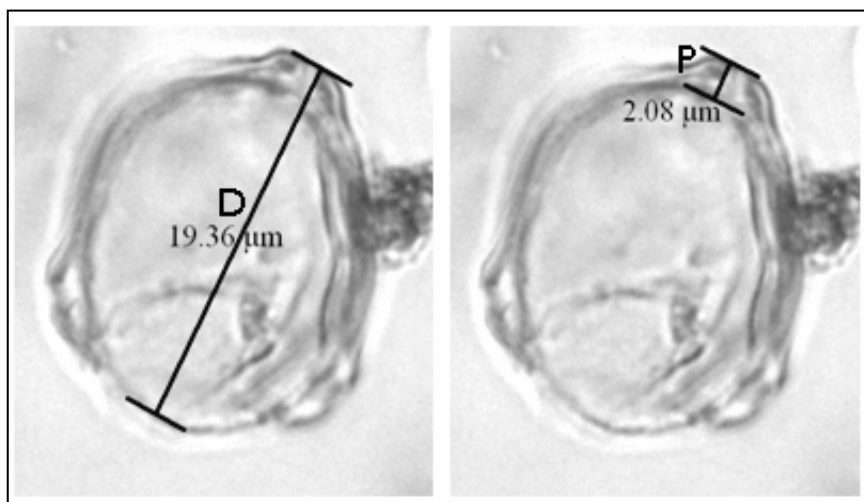


Figure 4: *Betula nana* pollen from Lower Lancarrow showing measurements recorded for species differentiation (D = grain diameter, P = pore depth).

Deciding on a method to differentiate the birch pollen was difficult; Birks (1968b) found that D/P was the best means of distinguishing *B. nana* from *B. pubescens*, while Karlsdóttir *et al* (2007) found that grain diameter (D) gave a clearer separation with fewer grains in the overlap zone. Mäkelä (1996) investigated the differences between *B. nana*, *B. pubescens* and *B. pendula*, finding that mean D for each species is distinct (Table 1), whereas Prentice *et al* (1981) report significant overlaps in all of the measurements. *B.*

pendula is intermediate between *B. nana* and *B. pubescens* in terms of D and P; as all three types are native to the UK and can occur on heath/moorland (see Clapham *et al* 1962; Stace 1997) it is not possible to exclude any of them with confidence.

Table 1: Mean values of D (diameter – see Figure 4) for *Betula pubescens*, *B. pendula* and *B. nana* (after Mäkelä 1996).

Species	Diameter / μm (D)	Standard deviation	Minimum value/ μm (-1STDEV*)	Maximum value/ μm (+1STDEV)
<i>Betula pubescens</i>	25.19	0.88	24.31	26.07
<i>Betula pendula</i>	21.37	1.54	19.83	22.91
<i>Betula nana</i>	17.31	1.65	15.66	18.96

*Standard deviation

Owing to the lack of consensus on the best means of separating *Betula* pollen, several methods were tried. In all cases both tree and dwarf birch grains were found to be present, though the numbers falling into each type varied, as did the quantity of indeterminate grains. For example, using Mäkelä's (1996) mean diameters plus or minus one standard deviation (Table 1) to define the limits for each species, of all the birch grains identified from the Lower Lancarrow samples, 16 were classified as dwarf birch, 47 as one or other of the tree birch species and only five as 'indeterminate birch'. Clegg *et al* (2005) identified the threshold for D/P in North American tree and dwarf birch species as 8.30 and for P as 2.55 μm , classing any pollen where D/P was greater than 8.30 and P was less than 2.55 μm as dwarf birch. Applying these limits to the pollen from Lower Lancarrow gives 37 dwarf birch, five indeterminate birch and 16 tree birch grains (so a far greater proportion of dwarf birch than was found using Mäkelä's method). Karlsdóttir *et al* (2007) observed a larger average grain diameter than Mäkelä for *B. nana* in their modern Icelandic birch pollen, indicating a greater probability of overlap between this and *B. pendula*. In addition, the mean D/P for Karlsdóttir *et al*'s (2007) *B. pubescens* grains was 8.61 while for *B. nana* it was 9.28, meaning that application of Clegg *et al*'s (2005) limits would incorrectly classify some of the Icelandic tree birch as dwarf birch.

Two-tailed T-Tests were applied to the datasets as separated by each of the above methods, in order to check the statistical probability that groups were distinct. While the outcome of these tests was encouraging, similar results were obtained through comparison of grains *within* the same species classification (eg the largest and smallest grains classified as *B. nana*), raising questions about the value of statistical analysis as a means of separating the *Betula* species. In summary, although the assemblage can be said to contain both dwarf and tree birch, it was not possible to identify individual grains to one type of the other without considering the overall distribution of birch grain measurements. Taking this into account together with the difficulty of deciding which criteria for separation were the most appropriate (eg Mäkelä 1996, Clegg *et al* 2005, Karlsdóttir *et al* 2007), it was decided that *Betula* species would not be plotted separately in the diagrams.

RESULTS

As mentioned previously, preliminary investigations including radiocarbon dating (Table 2) revealed that the deposits at Carn Galver and the Lizard were unsuitable for use in the project. The radiocarbon dates for the Carn Galver peat were completely inverted, suggesting that the remnants of a stack of cut fuel peat had been sampled. The Lizard deposits were heavily and completely permeated by large living root systems and rhizomes, and their stratigraphic integrity had been compromised. In addition, these deposits contained virtually no pollen. As a consequence, no further analyses were carried out for these sites. Although the first set of radiocarbon dates for Tregantallan Farm did not indicate any problems with the core, a second set of dates revealed age reversals and modern contamination (Table 2). Accordingly the stratigraphic integrity of the samples came into question; the deposits may have been disturbed during their formation and contamination might also have occurred during the sampling process. Pollen analysis had already been undertaken for this site (Figure 12, Appendix 1), but the results are not discussed here, as the integrity of the profile is questionable. The results from Treen Common and Lower Lancarrow proved much more promising and are discussed below.

Table 2: Radiocarbon results for the study sites (compiled and calibrated by John Meadows). Conventional radiocarbon ages (BP) were calibrated using the maximum intercept method (Stuiver and Reimer 1986) using OxCal v4.0.5 (Bronk Ramsey 1995; 1998; 2001; 2008) and the IntCal 04 calibration data (Reimer et al 2004). Fraction-modern (fM) results were also calibrated with this technique using the data of Kueppers et al (2004).

Site	Lab ID	Sample depth/cm	Material	$\delta^{13}\text{C}$ (‰)	Radiocarbon measurement	Calibrated date (95% confidence)
Carn Galver	SUERC -11297	16-17	Fine, charred ericaceous twigs, probably heather	-26.9	1340 ±35 BP	cal AD 640-770
	SUERC -11298	38-39	Fine, charred ericaceous twigs (probably <i>Calluna vulgaris</i>)	-29.2	1.1178 ±0.0048 fM	cal AD 1957-1996
Lower Lancarrow	OxA-17140	8-10	Uncharred herbaceous stem (monocot.) – single fragment	-27.0	1.30714 ±0.00358 fM	cal AD 1961-1979
	OxA-17217	27-29	Uncharred moss stems (probably <i>Sphagnum</i>)	-24.9	266 ±24 BP	cal AD 1525-1795
	OxA-17218	53-55	Uncharred <i>Carex</i> nutlets	-22.5	11690 ±50 BP	11760-11440 cal BC
	SUERC -12017	55-57	Uncharred <i>Carex</i> nutlets	-22.9	11545 ±40 BP	11520-11330 cal BC
	OxA-20312	62-63 (b)	Uncharred <i>Carex</i> nutlets	-24.8	11435 ±45 BP	11440-11250 cal BC
	SUERC -12019	70-72	Peat, humic acid	-28.8	11710 ±40 BP	11760-11470 cal BC
	SUERC -12020	70-72	Peat, humin fraction	-28.8	11995 ±40 BP	12020-11800 cal BC
Treen Common	SUERC -11302	22-24	Fine, charred ericaceous twigs (probably <i>Calluna vulgaris</i>)	-26.5	355 ±35 BP	cal AD 1440-1650
	OxA-17333	40-42	Uncharred ericaceous twigs (probably <i>Calluna vulgaris</i>)	-26.5	1067 ±30 BP	cal AD 890-1030
	SUERC -12018	92-94	Fine herbaceous material (cf Poaceae/Cyperaceae)	-33.4*	11010 ±40 BP	11100-10920 cal BC
	SUERC -13924	98-100 (I)	Poaceae or Cyperaceae leaves	-28.4	5090 ±35 BP	3970-3790 cal BC

Site	Lab ID	Sample depth/ cm	Material	$\delta^{13}\text{C}$	Radiocarbon measurement	Calibrated date (95% confidence)
Tregantallan Farm	OxA-17138	0-5	Uncharred twig (single fragment)	-29.0	1.09176 \pm 0.00372 BP	cal AD 1998-2001
	SUERC-12008	35-40	Peat, humic acid	-28.8	2400 \pm 35 BP	750-390 cal BC
	SUERC-12009	35-40	Peat, humin fraction	-28.9	2520 \pm 35 BP	800-520 cal BC
	OxA-20313	55-56 (2)	Uncharred herb roots, bulked	-27.0	1.06133 \pm 0.00312 fM	cal AD 1956-1957
	SUERC-23953	113-114 (1)	Uncharred herbaceous stem fragments	-25.0#	1125 \pm 50 BP	cal AD 770-1020
	SUERC-13925	115-120	Uncharred herbaceous stem fragments (cf monocot)	-26.7	1.1126 \pm 0.0036 fM	cal AD 1957-1997
	SUERC-22565	137-138 (1)	Charred herbaceous stem fragments	-25.5	4510 \pm 30 BP	3360-3090 cal BC
	SUERC-13926	161-162	Uncharred, single herbaceous stem fragment (cf monocot)	-26.9	4075 \pm 35 BP	2860-2490 cal BC
	OxA-17139	185-186	Uncharred leaf and leaf-base fragments (cf monocot)	-24.8	4425 \pm 31 BP	3330-2920 cal BC
	SUERC-22566	190-191 (1)	Uncharred herbaceous root fragments	-27.0	4370 \pm 30 BP	3090-2900 cal BC
	SUERC-12011	194-195	Peat, humic acid	-28.4	7810 \pm 35 BP	6750-6530 cal BC
	SUERC-12015	194-195	Peat, humin fraction	-28.1	7950 \pm 40 BP	7050-6680 cal BC
	SUERC-22567	204-205	Charred herbaceous stem and small twig fragments	-25.9	4635 \pm 30 BP	3520-3350 cal BC

* $\delta^{13}\text{C}$ value is extremely depleted for a terrestrial plant sample so the radiocarbon measurement should be regarded as a maximum age (for SUERC-12018).

$\delta^{13}\text{C}$ value is assumed, not measured, on account of the small sample size (for SUERC-23593)

Treen Common

The two uppermost radiocarbon dates from Treen Common fall into the early to mid-medieval period and the later medieval to post-medieval periods respectively (Table 2), while that from near the base of the sediments is early Neolithic (3970-3790 cal BC). An anomalously early late-glacial date from 92-94cm depth is thought to result from the presence of inwashed 'old' carbon, derived from eroded soils or peats in the surrounding area. This is supported by poor pollen preservation at this depth (compared to that in the underlying and overlying deposits), and the presence of a sand and gravel inwash layer immediately above the band of peaty material that was sampled for dating. Excluding the late-glacial date from the age-depth model suggests that the earliest sediments/pollen from Treen Common date from the late Mesolithic/early Neolithic period (Figure 5).

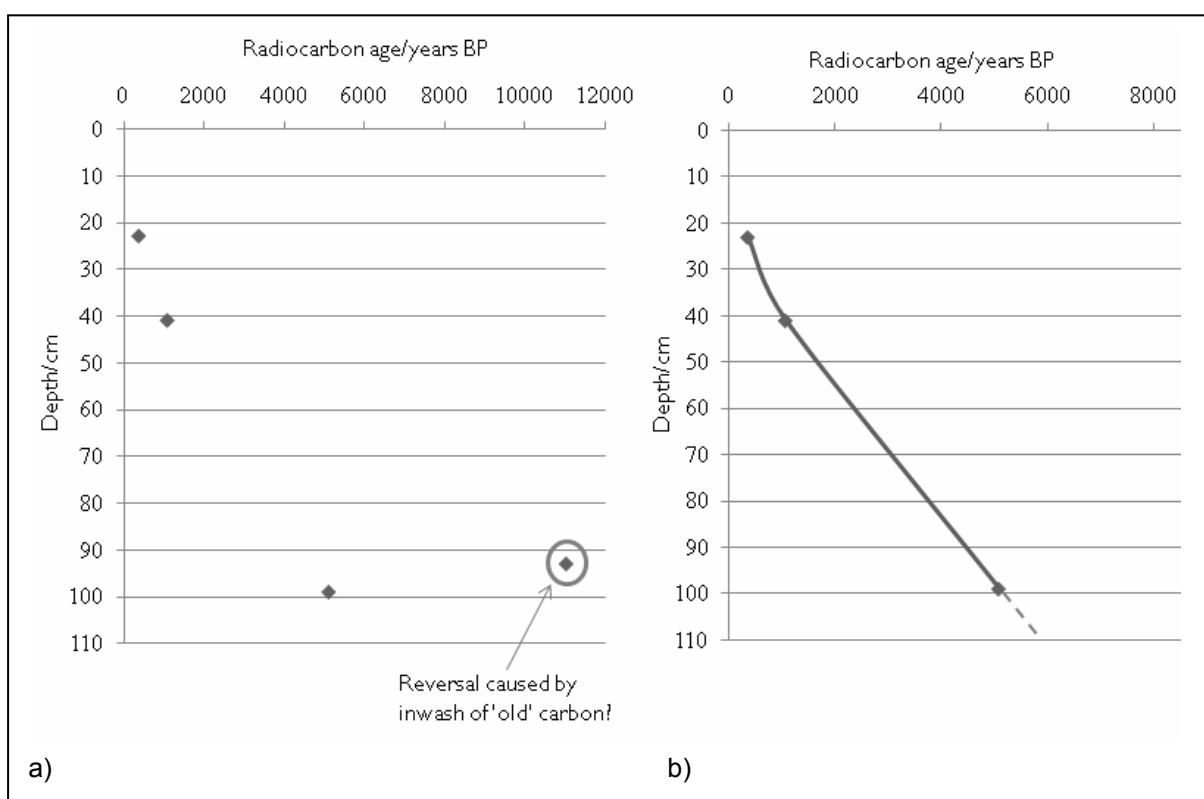


Figure 5: Age-depth models for Treen Common, showing a) all available radiocarbon dates and b) the extrapolated trend-line with the reversed measurement at 92-94cm removed.

The lower part of the profile is highly minerogenic, consisting mostly of silts, sands and gravels and having an estimated organic carbon content (based on percentage mass lost on ignition) of less than 10 per cent (Figure 6). Fibrous peat first occurs at approximately 80cm depth, reflected by a dramatic increase in organic carbon content, which rises to a maximum of 85 per cent at 46 and 60cm. There is a rapid decline in organic content in the upper 40cm of the monolith; although the composition of the peat does not appear

to be appreciably different to that below; the LOI data suggest increasing inorganic content towards the top of the profile.

Sediment description

The descriptions below follow the Troels-Smith classification system (1955) (see methodology); the codes used for components are defined in Table 5, Appendix 1. The lowest six layers had diagonally sloping interfaces (to the right); two depths are given to describe this feature. The uppermost 12cm of the profile were not sampled as the sediments were too wet and unconsolidated. None of the sediments were calcareous.

Table 3: Treen Common sediment descriptions (see methodology section and Table 5, Appendix 1).

12-20cm	Very dark reddish brown (7.5R 2/2), humified, fibrous peat. Some woody fragments and charcoal inclusions. Unstratified with very little elasticity. [1) 3, 2) 1, 3) 1, 4) 2, 5) 0, 6) 1, 7) 3, 8) Sh ³ 4 Th+ DI+ Anth+]
20-21.5cm	Greasy dusky red (10R 3/3) fibrous, very humified peat layer. Some herbaceous, woody and charcoal fragments. Darkens quickly on exposure to air. Diffuse upper boundary. [1) 3, 2) 1, 3) 1, 4) 2, 5) 0, 6) 1, 7) 4, 8) Sh ⁴ 4 Th+ DI+ Anth+]
21.5-24cm	Reddish black (10R 1.7/1) band, possibly indicating recent burning. Fibrous, plastic, well-humified peat with rare woody and herbaceous fragments and charcoal inclusions. [1) 3, 2) 1, 3) 1, 4) 2, 5) 0, 6) 3, 7) 4, 8) Sh ⁴ 4 Th+ DI+ Anth++]
24-43cm	Reddish black (10R 2/1), well-humified peat with herbaceous, woody and charcoal fragments. Fibrous, plastic matrix. [1) 3, 2) 1, 3) 1, 4) 2, 5) 0, 6) 3, 7) 4, 8) Sh ⁴ 4 Th+ DI+ Anth+]
43-80.5/43-85cm	Well-humified peat matrix with dark bands and fibrous plant remains. The peat becomes increasingly fibrous towards the top of the layer. There is an (inwashed?) band of gritty/clayey sediment at 74.5-75.5cm; descriptions in curly brackets refer to this layer. At 75.5-80.5cm there is a band containing sphagnum (Tb+). [1) 3, 2) 0 {1}, 3) 0, 4) 2, 5) 0, 6) 1-2, 7) 4, 8) Sh ⁴ 4 Th+ Dh+ Anth+ {Sh2 As2 Gs+ Gg+}]
80.5-90.5/85-95.5cm	Homogeneous, brownish black (7.5YR 3/2) clay with substantial amounts of coarse sand and gravel. Plastic matrix with granular mineral content and some fine sand and silt inclusions. No obvious stratification. Conspicuous upper boundary. [1) 3, 2) 0, 3) 0, 4) 2, 5) 0, 6) 2, 7) N/A, 8) GgI GsI As2 Ga+ Ag+]

91-93.5/95.5-98cm	Brownish black (7.5YR 3/2) clay with rare silt and charcoal inclusions. Homogeneous plastic matrix with conspicuous upper boundary. [1) 3, 2) 0, 3) 0, 4) 2, 5) 0, 6) 2, 7) N/A, 8) As ⁴ Ag ⁺ Anth ⁺]
93.5-96/98-99.5cm	Homogeneous black (5YR 1.7/1) organic clay with rare charcoal inclusions. Clearly defined layer. [1) 3, 2) 0, 3) 1, 4) 2, 5) 0, 6) 4, 7) 4, 8) As ³ Sh ⁴ I Anth ⁺]
96-105/99.5-108cm	Dark brown (7.5YR 3/3) clay with some silt, charcoal and a small amount of humified, organic material. [1) 2, 2) 0, 3) 0, 4) 2, 5) 0, 6) 3, 7) N/A, 8) As ⁴ Ag ⁺ Anth ⁺ Dh ³ +]
112-105.5/112-108cm	Coarse, gravelly clay with some silt and sand inclusions. Dark brown (7.5YR 3/3), homogeneous, plastic matrix containing a small amount of well-humified organic material and charcoal. Gravel content decreases towards the upper boundary – very diffuse upper limit. [1) 2, 2) 0, 3) 0, 4) 2, 5) 0, 6) 0, 7) N/A, 8) As ⁴ Ag ⁺ Gg ⁺ Gs ⁺ Ga ⁺ Anth ⁺ Dh ⁴ +]

Pollen

Pollen preservation was good throughout most of the Treen Common sediment sequence, though concentrations were low at the base of the profile and from approximately 85 to 90cm depth; both of these sections had a significant gravel component, which could indicate that they derived from inwashed material, a likely source of reworked (and poorly preserved) pollen. The number of unidentifiable grains (mostly degraded or crushed) peaks in these sections, supporting this hypothesis. The pollen diagrams were zoned by eye (Figures 6 and 7, 13 and 14 (Appendix 1)).

LPAZ (local pollen assemblage zone) 1: 112-83cm

The earliest assemblages at Treen Common reflect a largely open landscape, dominated by grasses and a variety of herbs. There are a small number of cereal-type grains at the base of the core. Cereal/large Poaceae (grass) grains were mostly found to be of *Hordeum*-type, a group that includes barley and many wild grasses, but there were also examples of *Avena/Triticum*-type (predominantly oat and wheat species) (Table 6, Appendix 1), which is indicative of agriculture in the catchment area. This is supported by the presence of Chenopodiaceae (Goosefoot/fat hen), *Urtica* sp (nettles) and *Artemisia*-type (mugworts/wormwood), all of which are found on disturbed or cultivated ground (eg see Oldfield 1963, 1969; Turner 1964; Dimbleby 1978; Behre 1981, 1988; Berglund et al 1986; Vorren, 1986).

Arboreal pollen makes a minimal contribution at this stage, consisting of small percentages of *Pinus sylvestris* (pine), *Ulmus* (elm), *Betula* (birch), *Quercus* (oak), *Corylus avellana*-type (hazel/bog myrtle) and *Salix* (willow). Pollen from heath vegetation is sparse in LPAZ 1, but single grains of undifferentiated *Erica* and *Vaccinium*-type (including cowberry, bilberry,

whortleberry, cranberry) were found in the basal sample and both *Erica ciliaris*-type (including *E. vagans* (Cornish heath)) and *E. tetralix* (Cross-leaved heath) are present from 93.5cm upwards. Sedges, reeds and aquatics are common in this zone, suggesting wet conditions at the site. A substantial spike in unidentifiable grains and a significant drop in pollen concentrations coincide with the late-glacial radiocarbon date (11100-10920 cal BC), supporting the conclusion that inwashed 'old' carbon was present at this depth (see Table 2 and Figure 5).

LPAZ 2: 83-63cm

This zone is characterised by an expansion of arboreal taxa, particularly hazel, which reaches a maximum of 55 per cent of the TLP. Percentages of birch, willow and oak also increase and the first grains of *Alnus glutinosa* (alder) are found during this phase. Poaceae appears to decline (Figure 7), although concentration values suggest that grasses remain an important vegetation type in the landscape (Figure 14, Appendix 1). Other herbaceous taxa almost invariably decline or disappear during this zone, which seems to represent a period of woodland regeneration or colonisation. Ericaceous pollen is present in small amounts throughout LPAZ 2.

LPAZ 3: 63-43cm

Grasses and herbs increase during this phase, particularly *Plantago* spp (plantains) and *Cichorium intybus*-type (dandelion/chicory). Nettles are also present and arboreal taxa decline dramatically in this zone, suggesting a woodland clearance event. The herbs present are probably indicative of grazing as opposed to agriculture (eg see Oldfield 1963, 1969; Turner 1964; Dimbleby 1978; Behre 1981, 1988; Berglund et al 1986; Vorren 1986) and no cereals were found during LPAZ 3. The percentage of Pteropsida monolete indet. (ferns) decreases in this zone, while heaths remain present at low levels.

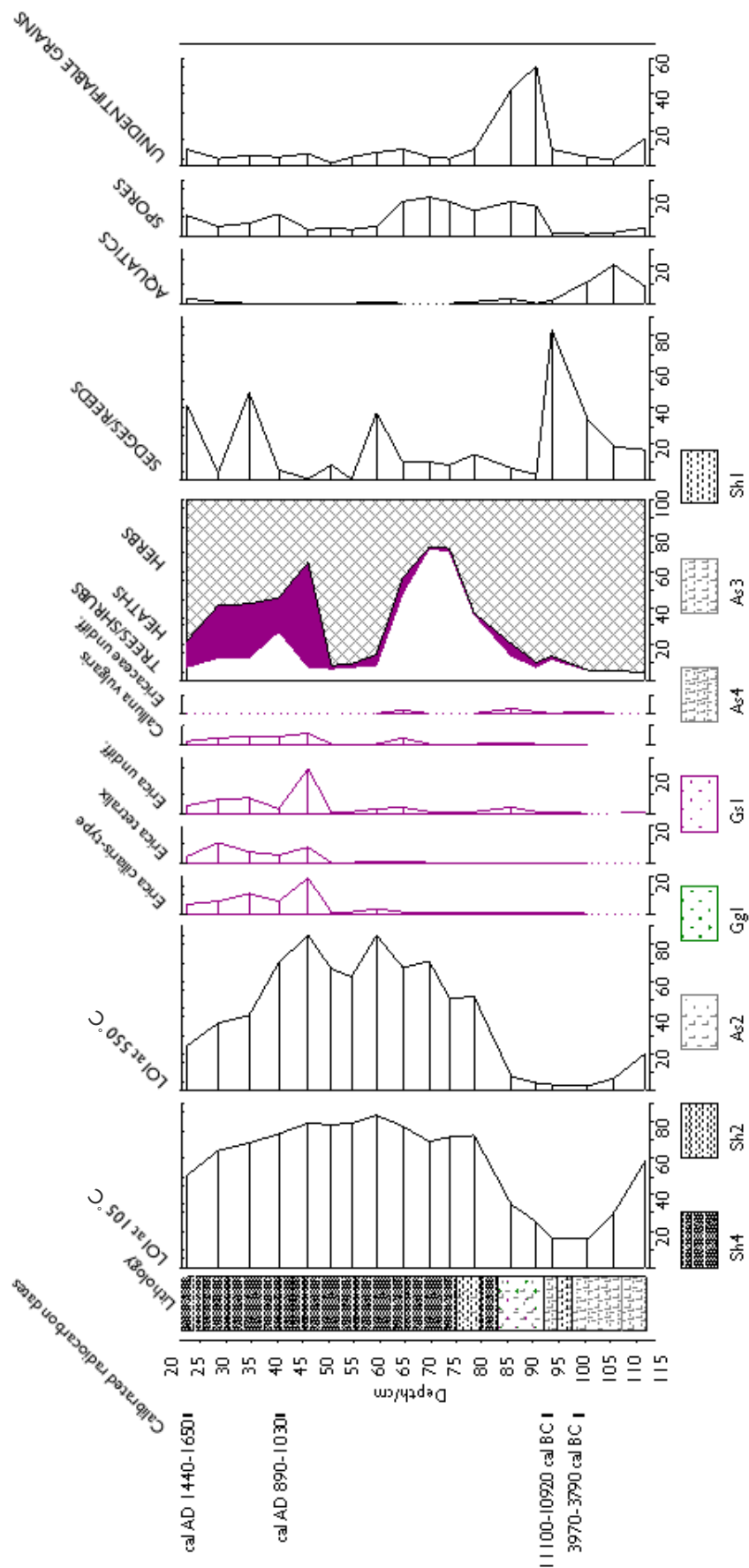


Figure 6: Treen Common pollen percentage diagram showing lithology, LOI, heathland taxa and cumulative pollen percentages. See Table 5, Appendix 1 for definitions of lithological codes (Sh, As, Ld and so forth).

LPAZ 4: 43-22cm (upper limit of sampling)

Zone 4 is marked by the expansion *Erica ciliaris*-type, *Erica tetralix* and *Calluna vulgaris* (heather). *E. ciliaris*-type is dominant over *E. tetralix* until at least the medieval period when both are present in similar percentages, so it seems likely that the spread of cross-leaved heath at the expense of other types of *Erica* (eg Cornish heath) is a relatively recent phenomenon (post-medieval). Poaceae pollen declines to some extent in this period, while *Corylus avellana*-type increases to around 10 per cent of the TLP after an initial peak of almost 20 per cent. A few large grasses/cereals are present, including the first examples of *Secale cereale* (rye) at the site, together with a slight increase in *Plantago* spp (plantains). Cyperaceae undiff. (sedges, rushes and cotton-grasses) and Sphagnum moss expand in this zone, suggesting wetter conditions on the site, which are also reflected by the presence of *Nymphaea alba* (waterlilies). Pteropsida monolete indet. and *Polypodium* (polypody) also increase at this stage.

Lower Lancarrow

The upper part of the monolith from Lower Lancarrow proved to be far younger than the lower section, indicating truncation at approximately 50cm, as is demonstrated by plotting the age in years BP against the depth (Figure 8); radiocarbon dates from the upper sediments are modern or post-medieval, while those below 50cm fall into the late-glacial period, but are not sequential. Field description of the sediments revealed fibrous peat with greasy, gyttja-like inclusions in the mid-section of the profile above a depth of 53cm; major differences between the two overlapping monoliths in this section suggest that these deposits may be the result of back-filling, or disturbance such as would be expected at the base of a peat cut.

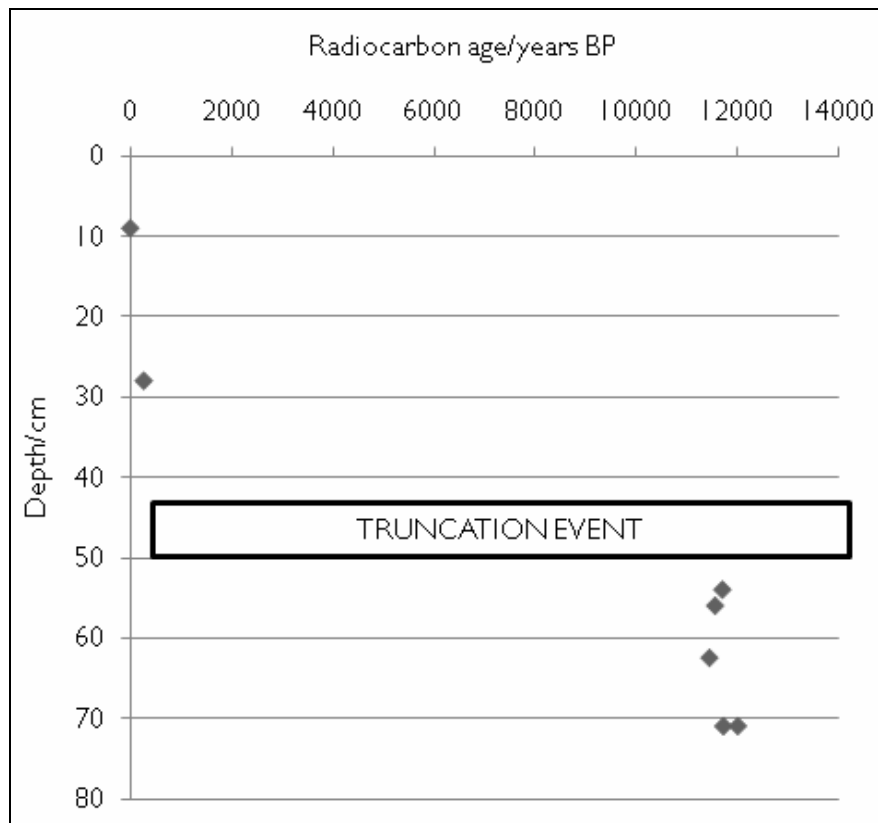


Figure 8: Age-depth model for Lower Lancarrow showing all available radiocarbon dates.

Sediment description

Owing to the likelihood of disturbance in the upper part of the profile, the descriptions below cover only the sediments below 49cm depth. The LOI data indicate very low organic carbon content (less than 5 per cent of the dry mass) in the clay and gravel at the base of the monolith, increasing to approximately 20 per cent above this depth. Organic carbon content increases from approximately 61cm upwards, reaching a maximum of over 90 per cent of the dry mass at 50-51cm depth.

Table 4: Lower Lancarrow sediment descriptions.

- 49-53.5cm Banded layers of gyttja and peat, approximately 1 cm thick (two of peat, two of gyttja), with a very diffuse upper boundary.
- Peaty bands:
Very dusky red (10R 2/2) and slightly elastic, consisting of moderately humified herbaceous material, degraded organics and some charcoal fragments.
[1) 3, 2) 2, 3) 2, 4) 2, 5) 0, 6) 0, 7) 2, 8) Dh²I Th²I LdI Anth+]
- Gyttja layers:
Brown red (5YR 2/4), homogeneous humus matrix containing a significant amount of herbaceous material.
[1) 2, 2) 1, 3) 1, 4) 2, 5) 0, 6) 0, 7) N/A, 8) Ld3 Dh²I]
- 53.5-69.5cm Brown red (5YR 2/4) gyttja with some herbaceous material (leaves and stems of sedges/grasses). Rare charcoal, sand, silt, clay and small gravel inclusions. Addition of KOH gives very little humus. The upper limit of the sediment unit is relatively clear.
- [1) 2, 2) 1, 3) 1, 4) 2, 5) 0, 6) 3, 7) N/A, 8) Ld3 Dh²I Anth+ As+ Ga+ Gs+ Ag+]
- 69.5-71.5cm Dark band of moderately humified herbaceous peat with a clear upper boundary. Very dusky red (10R 2/2) in colour, with a homogeneous, fibrous structure and some charcoal fragments.
- [1) 3, 2) 2, 3) 2, 4) 2, 5) 0, 6) 3, 7) 2, 8) Dh²I Th²I LdI Anth+]
- 71.5-76/78cm (slopes down to one side) Brown red (5YR 2/4) homogeneous gyttja containing some fibrous herbaceous material, with charcoal, sand, silt, clay and small gravel inclusions. Conspicuous upper limit.
- [1) 2, 2) 2, 3) 1, 4) 2, 5) 0, 6) 2, 7) N/A, 8) Ld3 Dh²I Anth+ As+ Ga+ Gs+ Ag+]
- 76/78-79cm Dark brown (10YR 2/3), homogeneous gravel (most stones measuring 5-20mm in diameter) and clay layer containing some silt, sand and woody fragments. Diffuse upper boundary.
- [1) 2, 2) 0, 3) 0, 4) 2, 5) 0, 6) 1, 7) N/A, 8) AsI Gg² GsI Ag+ Ga+ DI+]

Pollen

As explained above, the upper part of the Lower Lancarrow profile is thought to represent recent peat growth over a band of disturbed deposits resulting from back-filling, or having been subject to some other form of disturbance, and is far younger than the underlying sediment (Figure 8). For this reason the uppermost sediments were not sampled for pollen analysis. The radiocarbon ages on the lower section are also problematic (Table 2 and Figure 8), suggesting that the deposit may have been disturbed/mixed in the past. However, as the dates are consistently late-glacial it seems reasonable to consider the overall pollen assemblage as representative of the vegetation in this period. There are significant differences between the taxa present above and below a depth of approximately 68-9cm; on account of the dating problems it is not possible to say with certainty that the distinctive assemblages represent different time periods, or if so that these are sequential, but as this is a possibility the two sections are described separately here. Pollen diagrams were zoned by eye (Figures 10 and 11, 15 and 16 (Appendix 1)).

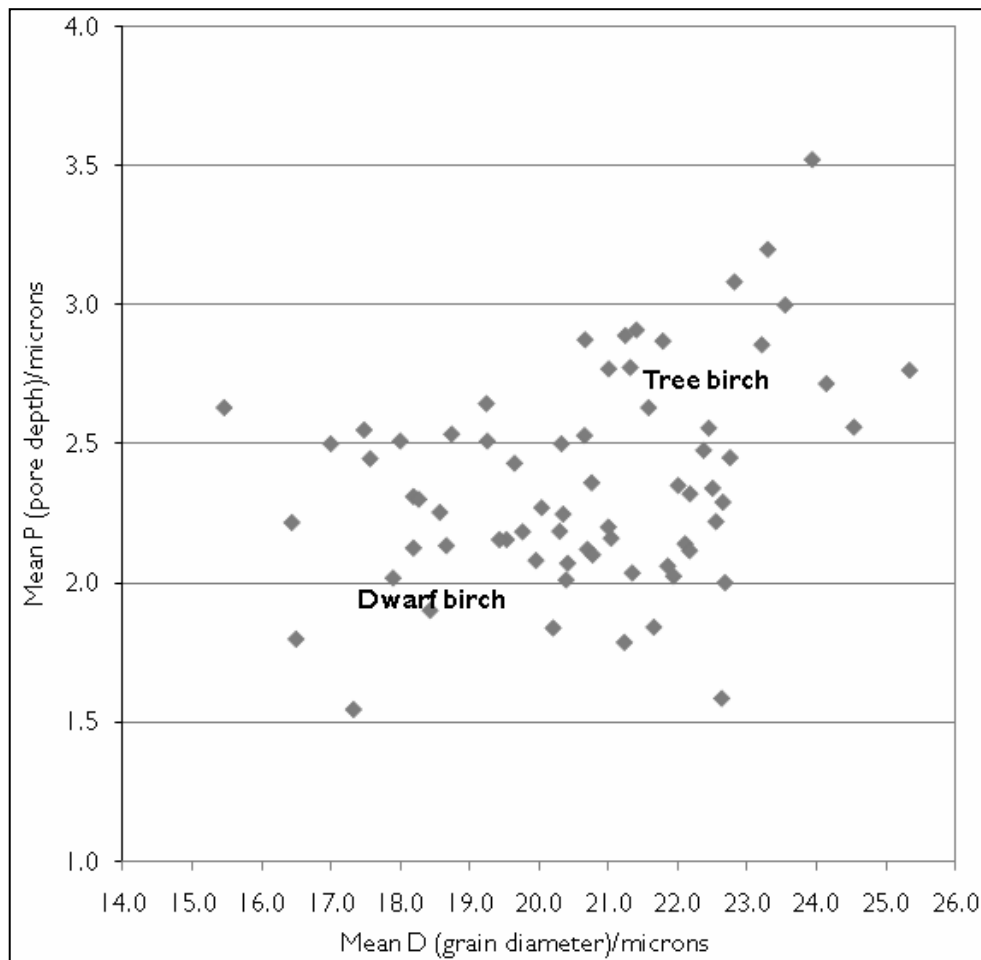


Figure 9: Lower Lancarrow *Betula* sp pollen measurements (mean D against mean P).

The distribution of grain and pore measurements for *Betula* spp indicates that both dwarf and tree birches were present throughout the late-glacial deposits from Lower Lancarrow (Figure 9). However, owing to the difficulty of identifying individual grains to dwarf or tree birch (see methodology section), it was decided that *Betula* pollen of different types ought not to be quantified in the diagrams.

LPAZ 1: 79.5-68.5cm

LPAZ 1 is dominated by open ground taxa, with approximately 60 per cent of the TLP consisting of Poaceae (grasses) at this depth. Herbaceous taxa make up over 85 per cent of the assemblage throughout this zone and include *Ranunculus acris*-type (buttercups), rosaceous types, Rubiaceae (madders, woodruffs and bedstraws) and *Artemisia*-type (mugwort/wormwood). The presence of significant quantities of *Cichorium intybus*-type (dandelion/chicory) might reflect poor (ie differential) pollen preservation at this depth, rather than a prevalence of plants of this type in the landscape. Pollen concentrations are very low throughout LPAZ 1 and unidentifiable grains reach values equal to 25 per cent of the TLP. As *Cichorium intybus*-type pollen is both robust and easily recognisable even in a degraded state, the importance of species in this group is likely to be exaggerated relative to more fragile pollen types.

Cyperaceae undiff. (sedges, rushes and cotton-grasses) also makes up a significant component of the assemblage and maximum values for this type reach the equivalent of 250 per cent relative to the TLP. Pollen from aquatic plants is important (maximum 20 per cent of the TLP) and is dominated by *Myriophyllum alterniflorum* (alternate-flowered water-milfoil) suggesting the presence of standing water on the site. Arboreal taxa make up between five and twelve per cent of the TLP at this depth, consisting mostly of *Salix* (willow), *Pinus sylvestris* (pine) and *Quercus* (oak). A small amount of birch was found in LPAZ 1, which included examples of *Betula nana* (dwarf birch). Ericaceous pollen, including *Erica ciliaris*-type (which includes *E. vagans*/Cornish heath), made up a small percentage of the assemblage throughout much of the profile, suggesting that heath vegetation was present, although probably not common, at the time.

LPAZ 2: 68.5-50cm

This zone is characterised by the expansion of heaths, which reach a maximum of over 40 per cent of the TLP in this zone, *Pteridium aquilinum* (bracken) and mosses (*Sphagnum*). There is also a marked increase in *Betula* (including *B. nana*) and *Salix* at this depth, while Poaceae declines and *Cichorium intybus*-type virtually disappears. Cyperaceae undiff. declines dramatically, as do aquatic species. *Menyanthes trifoliata* (buckbean/bogbean) is present in small quantities. This and the increase in *Sphagnum* suggest that conditions remain wet, but indicate a wet bog rather than a pond at this stage. The presence of *Valeriana dioica* (marsh valerian) and *Succisa pratensis* (devil's-bit scabious) is also indicative

of marshy/boggy conditions. Apiaceae (a large family including many annual and perennial herbs and (rarely) shrubs) and Rosaceous herbs, especially *Filipendula* (meadowsweet), become more common during this period. Heath taxa are dominated by *Erica ciliaris*-type (including *E. vagans*, Cornish heath) followed by *E. tetralix* (cross-leaved heath) and to a lesser extent *Calluna vulgaris* (heather). *Empetrum nigrum* (Crowberry) is also present.

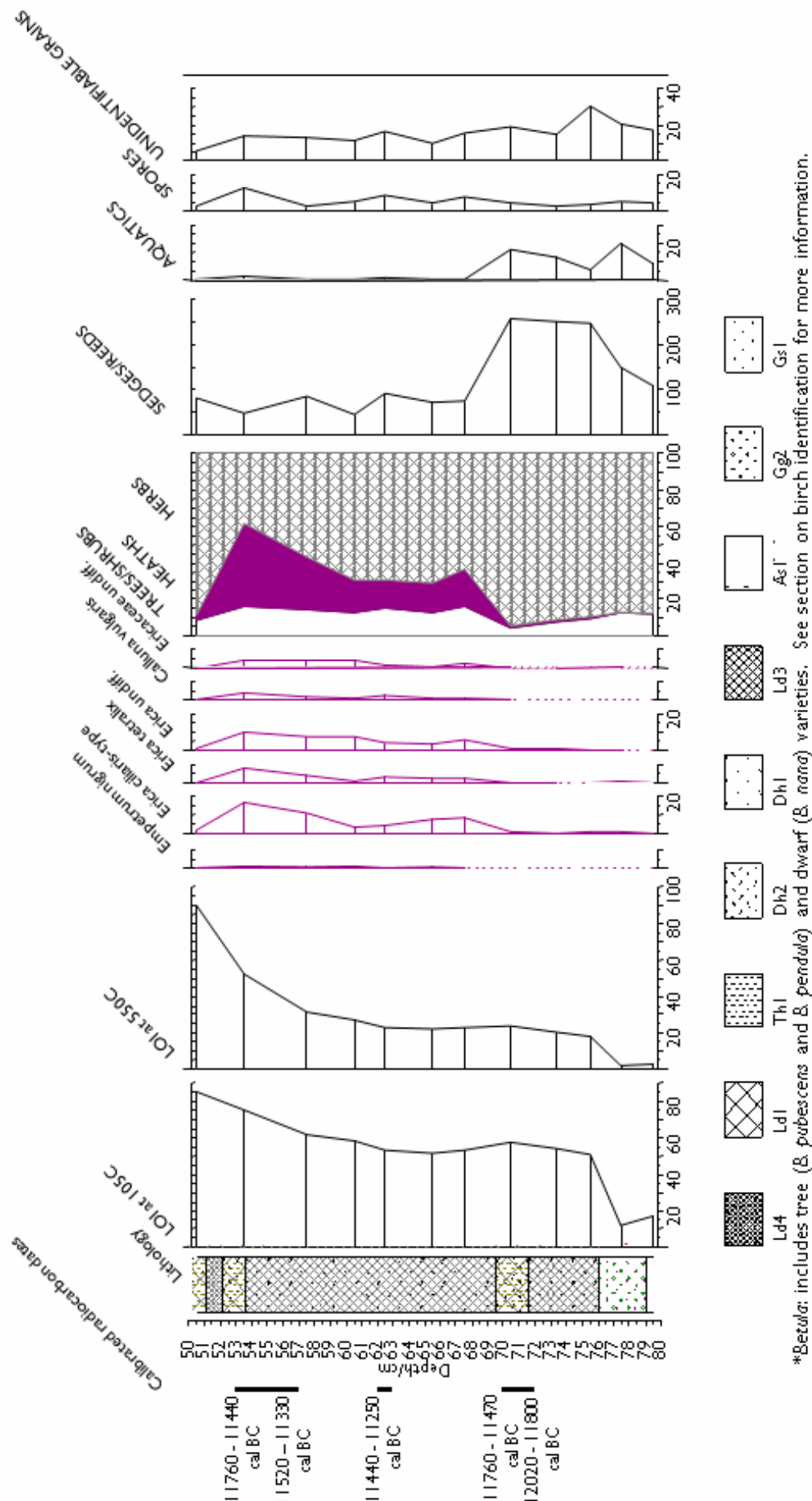


Figure 10: Lower Lancarrow pollen percentage diagram showing lithology, LOI, heathland taxa and cumulative pollen percentages. See Table 5, Appendix 1 for definitions of lithological codes (Sh, As, Ld and so forth).

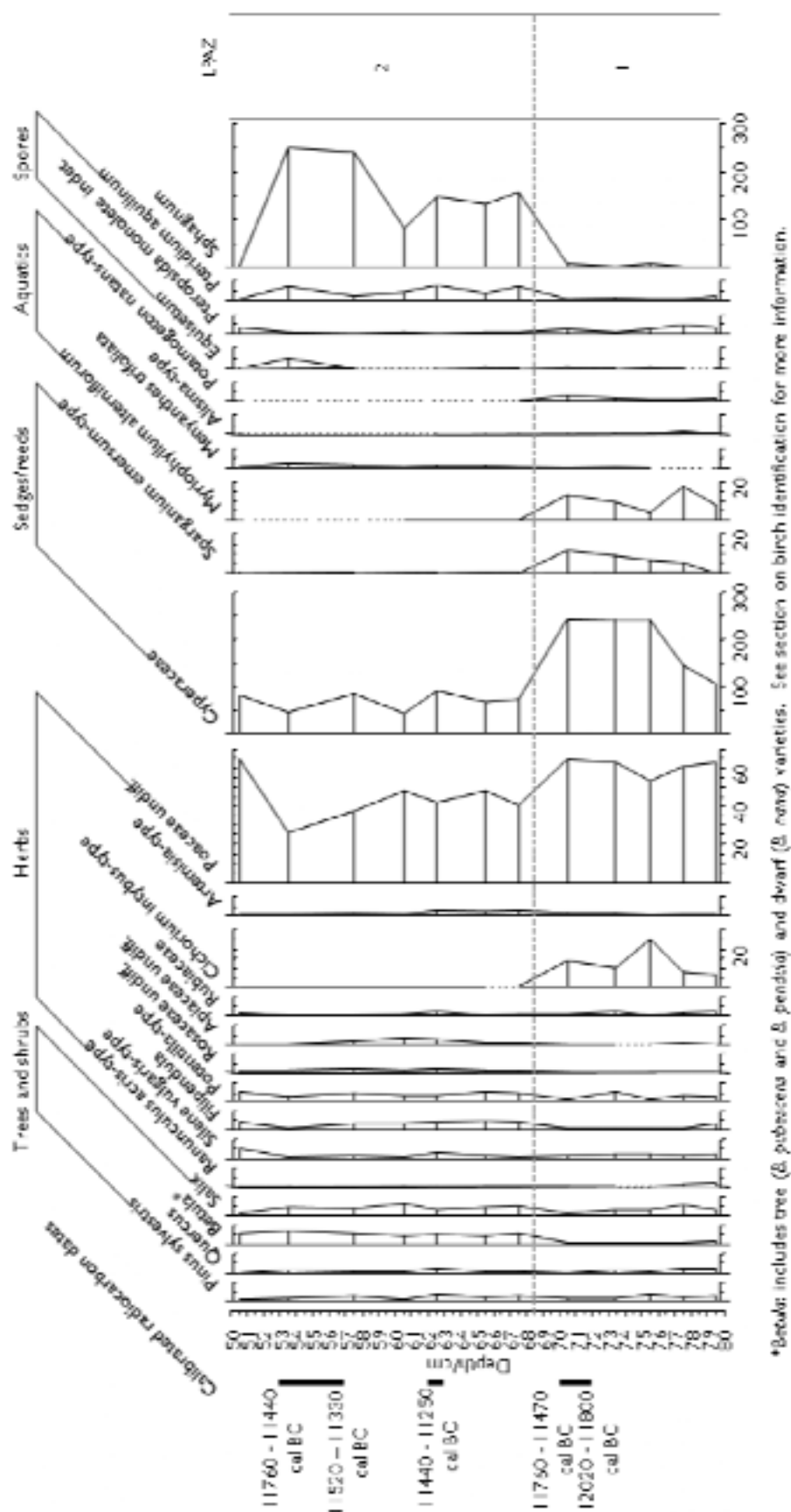


Figure 11: Lower Lancarrow pollen percentage diagram showing taxa with a maximum presence of 2% or greater of the TLP. See Figure 15, Appendix 1 for rare types (less than 2% of the TLP).

DISCUSSION

The principal aim of the work presented here was to establish the antiquity of the west Cornish heathland, in addition to elucidating the broader vegetation history of the region. Although several of the sites investigated proved to be problematic, the data from Lower Lancarrow and Treen Common have extended our knowledge of the landscape histories of Cammenellis and West Penwith respectively, and are discussed further below.

As explained previously, the deposits from Lower Lancarrow were found to be much older than expected, with radiocarbon dates falling within the 12th millennium BP (12th-13th millennia cal BC)(table 2) – the upper Palaeolithic. The profile is truncated and not all of the radiocarbon dates are sequential (Figure 8), which may indicate disturbance or inwash of 'old' carbon in unstable soil conditions, yet the radiocarbon measurements from the lower part of the profile indicate that the deposits are consistently late-glacial. Furthermore, the pollen data seem to represent two phases of development; one in which conditions at the site were very wet, evident from high percentages of aquatic taxa and sedges, and another, almost certainly later, that sees the onset of peat-forming conditions and the expansion of arboreal and heathland taxa (LPAZs 1 and 2 respectively, figures 10 and 11).

The earliest phase at Lower Lancarrow (LPAZ 1, figure 10) is characterised by open, tundra-like vegetation, with herbs (predominantly Poaceae) making up over 90 per cent of the total land pollen. Ericaceous pollen, although very rare, makes a contribution to the assemblage at this time and includes examples of *Erica ciliaris*-type. In the subsequent phase (LPAZ 2) heathland taxa (*Erica ciliaris*-type, *Erica tetralix*, *Calluna vulgaris* and *Empetrum nigrum*) expand to between 20 and 40 per cent of the total land pollen, with *E. ciliaris*-type dominating the heaths (figure 10). If, as seems likely, *E. ciliaris*-type represents *Erica vagans* in this assemblage, it appears that Cornish heath was not only present in the catchment area of Lower Lancarrow by the upper Palaeolithic, but was actually more common than cross-leaved heath or heather at this time.

Arboreal pollen percentages – especially *Betula* (birch) and *Salix* (willow) – also increase in LPAZ 2, reaching around 15 per cent of the total land pollen, perhaps owing to colonisation of grassland by woodland taxa. Pollen of both dwarf and tree birches (*Betula nana* and *B. pendula/pubescens* respectively) was found throughout the deposits; the UK distribution of the former is now confined to mountain moorlands in Northern Britain (Clapham *et al* 1962), and its presence at Lower Lancarrow is indicative of the cold, late-glacial climate. It is possible that the *Salix* pollen originates from dwarf willow (*Salix herbacea*), which is found in arctic conditions and was present in the UK during the last ice age⁴ (see Alsos *et al* 2009), but the expansion of willow might simply reflect wet conditions around the study site, supported by the abundance of *Sphagnum* during this phase.

⁴ Unfortunately *S. herbacea* pollen cannot easily be distinguished from other species of *Salix* (cf Moore *et al* 1991; Bennett, 1994).

The earliest pollen data from Treen Common indicate an open landscape persisting from the late Mesolithic/early Neolithic to the late Neolithic, ending at around 4000 BP (2620 – 2462 cal BC), if a relatively steady rate of accumulation between the radiocarbon dated samples is assumed (figure 5). The presence of *Avena/Triticum*-type (oats or wheat) and *Hordeum*-type (including cultivated barley) pollen, in addition to species indicative of cleared or cultivated ground such as *Urtica* sp (nettles), *Trifolium*-type (clover/trefoils) and *Artemisia*-type (mugwort/wormwood) pollen, suggests that farming was taking place in the area (e.g. see Oldfield 1963, 1969; Turner 1964; Dimbleby 1978; Behre 1981, 1988; Berglund et al 1986; Vorren, 1986). Cereal pollen is large, heavy and produced in small quantities, so the presence of this in the deposits suggests cereal cultivation (or cereal processing) nearby (cf Edwards et al 1986; Tweddle et al 2005), presumably by the earliest farmers in the region. Conditions at or near to the site are likely to have been wet, indicated by the presence of Cyperaceae undiff. (sedges, rushes and cotton-grasses) and aquatic taxa such as *Myriophyllum alterniflorum* (alternate-flowered water-milfoil) and *Potamogeton natans*-type (pondweed). In this environment, some of the Poaceae identified in the assemblages may originate from wetland grasses or *Phragmites* sp. (reeds)(see Barber 1988).

Pollen of ericaceous taxa is present in the earliest deposits, with *Erica ciliaris*-type (including *E. vagans*, Cornish heath), *Erica tetralix* (cross-leaved heath) and *Calluna vulgaris* (heather) first appearing in the early Neolithic (c 4700 BP, or 3630-3370 cal. BC)(Figures 5 and 6). Although heaths constitute only a small part of the assemblage their presence at this early stage is interesting; previous studies in West Penwith had suggested that heath vegetation was largely absent throughout prehistory (eg Scaife 1996; Straker 2011).

Towards the end of the Neolithic (start of LPAZ 2) there is a dramatic expansion of *Corylus avellana*-type, which is thought to represent hazel, although the presence of *Myrica gale* (bog myrtle) cannot be ruled out entirely as the pollen is difficult/impossible to differentiate (eg Moore et al 1991; Bennett 1994). *Betula* sp (birch), *Quercus* (oak) and *Salix* (willow) also increase at this time, suggesting woodland regeneration. Anthropogenic indicators are largely absent during this period and herbaceous taxa decline overall, which could be interpreted as evidence for abandonment of local farmland. This phase lasts until the late Bronze Age/early Iron Age (approximately 2550 BP, 544 - 804 cal BC) when grasses and anthropogenic indicators increase and trees decline (LPAZ 3). The absence of pollen of cereals and weeds associated with crops indicates a grazed landscape rather than a cultivated one at this time; this is not to say that crop farming did not occur in the area – only that there is no clear evidence to support it in the pollen record. This phase continues through the Iron Age and Romano-British periods, into early medieval times.

The most important change with regard to heathland development occurs in the early medieval period (c 1150 BP, cal AD 779 – 976), when heathland taxa peak at around 60 per cent of the total land pollen. *Erica ciliaris*-type, *Erica tetralix* and *Calluna vulgaris* increase dramatically, while herbaceous taxa and indicators of grazing decline, perhaps

owing to expansion of heath onto farmland. This spread may have been encouraged by overgrazing in earlier periods, resulting in a loss of soil fertility and the spread of plants better suited to nutrient-poor habitats (cf Limbrey, 1975). It is probable that some of the Poaceae pollen from this and later periods originates from grasses such as *Molinia caerulea* (purple moor-grass) and *Danthonia decumbens* (heath grass), which grow on heathland and in acid grasslands (see Clapham *et al* 1962; Stace 1997). After the initial peak, heathland taxa decline to around 25 to 30 per cent of the total land pollen, but remain far more prevalent than in earlier periods. This coincides with the early to middle medieval period, which is also characterised by wetter conditions at the site, evinced by the increase in sedges and Sphagnum and the presence of aquatics (*Nymphaea alba*, waterlilies). Agricultural indicators and cereals, including the first examples of *Secale cereale* (rye) are also found at this time, suggesting a mixture of farmland and heath in the landscape, which persists until the medieval or post-medieval period (355 +/-35 BP, cal AD 1440-1650)(the upper limit of sampling).

As mentioned previously, Vanessa Straker's extensive review of palynological work in West Cornwall (2011) highlighted the paucity of dated pollen sequences available from the region. With the exception of a single study at St Loy (West Penwith) showing vegetation characteristic of Arctic tundra (Scourse 1999), prior to this study there were no data available within the study area relating to earlier than the late Mesolithic period (Straker 2011). Previous work in West Cornwall suggested that heath vegetation colonised the Lizard prior to the Bronze Age, but did not reach far into West Penwith until the historic period (Robinson *et al* 2011), while the landscape history of Cammenellis was poorly understood (Herring 2011, 102). The palynological data presented here demonstrate that *Erica ciliaris*-type pollen, which is distinct from *E. tetralix* and likely to originate from *Erica vagans* – Cornish heath – in this area, was present in Cammenellis as early as the late-glacial period (c 12000 cal BC) and that Ericaceous species had reached West Penwith by late-Mesolithic/early Neolithic times (c 3970-3790 cal BC), although the first identifiable examples of *E. ciliaris*-type pollen do not occur here until perhaps 300 years later (Figure 5). Furthermore, a significant expansion of heathland in this area occurred in the early medieval period, and although both *Erica ciliaris*-type and *E. tetralix* are represented at Treen Common from the early Neolithic onwards, *E. ciliaris*-type is generally more prevalent, suggesting that the dominance of *E. tetralix* is a recent (post-medieval) phenomenon. Squill (*Scilla* sp), which is also characteristic of West Cornish heathland, was not found in any of the deposits examined. Owing to its fragile nature, Liliaceous pollen is less likely to survive than most other taxa, particularly in the earlier deposits investigated here (eg at Lower Lancarrow), for which preservation was generally poor.

The work presented here has added to our knowledge of the development of the west Cornish heath, establishing an early, late-glacial date for the first occurrence of ericaceous taxa in the region and identifying a period of heathland expansion in West Penwith in the early medieval period. However, the palynological record for southwest England remains patchy, owing at least in part to the difficulty of finding suitable sampling sites and

stratigraphically intact deposits, as demonstrated by the problems encountered with the cores from Carn Galver, Lizard Common and Tregantallan Farm. In terms of future work in the area, it is probably worth revisiting sites investigated previously where records are known to be well-preserved (eg Chysauster, Scaife 1996; and see Straker 2011) in order to obtain a more detailed/higher resolution pollen record and radiocarbon dating evidence.

Appendix I: Additional figures and tables

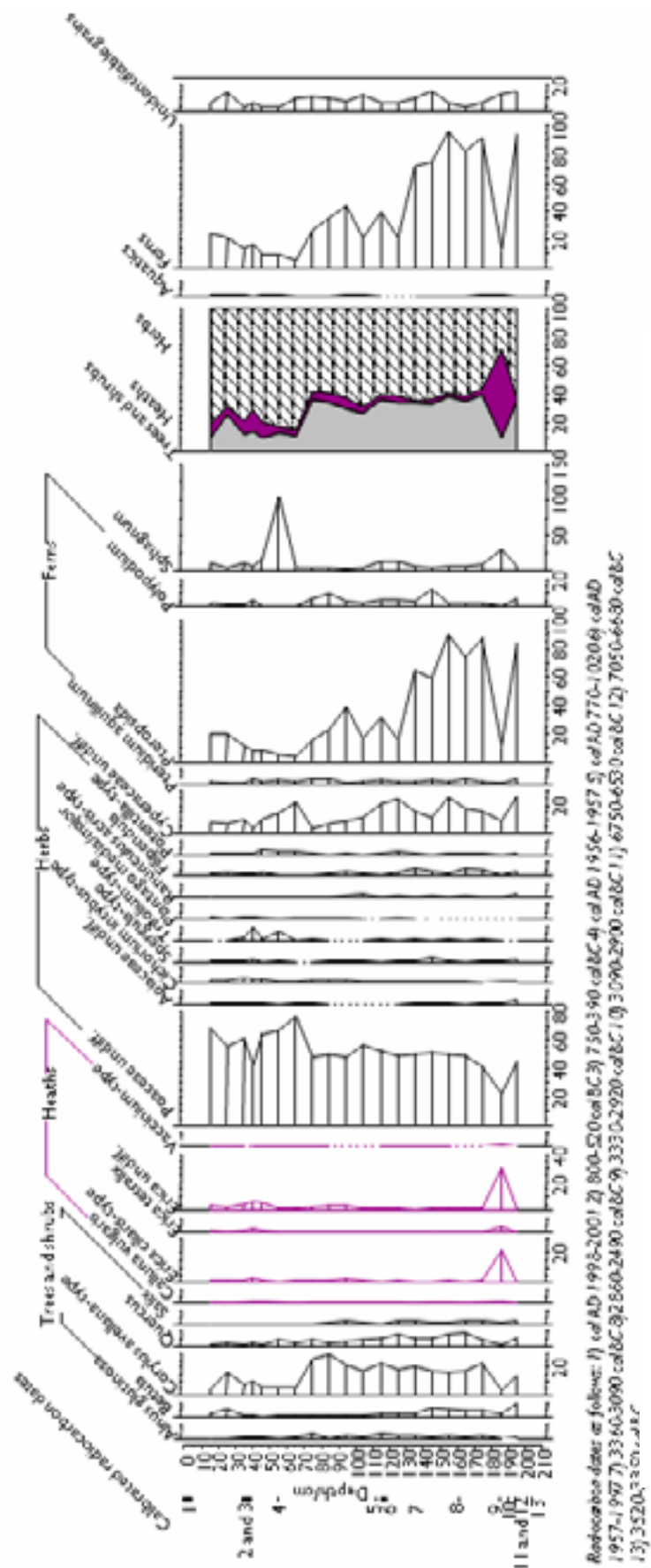
Table 5: Sediment components used in descriptions and pollen diagram lithologies (after Troels-Smith, 1955)

Code	Component type	Definition
As	<i>Argilla steatoides</i>	Clay – minerogenic particles measuring less than 0.002mm
Ag	<i>Argilla granosa</i>	Silt – minerogenic particles measuring 0.002-0.06mm
Ga	<i>Grana arenosa</i>	Sand – minerogenic particles measuring 0.06-0.6mm
Gs	<i>Grana saburralia</i>	Coarse sand/small stones measuring 0.6-2mm
Gg	<i>Grana glareosa</i>	Stones/pebbles measuring 2-20mm (2-6mm Gg <i>minora</i> , 6-20mm Gg <i>majora</i>)
Dg	<i>Detritus granosus</i>	Small woody and herbaceous fragments together with unidentifiable fossils or fragments of these, measuring greater than 0.1mm and less than 2mm in length
Dh	<i>Detritus herbosus</i>	Herbaceous plant fragments greater than 2mm in length
DI	<i>Detritus lignosus</i>	Woody fragments greater than 2mm in length
Ld ⁴ (Lh)	<i>Limus humosus</i>	Similar to Sh, but refers to lake mud rather than humified peat. Homogeneous deposit, humous substance, fragments less than 0.1mm in length. Mud/marl, fragments of plants, animals and decomposed organics.
Sh	<i>Substantia humosa</i>	Humous substance – completely disintegrated or decomposed organic substances/humic acids. Black and structureless (ie fully humified peat)
Tb	<i>Turfa bryophytica</i>	Peat composed of moss, with macroscopic structure (not fully humified, may be fresh/unhumified)
Th	<i>Turfa herbacea</i>	Peat composed of roots, rhizomes and stems of herbaceous plants
Anth	<i>Anthrax</i>	Charcoal

Depth/ cm	Grain diameter/ μm	Diameter at 90°/μm	Pollen index	Pore diameter/ μm	Annulus thickness/ μm	Annulus diameter/ μm	Species/type
<i>Table 6: Measurements and classifications of Treen Common cereals/large grasses</i>							
22.5	51.7	N/A	N/A	4.3	4.5	12.1	Avena/Triticum- type
22.5	41.7	N/A	N/A	4.6	3.0	10.3	Avena/Triticum- type
28.5	43.8	N/A	N/A	3.7	3.9	10.5	Avena/Triticum- type
28.5	37.5	N/A	N/A	3.9	3.8	10.7	Hordeum/Avena/ Triticum-type
28.5	46.7	N/A	N/A	4.0	3.1	9.7	Hordeum/Avena/ Triticum-type
28.5	37.0	N/A	N/A	3.5	3.0	9.0	Triticum-type
28.5	42.9	N/A	N/A	3.3	3.0	9.6	Hordeum-type
28.5	42.9	N/A	N/A	3.8	2.7	8.1	Hordeum-type
28.5	52.4	36.1	1.45	3.8	3.1	9.6	Secale cereale
28.5	46.9	32.5	1.44	3.1	2.8	8.7	Secale cereale
34.5	43.1	N/A	N/A	3.3	3.2	9.8	Hordeum-type
34.5	47.3	30.7	1.54	2.3	4.0	9.5	Secale cereale
34.5	50.8	28.7*	1.77	3.1	3.3	9.5	Secale cereale
34.5	47.8	29.7	1.61	3.3	3.6	9.4	Secale cereale
34.5	48.7	33.6	1.45	3.9	3.1	9.4	Secale cereale
34.5	50.3	26.9*	1.87	4.3	2.7	9.3	Secale cereale
34.5	44.1	29.0*	1.52	3.9	2.9	9.7	Secale cereale
100.5	36.5	N/A	N/A	3.7	4.4	12.2	Hordeum/Avena/ Triticum-type
100.5	34.5	N/A	N/A	3.3	3.6	10.4	Triticum-type
100.5	35.0	N/A	N/A	3.0	3.5	10.0	Hordeum-type
100.5	32.2	N/A	N/A	4.6	1.8	8.9	Hordeum-type
100.5	32.0*	N/A	N/A	3.3	3.0	8.0	Hordeum-type
100.5	32.2	N/A	N/A	3.2	26.0	8.5	Hordeum-type

Depth/ cm	Grain diameter/ µm	Diameter at 90°/µm	Pollen index	Pore diameter/ µm	Annulus thickness/ µm	Annulus diameter/ µm	Species/type
100.5	32.5	N/A	N/A	4.3	1.8	6.4	Wild grass
100.5	25.3	N/A	N/A	3.2	2.5	7.8	Wild grass
105.5	27.5*	N/A	N/A	3.6	2.4	9.1	Hordeum-type
105.5	38.9	N/A	N/A	2.7	3.5	9.3	Hordeum-type
105.5	33.7	N/A	N/A	3.9	3.6	10.6	Hordeum/Avena/ Triticum-type
105.5	36.5	N/A	N/A	3.9	3.2	9.3	Hordeum-type
105.5	34.2	N/A	N/A	3.6	3.0	9.4	Hordeum-type
105.5	34.7	N/A	N/A	2.7	2.4	7.2	Wild grass
111.5	40.8	38.1	1.07	3.3	3.9	11.1	Avena/Triticum- type
111.5	40.3	39.2	1.03	3.7	4.1	11.0	Avena/Triticum- type
111.5	43.3	N/A	N/A	4.2	3.5	10.6	Avena/Triticum- type
111.5	35.0*	N/A	N/A	4.0	2.9	8.9	Hordeum-type
111.5	34.1	33.4	1.02	3.7	3.2	10.8	Hordeum-type
111.5	34.2*	N/A	N/A	3.6	3.5	10.0	Hordeum-type
111.5	35.4	33.8	1.05	3.4	3.5	9.5	Hordeum-type
111.5	35.6*	27.2*	1.31	3.0	2.8	8.6	Hordeum-type (not <i>S. cereale</i>)
111.5	31.3*	27.9*	1.12	2.2	3.9	9.0	Hordeum-type/ wild grass
111.5	27.6*	28.5*	0.97	3.8	2.5	8.2	Hordeum-type/ wild grass
111.5	35.1	N/A	1.43	3.1	2.2	6.5	Wild grass
111.5	34.4*	28.7*	1.20	3.4	2.4	7.2	Wild grass
111.5	28.4*	23.8*	1.19	2.1	2.8	7.4	Wild grass

*Grain would not unroll fully so the maximum measurement may be greater



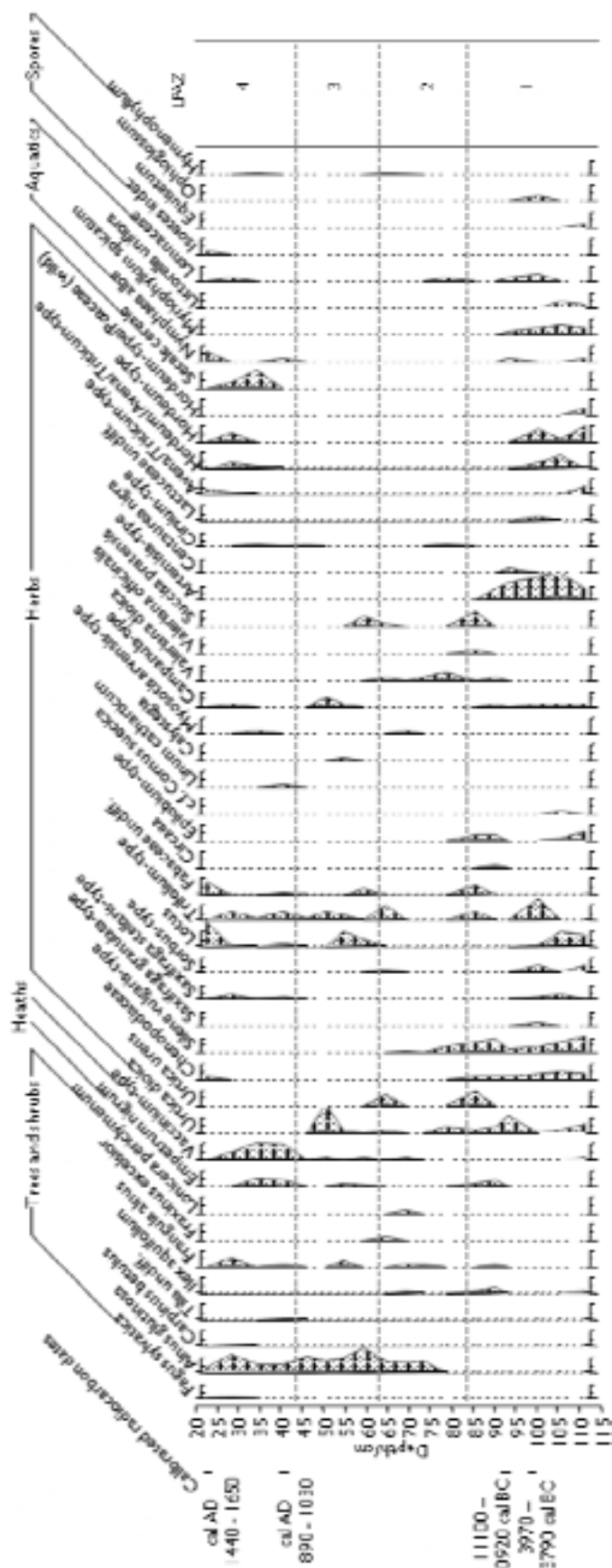


Figure 13: Treen Common pollen percentage diagram showing rare taxa (maximum presence of less than 2% of the TLP). All types are exaggerated by a factor of 10.

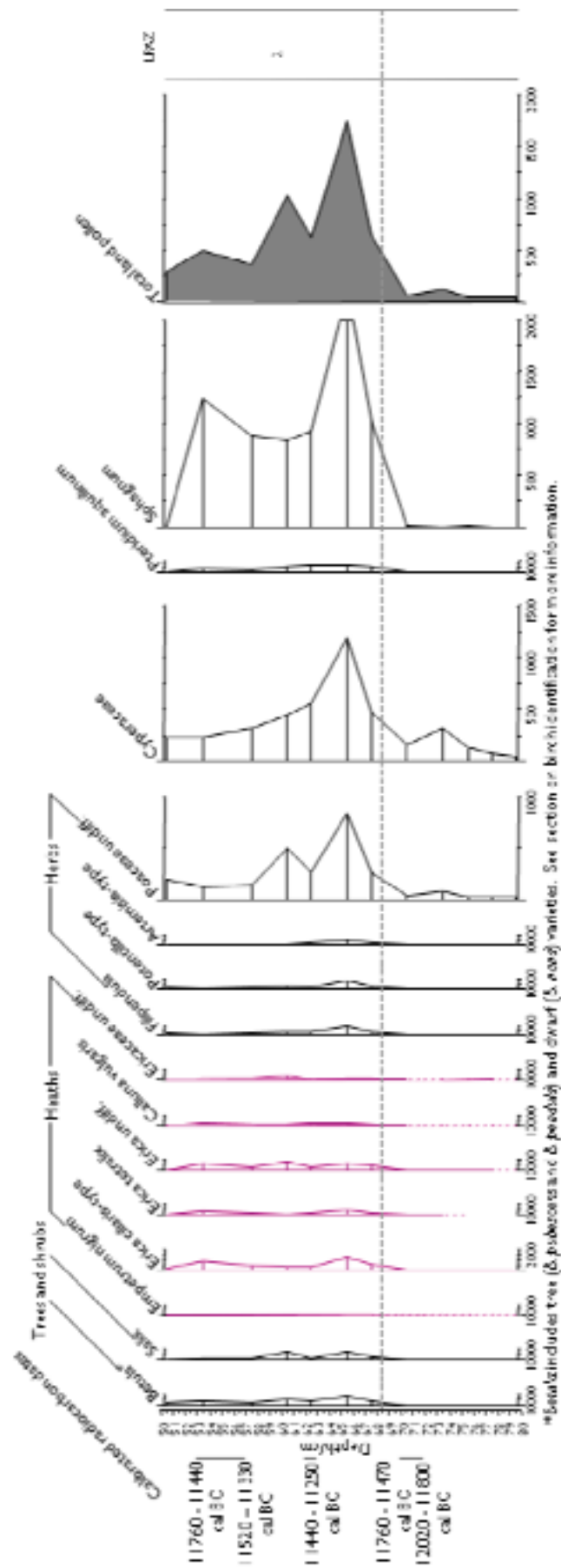


Figure 16: Lower Lancarrow pollen concentration diagram showing key taxa (the scale factor for all graphs in this diagram is 3×10^{-5} (0.00003)).

REFERENCES

- Alsos, I G, Alm, T, Normand, S and Brochmann, C 2009 'Past and future shifts and loss of diversity in dwarf willow (*Salix herbacea* L.) inferred from genetics, fossils and modelling', *Global Ecology and Biogeography* **18**, 223-239
- Amesbury, M J, Charman, D J, Fyfe, R M, Langdon, P G and West, S 2008 'Bronze Age upland settlement decline in southwest England: testing the climate change hypothesis', *Journal of Archaeological Science* **35**, 87-98
- Andersen, S T 1979 'Identification of wild grass and cereal pollen', *Danmarks Geologiske Undersøgelse, Årbog*, **1978**, 66-92
- Barber, K E 1982 'Peat-bog stratigraphy as a proxy climate record', in Harding, A F (ed) *Climatic change in Later Prehistory*. Edinburgh: Edinburgh University Press, 103-113
- Barber, K E 1988 'A critical review of the role of pollen-analytical research in the environmental archaeology of central southern England', *Circaea* **5** (2), 111-114
- Behre, K E 1981 'Anthropogenic indicators in pollen diagrams', *Pollen et spores* **23**, 224-245
- Behre, K E 1988 'The role of man in European prehistory', in Huntley, B and Webb, T (eds) *Vegetation history (handbook of vegetation science volume 7)*. Dordrecht; Boston; London: Kluwer Academic Publishers, 633-672
- Bennett, K D 1994 *Annotated catalogue of pollen and pteridophyte spore types of the British Isles*. Cambridge: Department of Plant Sciences, University of Cambridge
- Berglund, B E, Persson, T, Emanuelsson, U and Persson, S 1986 'Pollen/vegetation relationships in grazed and mowed plant communities of South Sweden', in Behre, K E (ed) *Anthropogenic indicators in pollen diagrams*. Rotterdam; Boston: A A Balkema, 37-51
- Berridge, P and Roberts, A 1986 'The Mesolithic period in Cornwall', *Cornish Archaeology* **25**, 7-34
- Birks, H J B 1968a *Field description and characterisation of sediments*, Subdepartment of Quaternary Research, Note 4 (regarding Troels-Smith 1955)
- Birks, H J B 1968b 'The identification of *Betula nana* pollen', *New Phytologist* **67**, 309-314
- Bronk Ramsey, C 1995 'Radiocarbon calibration and analysis of stratigraphy', *Radiocarbon* **36**, 425-430
- Bronk Ramsey, C 1998 'Probability and dating', *Radiocarbon* **40**, 461-474

- Bronk Ramsey, C 2001 'Development of the radiocarbon calibration program', *Radiocarbon*, **43**, 355-363
- Bronk Ramsey, C 2008 'Deposition models for chronological records', *Quaternary Science Reviews* **27**, 42-60
- Brown, T 2008 'The Bronze Age climate and environment of Britain', in *Bronze Age Review* **1**, 7-22
- Caseldine, C 2001 'Changes in *Betula* in the Holocene record from Iceland – a palaeoclimatic record or evidence for early Holocene hybridisation', *Review of Palaeobotany and Palynology* **117**, 139-152
- Charman, D, Hendon, D and Woodland, W 2000 *The identification of testate amoebae (Protozoa: Rhizopoda) in peats*. Technical Guide No. 9, Quaternary Research Association
- Clapham, A R, Tutin, T G and Warburg, E F 1962 *Flora of the British Isles*. Cambridge: Cambridge University Press
- Clegg, B J, Tinner, W, Gavin, D G and Hu, F S 2005 'Morphological differentiation of *Betula* (birch) pollen in northwest North America and its palaeoecological application', *Holocene* **15**, 229-237
- Dimbleby, G 1978 *Plants and archaeology*. London: John Baker
- Dudley, P 2011 *Goon, hal, cliff and croft: the archaeology and landscape history of west Cornwall's rough ground*. Truro: Cornwall Council
- Edwards, K J, McIntosh, C J and Robinson, D E 1986 'Optimising the detection of cereal-type pollen grains in pre-elm decline deposits', *Circaea* **4**, 11-13.
- Godwin, H 1975 *The history of the British flora*. Cambridge: Cambridge University Press
- Grimm, E C 1991-3 *Tilia version 2.0.b.4* (computer program) Springfield, Illinois: Illinois State Museum
- Heiri, O, Lotter, A F and Lemcke, G 2001 'Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results', *Journal of Paleolimnology* **25**, 101-110
- Herring, P 2011 'Prehistory (to c AD 400)', in Dudley, P (ed) *Goon, hal, cliff and croft: the archaeology and landscape history of west Cornwall's rough ground*. Truro: Cornwall Council, 13-22

Huntley, B and Birks, H J B 1983 *An atlas of past and present pollen maps for Europe: 0-13000 years ago*. Cambridge; London; New York; New Rochelle; Melbourne; Sydney: Cambridge University Press

Karlsdóttir, L, Thórsson, **Æ Th**, Hallsdóttir, M, Sigurgeirsson, A, Eysteinnsson, Th and Anamthawat-Jónsson, K 2007 'Differentiating pollen of *Betula* species from Iceland', *Grana* **46**, 78-84

Karlsdóttir, L, Hallsdóttir, M, Thórsson, **Æ Th** and Anamthawat-Jónsson, K 2008 'Characteristics of pollen from natural triploid *Betula* hybrids', *Grana* **47**, 52-59

Kueppers, L M, Southon, J, Baer, P and Harte, J 2004 'Dead wood biomass and turnover time, measured by radiocarbon, along a subalpine elevation gradient', *Oecologia*, **141**, 641-651

Limbrey, S 1975 *Soil science and archaeology*. London; New York; San Francisco: Academic Press

Mäkelä E 1996 'Size distinctions between *Betula* pollen types – a review', *Grana* **35**, 248-256

Mäkelä E M 1998 'Birch pollen measurements and the history of birch at Bruvatnet, Norwegian Lapland', *Grana* **37**, 358-366

Moore, P D, Webb, J A and Collinson, M E 1991 *Pollen analysis*. Oxford; London; Edinburgh; Boston; Melbourne; Paris; Berlin; Vienna: Blackwell Scientific Publications

Ogden, C and Hedley, R 1980 *An atlas of freshwater testate amoebae*. British Museum (Natural History), Oxford: Open University Press

Oldfield, F 1963 'Pollen-analysis and man's role in the ecological history of the south-east Lake District', *Geografisker Annaler* **45** (1), 23-40

Prentice, I C 1981 'Quantitative birch (*Betula* L.) pollen separation by analysis of size frequency data', *New Phytologist* **89**, 145-157

Reimer, P J, Baillie, M G L, Bard, E, Bayliss, A, Beck, J W, Bertrand, C J H, Blackwell, P G, Buck, C E, Burr, G S, Cutler, K B, Damon, P E, Edwards, R L, Fairbanks, R G, Friedrich, M, Guilderson, T P, Hogg, A G, Hughen, K A, Kromer, B, McCormac, G, Manning, S, Bronk Ramsey, C, Reimer, R W, Remmele, S, Southon, J R, Stuiver, M, Talamo, S, Taylor, F W, van der Plicht, J and Weyhenmeyer, C E 2004 'IntCal04 Terrestrial radiocarbon age calibration, 0-26 cal kyr BP', *Radiocarbon* **46**, 1029-1058

- Robinson, D E, Straker, V, Hamilton, D and Hazell, Z 2007 'The HEATH project – unravelling the heathland history of West Cornwall', *Research News* (English Heritage Newsletter) **6**, 12-15
- Robinson, D E, Forster, E, and Hazell, Z 2011 'Recent studies of vegetation history in west Cornwall', in Dudley, P (ed) *Goon, hal, cliff and croft: the archaeology and landscape history of west Cornwall's rough ground*. Truro: Cornwall Council, 72-4
- Scourse, J D, 1999 'St Loy', in Scourse, J D and Furze, M F A (eds) *The Quaternary of west Cornwall. Field Guide*, London: Quaternary Research Association, 108-12
- Stace, C 1997 *New flora of the British Isles*. Cambridge; New York; Oakleigh; Madrid; Cape Town: Cambridge University Press
- Stockmarr, J 1971 'Tablets with spores used in absolute pollen analysis', *Pollen et spores*, **13**, 615-621
- Straker, V 2011 'Palaeo-environmental literature review', in Dudley, P (ed) *Goon, hal, cliff and croft: the archaeology and landscape history of west Cornwall's rough ground*. Truro: Cornwall Council, 75-83
- Stuiver, M and Kra, R S 1986 'Editorial comment', *Radiocarbon* **28**, ii
- Stuiver, M and Reimer, P J 1986 'A computer program for radiocarbon age calculation', *Radiocarbon*, **28**, 1022-30
- Tinsley, H 1999 *Pollen assessment of samples from buried peat at Porthallow, Cornwall* (unpublished report for Cornwall Archaeological Unit)
- Troels-Smith, J 1955 *Karakterisering af løse jordarter (Characterization of unconsolidated sediments)*. Copenhagen: A Reitzels Forlag
- Turner, J 1964 'The anthropogenic factor in vegetational history. I. Tregaron and Whixall Mosses', *New Phytologist* **63** (1), 73-90
- Tweddle, J C, Edwards, K J and Fieller, N R J 2005 'Multivariate statistical and other approaches for the separation of cereal from wild grass pollen using a large Holocene dataset', *Vegetation History and Archaeobotany* **14**, 15-30
- US soil conservation service 2000 *Munsell soil colour chart*
- van Geel, B, Buurman, J and Waterbolk, H T 1996 'Archaeological and palaeoecological indications of an abrupt climate change in The Netherlands, and evidence for climatological teleconnections around 2650 BP', *Journal of Quaternary Science* **11** (6), 451-460

(various authors) 1986 *Cornish Archaeology* **25** (Anniversary edition), available online at:- www.cornisharchaeology.org.uk (accessed 21/03/2011)

Vorren, K D 1986 'The impact of early agriculture on the vegetation of northern Norway: a discussion of anthropogenic indicators in biostratigraphical data', in Behre, K E (ed) *Anthropogenic indicators in pollen diagrams*. Rotterdam; Boston: A A Balkema, 1-18

WEBSITES:

The Heath Project website. Available at:- www.theheathproject.org.uk (accessed 20/03/2011)



ENGLISH HERITAGE RESEARCH DEPARTMENT

English Heritage undertakes and commissions research into the historic environment, and the issues that affect its condition and survival, in order to provide the understanding necessary for informed policy and decision making, for sustainable management, and to promote the widest access, appreciation and enjoyment of our heritage.

The Research Department provides English Heritage with this capacity in the fields of buildings history, archaeology, and landscape history. It brings together seven teams with complementary investigative and analytical skills to provide integrated research expertise across the range of the historic environment. These are:

- * Aerial Survey and Investigation
- * Archaeological Projects (excavation)
- * Archaeological Science
- * Archaeological Survey and Investigation (landscape analysis)
- * Architectural Investigation
- * Imaging, Graphics and Survey (including measured and metric survey, and photography)
- * Survey of London

The Research Department undertakes a wide range of investigative and analytical projects, and provides quality assurance and management support for externally-commissioned research. We aim for innovative work of the highest quality which will set agendas and standards for the historic environment sector. In support of this, and to build capacity and promote best practice in the sector, we also publish guidance and provide advice and training. We support outreach and education activities and build these in to our projects and programmes wherever possible.

We make the results of our work available through the Research Department Report Series, and through journal publications and monographs. Our publication Research News, which appears three times a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities. A full list of Research Department Reports, with abstracts and information on how to obtain copies, may be found on www.english-heritage.org.uk/researchreports

For further information visit www.english-heritage.org.uk

