Mid- to late-Holocene vegetation history of Greater Exmoor, UK: estimating the spatial extent of human-induced vegetation change

FYFE, R.M.*, BROWN, A.G. AND RIPPON, S.J.

School of Geography, Archaeology and Earth Resources, University of Exeter Amory Building, Rennes Drive, Exeter, EX1 2BU, UK

corresponding author: R.M. Fyfe

e-mail   r.m.fyfe@exeter.ac.uk
phone: 0044 (0)1392 264395
fax: 0044 (0)1392 263342

Abstract

This paper presents the results from three pollen profiles from a group of small spring mire sites on the southern edge of Exmoor in south west England. The size and topography of these sites allow detailed local landscape histories around each site to be reconstructed which broadly cover the mid- to late-Holocene. Comparison of the individual local landscape histories demonstrates the scale of spatial variation in vegetation around the upland edge, and facilitates understanding of human-landscape interactions from the early Neolithic onward. In the early Neolithic significant short-term woodland disturbance is recorded around the upland fringe, including clearance of oak-hazel-elm woodland, suggesting that the shift from Mesolithic to Neolithic is not marked by a gradual environmental transition. Following this, there is clear evidence of Neolithic management of upland heath using fire, presumably for the management of upland grazing. Woodland clearances are recorded throughout the later Prehistoric period; however, the use of multiple profiling suggests that woodland clearance is spatially discrete, even within an area of 4 km^2. Pastoral land use is dominant around the uplands until around A.D. 900-1000 and there is no discernible Roman or post-Roman period impact in the vegetation, suggesting cultural stability from the late Iron Age to the early Medieval period. By A.D. 1100 there is a shift to a mixed arable-pastoral farming which appears to continue well into the post-medieval period.

Introduction

One of the more problematic issues in studying human-environment relations around upland areas is the use of palynological sites which record vegetation

history at an appropriate spatial scale, and which are located within suitable areas of the landscape (Edwards 1999). Following the pioneering work of Pennington (1970) and Turner (1970) pollen analytical studies in upland areas have tended to concentrate on data from either blanket mire sequences (see reviews in Tipping 1994; Simmons and Innes 1987; Caseldine 1999) or lakes (Pennington 1965; Pennington et al. 1972). Although these study sites have provided detailed information about the nature and timing of human impact it is difficult to make inferences about the spatial extent of human impact on the landscape (Edwards 1979; Brown 1999). This is due to the scale of their pollen source areas, which is likely to be regional in nature (Jacobsen and Bradshaw 1981; Prentice 1985). Most work has also concentrated on the prehistoric period, although such sites are located in areas likely to be have been marginal in terms of prehistoric domestic settlement. As a result, our understanding of landscape change and human impact on vegetation tends to be at a regional level, and there are few data to demonstrate the importance of local changes within landscapes, and crucially, the spatial dimensions of human-induced vegetation change. Dumayne-Peaty and Barber (1998) have demonstrated the importance of using multiple pollen profiles from single sites to demonstrate vegetation differences on a small spatial scale. However this work was undertaken on raised mire sites which reflect regional vegetation history, although multiple site profiling has proved useful in understanding woodland disturbance at a small spatial scale (e.g. Smith and Cloutman 1988; Simmons and Innes 1996). An attempt to use small pollen sites in conjunction with surrounding archaeological data for an upland fringe has been published by Skinner and Brown (1999).

This paper uses multiple pollen profiles to highlight the importance of local landscape histories in developing detailed vegetation reconstructions. Palaeoecological analyses on three small spring mire sites have been used to identify local differences in vegetation history. The sites used in this study are small soligenous mires, between 20 and 40 m wide, but up to several hundred metres long. Owing to their restricted width, the pollen source distance for the sites should be small. The question of the size of the pollen source area has been discussed by Jacobsen and Bradshaw (1981), and more recent attempts have been made to quantify aspects of pollen source area (Prentice 1985; Sugita 1993, 1994,

1998). For sites within the size range used in this study, the local and extra-local relevant source area should be in the order of hundreds of metres (Jacobsen and Bradshaw 1981). The sites are located beyond the present-day margins of the enclosed landscape on the southern upland fringes of Greater Exmoor (around 300 to 340 m OD). As a result they have the potential to record landscape continuity and/or change in the area of the landscape sensitive to fluctuations in land use pressure or settlement over the last 5000 years. This period is particularly significant as palaeoecological studies in south west Britain have traditionally focussed on the upland area of Dartmoor (e.g. Simmons 1964; Smith et al. 1981; Simmons et al. 1983; Caseldine and Hatton 1993), and there are few securely dated sequences spanning the latter half of the Holocene (Caseldine 1999).

The three sites, Long Breach (SS81863097, 341 m OD), Gourte Mires (SS82472969, 291 m OD) and Ansteys Combe (SS82722968, 282 m OD), are located on Molland Common, which lies on the south side of the Exmoor plateau (Fig. 1). The sites all lie beyond the present enclosed field systems in the head of the drainage of Danes Brook (Long Breach) and the headwaters of the Yeo (Gourte Mires and Ansteys Combe) (Fig. 2a). They are however within an area of earthworks of a relict landscape which suggests that the upper limit of agriculture was once much higher than today. Long Breach is a gently sloping valley mire on the higher and flatter central portion of Molland Common. Gourte Mires is a spring-fed mire, draining the edge of the flatter upland above a steep-sided valley. Ansteys Combe is a spring-fed mire situated within the base of a steep-sided valley (Fig. 2b). The underlying geology is the steeply bedded sandstones, siltstones and slates of the Upper Devonian Pickwell Down Formation. The present vegetation across Molland Common is dominated by dwarf shrubs, mainly *Calluna vulgaris* and *Ulex europaeus* across the higher, flatter part of the upland. Acid grassland, dominated by *Molinia caerulea*, is present in small patches and slopes are frequently dominated by *Pteridium*. The steep-sided valleys draining to the south of Molland Common include open woodland dominated by *Quercus* and *Corylus* within the limits of the enclosed landscape, the enclosed land being dominated by improved pasture. The wind-rose from Liscombe, located 6 km to the east of Molland Common, shows the dominant westerly and south westerly

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winds (Fig. 2c). This would suggest that Gourte Mires and Ansteys Combe would receive pollen blown up-valley to a greater extent than Long Breach.

Materials and Methods

Site stratigraphy was investigated using a 5 cm wide gouge corer, and sites were sampled using a 5 cm wide Russian-type corer (Jowsey 1966). The choice of sample core was made based upon the deepest peat sequence at each site. Sub-sampling for pollen analysis was undertaken in the laboratory using 0.5 cm peat slices, taken at 4 cm intervals from each core; pollen preparation followed standard procedures (Faegri et al. 1989). Pollen and spores were identified using the keys in Moore et al. (1991), Andrew (1984) and the University of Exeter reference collection. A minimum sum of 500 land pollen grains was counted. Results are shown as percentage total land pollen for land pollen types, and percentage total land pollen and spores for spores. Pollen nomenclature follows Bennett (1994); differentiation of Poaceae and cereal types follows Andersen (1978). Charcoal was also counted within two size classes: 10-50 µm and >50 µm, and is expressed as concentration data. Slices of sediment 5 cm thick were used for dating; samples were submitted to the Radiocarbon facility at Waikato, New Zealand. It had been the intention to use conventional dating on these samples; however, insufficient carbon necessitated their analysis using AMS radiocarbon dating. Five dates were submitted from Long Breach, four dates from Gourte Mires and six from Ansteys Combe. Dates are expressed as uncalibrated B.P., calibrated age ranges expressed as years B.C./A.D (to 2 sigma) are also provided in the discussion. Calibration was performed with the Calib 4.0 program (Stuiver and Reimer 1993).

Results

Radiocarbon results and time-depth chronology

Radiocarbon results from the sites are given in Table 1. Fig. 3 shows the time-depth curves for the sites Long Breach and Gourte Mires. There appears to be no

contamination in the dating of these sites. Time-depth curves for these sites are constructed by linear interpolation between radiocarbon dates, providing an age range for each pollen sample.

The results from the six radiocarbon samples from Ansteys Combe reveal a problem in the construction of a time-depth series by linear interpolation for the site. The dates show two reversals, and the middle two dates produce similar results (Fig. 3). The lower two dates show a reversal (1920±60 B.P. at 145-150 cm; 3830±60 B.P. at 134-139 cm). The older of the two dates can be questioned through examination of the loss-on-ignition data for this section of the core (Fig. 3). The date 3830±60 B.P., at 134-139 cm is associated with a fall in loss-on-ignition values, suggesting that this sample could contain old carbon from inwashed soils. The date of 1920±60 B.P. is associated with higher loss-on-ignition values, and as such is more likely to represent the true age of the sediment. The upper two dates also show a reversal (420±60 B.P. at 35-40 cm; 1120±60 B.P. at 25-30 cm). The date at 25-30 cm can be rejected and the date at 35-40 cm accepted by plotting the curve for the early 18th century A.D. *Pinus sylvestris* rise, which suggests the sample at 25-30 cm to be around 800 years too old. The middle two dates from Ansteys Combe are similar. Correlation of the pollen sequence from Ansteys Combe and Gourte Mires suggests the date of 1160±70 B.P. at 80-85 cm is likely to represent an accurate estimate of the age of the sample. As a consequence, the date of 1110±70 B.P. at 60-65 cm depth is unlikely to represent an accurate estimate of the age of the sample, and probably reflects contamination through inwash of older soil material.

Long Breach

Site stratigraphy

The site is around 30 m wide, and extends for 400 m on a slope of approximately 0.05m m⁻¹. The stratigraphy is predominantly comprised of monocotyledonous peat, within which there are variations in the moss content (Fig. 4). Towards the upper end of the site the monocotyledonous peat overlies a stiff silty sand which includes abundant weathered bedrock clasts.

Pollen zonation

Forty-seven pollen levels were counted at 4 cm intervals over a total depth of 184 cm from core no. 6 at Long Breach (Fig. 5). Five local pollen assemblage zones were determined, which are described below (the code LBMC is used to distinguish the site from that of Lobbs Bog, Rackenford: Fyfe et al. in prep).

LBMC-1 (184-150 cm), ca. 5400-4650 B.P., *Quercus-Corylus-Succisa*

This zone is dominated by tree and shrub pollen. *Quercus* and *Corylus avellana* are the dominant species. Other tree taxa present include *Ulmus* and *Pinus* (both around 3%). *Alnus* is recorded at low levels, declining to trace amounts. Heath vegetation is poorly represented at the base of the diagram, but *Calluna* gradually increases towards the top of the zone (to 20%). Of the herbaceous taxa, *Succisa* is the dominant species. Poaceae are recorded at levels of around 7%, and grassland herbs such as *Centaurea nigra*, *Potentilla*-type and *Ranunculus acris*-type are recorded throughout the zone, as are *Polypodium* and Pteropsida at high levels.

LBMC-2 (150-130 cm), ca. 4650-4240 B.P., Poaceae-*Quercus-Corylus*

This zone is characterised by an increase in Poaceae (up to 35%). *Succisa*, Cyperaceae and heath pollen decline at the start. Arboreal pollen continues to be dominated by *Quercus* and *Corylus*, and other than a recovery from a dip at the top of zone LBMC-1, these taxa remain constant. *Ulmus* and *Pinus* decline at the start to trace levels, and *Alnus* increases. The start of the zone is also characterised by the commencement of a constant significant charcoal curve.

LBMC-3 (130-58 cm), ca. 4240-2400 B.P., Poaceae-*Corylus-Quercus*

A gradual decline in both *Quercus* and *Corylus* characterises this zone. Poaceae increase to 45%, and grassland herbs, including *Centaurea nigra*, Lactuceae, *Plantago lanceolata*, *Potentilla*-type and *Ranunculus acris*-type become common

at low levels (2 to 5%). *Pteridium* increases, and charcoal continues to be recorded in significant amounts.

LBMC-4 (58-26 cm), ca. 2400-600 B.P., Poaceae-Cyperaceae

The bottom of this zone is characterised by the lowest levels of arboreal pollen recorded at the site. *Quercus* and *Corylus* both display a trough, prior to recovering to low levels. Herbaceous pollen is dominant, and Poaceae is the main pollen type recorded. Grassland herbs, including *Centaurea nigra*, Lactuceae, *Plantago lanceolata*, *Potentilla*-type and *Ranunculus acris*-type, are recorded in low, yet significant, levels throughout the zone. *Avena/Triticum* type cereal pollen is recorded consistently through the zone, a small peak in *Anthemis*-type occurring at the start of the *Avena/Triticum*-type curve. Heath pollen is recorded at significant levels (*Calluna* at 10%).

LBMC-5 (26-0 cm), ca. 600-0 B.P., Poaceae-*Calluna*

The start of the zone is characterised by declines in *Quercus* and *Corylus* to low levels (both below 5%). Towards the top of the diagram *Pinus* rises, reflecting the development of pine plantations in the area. Heath vegetation increases, and there are declines in grassland herbs, including *Centaurea nigra* and Lactuceae. Charcoal concentrations drop to very low levels.

Gourte Mires

Site stratigraphy

Four stratigraphic cross sections were examined across Gourte Mires. The width of the mire varies from around 80 m at the top of the site to around 30 m at the lowest transect. The site is around 150 m long, draining to the south into the headwaters of the Yeo valley. The stratigraphy is predominantly comprised of monocotyledonous peat (Fig. 4). Towards the upper end of the site the monocotyledonous peat overlies a stiff silty sand, which includes abundant weathered bedrock clasts.

Pollen zonation

Forty-eight pollen levels were counted at 4 cm intervals from core no. 10 over a total depth of 200 cm (Fig. 6). Pollen was not processed from the top 10 cm of the core as the material was desiccated. Four local pollen assemblage zones were determined.

GM1-1 (200-150 cm), ca. 4100-3100 B.P., Poaceae-*Quercus-Corylus*

This zone is characterised by equal amounts of tree, shrub and herbaceous pollen. *Quercus*, *Corylus* and *Alnus* are the dominant tree and shrub taxa recorded. Heath pollen is present at low but significant levels. The herbaceous taxa are characterised by Poaceae, and only Lactuceae, *Plantago lanceolata*, *Potentilla*-type and *Succisa* are represented at above trace levels. Pteropsida spores are recorded at consistent levels. Charcoal declines slightly towards the top of the zone.

GM1-2 (150-70 cm), ca. 3100-1950 B.P., Poaceae-*Corylus-Quercus*

The start is characterised by a step-decline in arboreal pollen taxa, notably *Quercus*, *Corylus* and *Alnus*, and by a rise in heath pollen. Pteropsida also decline to trace levels. Representation of herbaceous taxa, e.g. *Plantago lanceolata* and *Potentilla*-type increases. The zone is subdivided into three sub-zones, based on variation in both the *Pteridium* and Cyperaceae curves, which show increased values at around 138-126 cm depth.

GM1-3 (70-30 cm), ca. 1950 - 1000 B.P., Poaceae-*Calluna*

The beginning of this zone is characterised by a second decline in arboreal taxa, and an increase in heath taxa. *Quercus* levels are low, whilst those of *Corylus* level out following a decline at the end of the preceding zone. *Calluna* shows a dramatic peak at the start, its levels then fluctuating throughout the zone. Poaceae values also fluctuate, but it continues to be the dominant pollen recorded.

Grassland herbaceous taxa are well represented, including Lactuceae, *Centaurea nigra*, *Plantago lanceolata* and *Potentilla*-type.

GM1-4 (30-10 cm), ca. 1000-200(?) B.P., Poaceae-*Calluna*-Cyperaceeae

The start is marked by a decline in grassland herbaceous species (including *Centaurea nigra* and *Succisa*), and the appearance of cereal types (*Hordeum*-type, *Avena/Triticum*-type, *Secale cereale*) and weeds of arable cultivation (*Anthemis*-type). The zone is characterised by low woodland representation, and elevated levels of Cyperaceae. Charcoal concentrations fall to low levels.

Ansteys Combe

Site stratigraphy

Ansteys Combe is a small, narrow valley head draining south into the Yeo valley. A single coring transect runs down the site. The site is approximately 10 m in size at its widest point, and extends for 150 m, with a slope of around 0.11m m^{-1}. The site is comprised of well-humified monocotyledonous peat, with frequent inwash bands made up of sand and small grit lenses.

Pollen zonation

Forty pollen levels were counted at 4 cm intervals from core no. 6 over a total depth of 160 cm (Fig. 7). Five local pollen assemblage zones were determined.

AC1-1 (160-138 cm), ca. 2100-1800 B.P., *Calluna-Quercus*-Poaceae

This zone is characterised by indicators of open heath; *Calluna* is the dominant pollen throughout the zone. Grassland is also locally present, Poaceae being the dominant herbaceous type, and grassland herbs, including *Centaurea nigra* and Lactuceae, are recorded at significant levels. Woodland, dominated by *Quercus* and *Corylus*, is well represented, accounting for between 25 and 40% of the total.

Several woodland shrubs and herbs are present, including *Hedera helix* and *Mercurialis perennis*. Pteropsida (monolete) undiff. spores are also abundant.

AC1 -2 (138-82 cm), ca. 1800-1150 B.P., *Quercus-Calluna*-Poaceae

The start of this zone is marked by a decline in heath pollen, and increased representation of woodland, notably *Quercus* and *Alnus*. Representation of *Hedera* increases towards the middle of the zone. Grassland continues to be well represented, and values for Poaceae do not change throughout the zone. There are increases in local herbaceous taxa, including *Scrophularia*, *Gentianella campestris*-type and *Succisa*: these probably represent on-site vegetation.

AC1-3 (82-62 cm), ca. 1150-800 B.P., Poaceae-*Calluna*

The beginning is characterised by a decline in woodland taxa, and an increase in open-ground taxa. *Quercus* declines to levels of around 10%; associated woodland shrubs and ferns, including *Hedera helix,* Pteropsida (monolete) undiff. and *Polypodium*, are reduced. Grassland taxa increase, with peaks in Poaceae, and to a lesser extent in *Potentilla*-type and *Plantago lanceolata*. Cereals are recorded at significant levels, notably *Secale cereale* and *Hordeum*-type (*sensu* Anderson 1978) which increase from the sporadic records in the preceding zone. Associated weeds of cultivation, such as *Anthemis*-type, are recorded.

AC1-4 (62-30 cm), ca. 800-200 B.P., *Calluna*

Heath pollen at levels over 70% characterises this zone. Cereal types continue to be recorded at significant levels, along with associated weeds of cultivation (e.g. *Anthemis*-type). Grassland pollen is reduced; woodland is also recorded in the lowest levels of the sequence.

AC1-5 (30-0 cm), ca. 200-0 B.P., *Calluna*-Poaceae

The start of the zone is characterised by a decline in heath pollen, although *Calluna* remains the dominant taxon. Increases occur in both grassland (including

Poaceae, *Ranunculus acris*-type and Lactuceae), and woodland taxa (including *Quercus* and *Corylus*). There is an increase in *Pinus* at the start of the zone.

Statistical analyses

The data sets from Gourte Mires and Long Breach were subjected to a PCA, executed in CANOCO (ter Braak 1987). The pollen data were run separately to investigate within-site variability between samples, and as a combined dataset to investigate between-site variability. Combined datasets must be used to compare between-site variability as this method ensures both datasets are plotted on the same axis, and are responding to the same environmental variables. The data from Ansteys Combe were not included: visual inspection of the data shows significant difference from the other pollen sites, in particular the presence of significant amounts of *Quercus* until around 1000 B.P. and the subsequent dominance of *Calluna* in the record. Dominance of individual taxa in an analysis has been shown to lead to meaningless results in statistical analysis (ter Braak 1987). Results presented here are therefore from the analysis of combined data from Long Breach and Gourte Mires.

The combined PCA was executed using a filtered dataset. The species included were those present at significant levels at both sites (Table 2). The first axis eigenvalue of 0.515 shows the majority of the variance in the dataset can be explained by a single environmental gradient. The ranking of the species along the first axis shows that open grassland species fall to the left of the axis (e.g. Poaceae, *Plantago lanceolata* and Lactuceae) whereas woodland species, including *Quercus*, *Ulmus* and *Corylus*, plot to the right of the axis with strong positive scores (Table 2). Pteropsida and *Polypodium* have strong positive scores, suggesting a strong association with woodland. It may be surprising that *Fagus* is associated with Poaceae and other open landscape taxa. Within the modern Exmoor landscape *Fagus* is one of the major hedging species, and is abundant on boundaries, which may explain its presence with open landscape species.

The most likely explanation of the first axis species scores is disturbance, probably by management of the upland landscape. *Succisa* represents undisturbed

heath vegetation, and as such also has a high positive score. This is reflected in an indication of 'openness' of the landscape in the analysis, with woodland taxa. A plot of the first axis scores of both sites plotted against the age estimate of the samples reflected the level of 'openness' or disturbance in the data (Fig. 8). The sample values for Long Breach fall steeply at around 4700 B.P. This reflects the significance of the elm decline recorded at this time in the pollen diagram (at the start of zone LBMC-2). A second stepped decline at around 4200 B.P. reflects the further expansion of grasses at Long Breach. In the Gourte Mires data a steady decline in first axis scores from ca. 3500 B.P. reflects the decrease in woodland between ca. 3500 and 3000 B.P. in the fossil data (zone GM1-2). Nevertheless first axis scores for the fossil data are higher at Gourte Mires, presumably because the dataset is reflecting woodland in the combe below. The analysis fails to pick out the reduction in woodland cover at the start of pollen zone GM1-3. This may be a result of a decline in Poaceae at the same time, while the main change in *Calluna*, which has a medium score in the PCA analysis, results in little change in the sample scores at this level.

Interpretation and discussion

Vegetation character during the later Mesolithic on southern Exmoor

The oldest deposits in the study are from Long Breach, where peat accumulation started during the later Mesolithic, around 5400 B.P. (4750-4350 B.C.). At this time the landscape was predominantly wooded (pollen zone LBMC-1), with oak and hazel the dominant trees and elm present at low levels, probably at the edge of its distribution. The open part of the landscape around Long Breach was dominated by open damp heath, including heather and sedges. Archaeological evidence of any Mesolithic presence in the surrounding landscape is absent, and the pollen evidence does not suggest any human impact on the vegetation in the local or extra-local area.

At Exebridge, to the south of Exmoor, Fyfe et al. (in press) recorded later Mesolithic woodland disturbance by fire starting at 7710±60 B.P. (6650-6440

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B.C.). In a re-examination of the development of peat and heath vegetation on Dartmoor, Caseldine (1999) argues that later Mesolithic communities used fire to manipulate the vegetation of the uplands, maintaining openness at the ecotone between upland woodland and the open summit areas. At Black Ridge Brook, Bellever and Pinswell, charcoal records suggest this was most prevalent between ca. 7700 and 6100 B.P. (5750-4150 B.C.). However, at Long Breach there is no evidence that fire played a role in the management or creation of open heathland at the ecotone edge on Exmoor during the end of the later Mesolithic period.

The character of the upland vegetation during the Neolithic

At Long Breach there is an abrupt change (occurring over at most 85-100 years) in the character of the vegetation around Molland Common shortly before 4700±60 B.P. (3640-3360 B.C.). This is marked by several palynological features, starting with a short-lived decline in the dominant oak-hazel woodland, along with a permanent decline in elm at the end of the clearance event. This is taken to mark the change from the Mesolithic to the Neolithic. The clearance episode may have lasted between 50 and 200 years; woodland regeneration occurs at 4700±60 B.P. (3640-3360 B.C.). During the phase of reduced woodland, representation of heathland within the pollen record increases. It is possible that the increase in heathland represents a change in pollen recruitment to the site: woodland clearance may have opened the site environs resulting in an increase in pollen from the uplands. The evidence from The Chains suggests that the central uplands of Exmoor were dominated by wet heath communities before 4170±75 B.P. (2910-2500 B.C., Moore et al. 1984). Alternatively, the damp heath communities around Long Breach may have expanded onto formerly wooded areas in the local surroundings. At the end of the clearance episode, the oak-hazel woodland returns to former levels, suggesting only a temporary clearance (or clearances) around the site at the start of the Neolithic. Elm does not recover to former levels when oak-hazel regenerates, and does not appear at significant levels in the vegetation history of the area at any later date.

The timing of the elm decline fits the broad pattern seen for southern Britain (Beckett and Hibbert 1979; Scaife 1988; Peglar 1993). However the nature of the

decline, in association with a decline in oak-hazel woodland, is unusual for British sequences. Relative percentage values of non-elm deciduous woodland species usually remain steady throughout the elm decline, although there is evidence of small pre-elm decline clearances, for example at Hockham Mere, Norfolk (Sims1978) and Gatcombe Withy Bed, Isle of Wight (Scaife 1988). The strong element of woodland clearance around Long Breach broadly supports models of human impact, possibly combined with pathogenic attack (Peglar and Birks 1993; Peglar 1993; Parker et al. 2002). It has been argued that small openings in the canopy would have assisted the vectors of pathogenic attack. The scale of clearance around Long Breach would support this possibility although the elm decline is more gradual than the decline in oak and hazel, and the final elm decline occurs after oak and hazel return to higher values in the pollen sequence. Regeneration of elm might have been prevented by continued human activity, particularly woodland grazing, through exploitation of the gaps left by dead elms (Edwards and MacDonald 1991), grazing preventing re-growth of shoots, or continued low levels of disease. The surviving elm may have left a trace lasting several hundred years in the pollen record.

Post-dating the re-expansion of oak-hazel woodland around Long Breach, there is a phase of further vegetation change and disturbance. The character of the upland heath vegetation around Molland Common changes at 4700±60 B.P. (3640-3360 B.C.). The shift is characterised by a change from heather-dominated heath to grass-dominated heath, and is closely associated with the start of significant levels of burning in the palaeoecological record (zone LBMC-2). A direct link between the levels of microscopic charcoal and the shift to grass-dominated moorland vegetation cannot be established although the timing strongly suggests that there is a causal link between the increased burning and a shift away from heather-dominated vegetation. There is a strong association of *Calluna* and fire in the palaeoecological record (e.g. Odgaard 1992; Simmons 1996). However this tends to relate to spread of blanket mire vegetation, in particular the removal of trees and the creation of open land. Modern studies of burning on heather moorland show that heavy burning may lead to a shift to grass-dominated vegetation: Rodwell (1992) states that the National Vegetation Community type U3 (*Agrostis curtisii* grass heath), shows a strong relationship with burning regimes. Todd

(1996) suggests that *Molinia caerulea* will out-compete *Calluna* in stands that are heavily burned, with heavy grazing regimes also playing a role in control of heather, and there is evidence to suggest that uncontrolled or erratic fire may hamper regeneration of *Calluna*. Palaeoecological studies have demonstrated a possible strong causal link between charcoal and *Molinia* from macrofossil work (e.g. Chambers et al. 1999), and the deciduous nature of *Molinia* may lead to positive feedback in the frequency of fire on grass-heath. The upland vegetation of Dartmoor shows a strong relationship between charcoal (taken to be a proxy for fire frequency) and grass-heath (Caseldine and Hatton 1993).

It has been argued that fire history on Dartmoor, albeit in the later Mesolithic rather than the Neolithic, is related to hunting strategies to make animal movement and location more predictable in the landscape (Caseldine and Hatton 1993; Caseldine 1999). This is supported by earlier work by Mellars (1976), who argues that fire played a role in improving hunting strategies by maintenance and improvement of suitable grazing habitats, making the location of grazing herds more predictable. As well as fire, trampling and grazing by red deer (and sheep) have been shown to be important in shifting *Calluna* heath to grass-heath (most commonly dominated by *Agrostis capillaris* and *A. canina*) (Hester and Baillie 1998; Palmer and Hester 2000). Increased faecal material may also promote a shift towards more species-rich, grass-heath dominated vegetation. It is likely, therefore, that if the increase in charcoal reflects deliberate burning over parts of Molland Common during the Neolithic, it was undertaken to manage and maintain the upland for grazing. The presence of stone rows and circles across Exmoor (Riley and Wilson-North 2001) suggest that the upland may also have been part of a ritual or ceremonial landscape during the Neolithic period.

Spatial aspects of woodland clearance during the early Bronze Age

There is little evidence from Long Breach for significant vegetation changes around Molland Common between the later Neolithic and the middle Iron Age, with the exception of very gradual reduction in woodland cover during this period (pollen zones LBMC-3). However, the evidence from Gourte Mires strongly

suggests reduced woodland cover at 3560±60 B.P. (2120-1730 B.C.), during the start of the Bronze Age. Representation of oak-hazel-alder woodland falls, whilst there is an increase in the representation of heather-dominated heath, together with a period of reduced microscopic charcoal. A stepped increase in heather is also recorded at Long Breach (dated by interpolation at around 3500 B.P. i.e. ca. 2000 B.C.).

The discrepancy between the data from Long Breach and Gourte Mires suggests that the focus of valley woodland clearance at the start of the Bronze Age was towards the surrounding lower areas to the south of Molland Common. Long Breach does not reflect woodland changes; it is likely that the site reflects woodland from around the easterly draining Dane's Brook catchment, rather than the slopes and valley draining to the south into the Yeo valley. The difference between the sites allows some estimation of the patch size and scale of vegetation disturbance between these sites. Assuming the relevant source area (*sensu* Sugita 1994) of the sites to be similar, this must be at least half the distance between the sites, as they record different vegetation patterns. Thus the scale of disturbance, and relevant source area for Gourte Mires must be less than 500 m (half the distance between the two sites).

A number of undated field monuments that are ascribed to the later Neolithic and early Bronze Age are recorded from Molland Common. These include a stone setting comprising two upright and one recumbent stone, and ten round barrows which extend from East Ansteys Common to the east across the higher part of the study area (Riley and Wilson-North 2001). These monuments must have been sited within open landscapes on the flat interfluves, which supports the model of an open heath with wooded valleys. There is little archaeological evidence to suggest why woodland clearance occurs as recorded at Gourte Mires and not Long Breach; there are no archaeological field data to suggest the establishment of field systems on this part of the moor at this time. The palynological data may suggest that different areas of this part of the moor were utilised in different ways, hence the patchy woodland clearance. By contrast there is considerable evidence to show that comparable upland areas on Dartmoor were part of an agricultural landscape in the second millennium B.C. (Fleming 1979, 1988, 1994). The relict

field systems (reaves) on Dartmoor are most likely to have been established between 3250-3050 B.P. (1550-1350 B.C., Fleming 1994), although these may have represented a short period of landscape exploitation. The evidence for species-rich grassland around Gourte Mires and Long Breach is strong at the start of the Bronze Age, and it is possible that field-systems were established in the lower parts of the landscape, possibly extending onto the higher moorland, although there is no trace in the archaeological record of this. The results from earlier work on Exmoor also suggest Bronze Age landscape clearance. On The Chains woodland is reduced at 3505±120 B.P. (2190-1520 B.C., Moore et al. 1984), while at Hoar Moor woodland declines and grassland expands at ca. 3500 B.P. (2000-1500 B.C., Francis and Slater 1990). As these sequences are from blanket mire their pollen source area is more likely to be regional, suggesting a general phase of landscape clearance in the uplands during the early Bronze Age. Evidence from the lowlands to the south of Exmoor also shows an open landscape by the middle Bronze Age (Fyfe et al. in press). The timing of clearance in the blanket mire sequences, and the Gourte Mire sequence, is also broadly coincident with a phase of increased alluviation in the Barle valley to the north of Molland Common. This suggests increased sediment delivery to the river caused by accelerated woodland clearance (Fyfe et al. in press). Woodland appears to regenerate around Gourte Mires by ca. 3000 B.P. (1350-1100 B.C., dated by interpolation), that is towards the end of the Middle Bronze Age, and there is little significant change in the vegetation of the upland area until the mid- to late-Iron Age.

Woodland clearance during the later Iron Age

Both Long Breach and Gourte Mires show reduced woodland cover towards the end of the late Prehistoric period. At Long Breach there is a distinct drop in the levels of woodland shortly after 2380±60 B.P. (770-370 B.C.), which is characterised by a decline in oak, hazel and alder. At Gourte Mires woodland is similarly reduced from 2230±70 B.P. (410-90 B.C.). The decline in oak is rapid, while hazel and alder decline slowly. This suggests either selective removal of oak from mixed woodland with hazel and alder preferentially retained, or clearance of stands of oak. There is no overlap at one standard deviation between

the dates from Long Breach and Gourte Mires for this clearance. However, after calibration there is some slight overlap between the age ranges. At Long Breach the date precedes the woodland decline while at Gourte Mires the position of the date is during the woodland decline. This strongly suggests that the event occurred at both sites at around the same time. Later Iron Age woodland clearance on Exmoor is also recorded at Moles Chamber and is characterised by a reduction in oak-hazel woodland at around 400 m OD (Fyfe et al. submitted). The evidence from Exmoor for woodland clearance during this period supports a wider regional pattern of later Iron Age woodland clearance. This clearance was common across northern and western Britain, being recorded at South Cumbria (Wimble et al. 2000), Lancashire (Mackey and Tallis 1994), North Cumbria (Dumayne and Barber 1994), the Solway Firth (Tipping 1995), Wales (Turner 1964), Shropshire (Leah et al. 1988) and southern Scotland (Tipping 1994).

Although the sequence at Ansteys Combe does not start until around the end of the Iron Age, it is clear that significant oak-hazel woodland is recorded in the sequence at the end of the Iron Age and the start of the Romano-British period. At first glance this contradicts the evidence from Gourte Mires and Long Breach. However, the major pollen source area for Ansteys Combe will have been the valley below the site, owing to the very enclosed nature of the steep-sided valley head. The evidence therefore suggests that this area and other steep valley sides, are likely to have retained woodland through the later Iron Age and into the Romano-British period. Woodland would have been an important component of the Iron Age economy as a source of timber used in construction, of charcoal for industrial production such as iron working, and of fuel for domestic cooking and heating (Ralston 1999).

The evidence from Long Breach and Gourte Mires suggests a shift to wetter heath vegetation towards the later Iron Age. This shift may reflect the general decline in climate observed across much of North-West Europe during the later Prehistoric period (Lamb 1982; van Geel et al. 1996). Despite this shift to wetter heath, grass-heath was still dominant around the area, and the record of herbaceous taxa suggests that species-rich grass-dominated vegetation persisted. The continuous record of microscopic charcoal strongly suggests burning continued to be an

important tool in managing heath vegetation. It is possible that the apparent shift to damper heath vegetation, with a possible re-expansion of heather in the vegetation, did not reflect a climatic shift, but partitioning of the upland fringes and the establishment of "enclosed" and "unenclosed" compartments in the landscape. This may account for the continued presence of species-rich grassland in the vegetation history (within an enclosed landscape) whereas in an unenclosed landscape heather and wet-heath vegetation will have regenerated or developed. It is likely that enclosure began in the lowlands and expanded into the uplands up river valleys, whilst the higher parts of the landscape may have remained unenclosed.

Later Iron Age to early Medieval landscape continuity

From the later Iron Age to the early Medieval period there is very little change in the pollen record from Molland Common (pollen zones LBMC-4, GM1-3, AC1-1 and -2). This strongly suggests continuity and stability in the land use of the southern fringes of Exmoor for a period of up to 1000 years, and there is no reflection of the Roman period within the landscape. This supports the general concept of stability in rural south west England from the later Iron Age to the early Medieval reflected in the cultural record: there is no non-military domestic evidence for Roman presence throughout North Devon and Exmoor. The primary agricultural system during this period is pastoral, and the evidence from Ansteys Combe strongly suggests some woodland survival in the uplands draining the southern fringe of Exmoor. This woodland is most likely to have been part of a managed landscape, as a source of fuel, timber or for industrial processes. There is increasing evidence of iron production on Exmoor during the Roman period, requiring significant volumes of charcoal, although there is no archaeological evidence from the study area to suggest this activity was important there.

This open pastoral landscape with the use of fire in land management continues into the early Medieval period, supporting Francis and Slater's (1990, 1992) evidence from both Hoar Moor and Codsend Moor on central Exmoor. In contrast, Moore et al. (1984) identify a period of woodland regeneration at The Chains dated to 1500±60 B.P. (A.D. 420-660), which they suggested provided

evidence for "large scale migration of people to Brittany because of plague and famine" (Moore et al. 1984: Table 2). The evidence from both this study and the work of Francis and Slater (1990, 1992) clearly refutes the idea that de-population occurred across Exmoor in the early post-Roman period.

Medieval expansion of cultivation

By ca. 1000 B.P. (A.D. 1100) the evidence from all three sites indicates a change in the pattern of land use on the upland around Molland Common. The data from Gourte Mires exemplifies the shift (zone GM1 lpaz-4) with a rise in cereal pollen types (*Secale cereale* and *Avena/Triticum* types, *sensu* Andersen, 1978) and associated weeds of cultivation, dated to 1020±60 B.P. (A.D. 890-1170). Species associated with pastoral land use decline and there is a reduction in microscopic charcoal, suggesting a cessation of burning on the upland. At Ansteys Combe the rise in cereal cultivation (mostly *Secale cereale* and the *Hordeum* group, *sensu* Andersen, 1978) is dated to 1160±70 B.P. (A.D. 680-1020). The *Hordeum* group of Andersen (1978) provides difficulties in interpretation as it includes wet flush species, including *Glyceria*, and therefore may not reflect cultivation. However, the strong presence of *Secale cereale* and associated weeds of cultivation (e.g. *Anthemis*-type) from the start of zone AC1-3 must indicate cereal cultivation around Ansteys Combe. The onset of cultivation at Ansteys Combe also marks a dramatic decline in oak-dominated woodland around the site, with a strong shift to a heather-dominated heath. Cereals are also recorded from Long Breach during this period.

The evidence of cereal cultivation from around the tenth century A.D. on Molland Common (at 340 m OD) is not restricted to sporadic grains of cereal-type pollen, rather all three sites record significant levels of cereal pollen, in particular rye (*Secale cereale*). Pollen of cereals is notoriously poorly dispersed beyond the immediate location of cultivation (Vourela 1970). Therefore it is highly unlikely that the evidence from the Molland Common sites represents cereal grains blown up the combes to the sites, especially given the position of the valleys in relation to the prevailing winds, but rather reflects the extension of cereal cultivation onto the upland. The archaeology of the surrounding upland strengthens this

interpretation and documentary evidence indicates that the nearby farms at Lyshwell, Cloggs and Shircombe (1.5 kilometres downstream from the site at Long Breach), are the remnant of a larger group of farmsteads (up to nine). However the historical data are insufficient to allow reconstruction of the number of settlements active during the later Medieval period (Riley and Wilson-North 2001: 129). Extensive relict medieval field systems extend across Molland Common and it is likely these relate to this large group of holdings. The decline in woodland around Ansteys Combe further suggests increased pressure on either woodland resources during the later Medieval period, or a requirement for increased open land for pastoral activities.

The pollen data from Long Breach show lower levels of cereal pollen than Gourte Mires or Ansteys Combe. This local difference may reflect different uses of parts of the upland fringes, for example pastoral activities around Long Breach, with arable (or possibly some form of rotational pastoral and arable) focussed around Gourte Mires and Ansteys Combe. Hatcher (1988) and Fox (1991) argue that arable cultivation in the South West would have formed part of a convertible husbandry scheme. Under this system fields were subject to short cultivation periods of 1 to 3 years, followed by extensive ley periods of around 5 and 7 years. It is possible that the pollen analyses from Ansteys Combe and Goure Mires reveal a 5-10 year rotation of fields on the upland, with permanent pasturing around Long Breach, at least until 650±60 B.P. (A.D. 1270-1420), when arable agriculture may have expanded up towards Long Breach.

The evidence for the timing of cessation of arable agriculture around Molland Common is less clear than the evidence for the start of cultivation. At Ansteys Combe and Long Breach the decline in *Secale cereale*, which is taken to represent the end of rye cultivation on the uplands, is broadly synchronous with the rise of pine. This is estimated to have been at around A.D. 1750-1800, representing the establishment of plantations around the fringes of the upland. The timing of the expansion of arable cultivation into the upland fringe, together with the apparent continuous presence of arable agriculture throughout the medieval and later period, suggests that a model of high medieval expansion and contraction of arable into the upland margins must be re-examined (Henderson and Weddell

1994). In fact this evidence may support a model of continuity from the early medieval well into the post-medieval period.

Conclusions

The use of multiple pollen profiles has clearly demonstrated the potential for the reconstruction of a detailed local vegetation history for a small geographical area and allowed an estimate of the scale of human clearance. Where sites record different vegetation patterns, a maximum estimate of patch size, or the scale of human disturbance, may be defined as half the distance between each site. Between Gourte Mires and Ansteys Combe this is around 150 m. Local variation in vegetation is clear through comparison of the sequences from small mires which reflect predominantly local and extra-local vegetation history. For example woodland is cleared by the late prehistoric period on the higher areas of the upland; however, the sequence at Ansteys Combe demonstrates survival or preservation of woodland on the steep valley sides immediately adjacent (within 0.5 km) to the uplands until the later medieval period. The earliest pollen data are from Long Breach, beginning during the later Mesolithic, around 5400 B.P. (4750-4350 B.C.). The landscape around southern Exmoor was partially open; the woodland was predominantly oak-hazel, and low levels of elm are recorded, probably near the limits of its distribution. The open landscape was characterised by heather-dominated heath. The change from the Mesolithic to the Neolithic is clearly marked in the study area by a significant decline in all woodland species, suggesting the creation of clearings or significant open land around the upland shortly before 4700±60 B.P. (3640-3360 B.C.). This occurred around the classic elm-decline date, although unlike other elm-decline events recorded from southern England there was a decline in oak-hazel woodland as well. This change does not fit with the transition model for the Mesolithic/Neolithic boundary, but suggests a sudden adoption of pastoralism or the possible immigration of pastoralists. The evidence from Long Breach shows that oak-hazel woodland regenerated shortly after the decline. This is corroborated by the Gourte Mires data which record significant oak-hazel woodland when the peat accumulation began at 3960±60 B.P. (2630-2280 B.C.). Shortly after the recovery of woodland there were significant changes in the nature of the open heathland vegetation. This

was characterised by a shift to grass-dominated heath, very probably representing deliberate management of the upland vegetation through burning to facilitate upland grazing from the early Neolithic onwards. The extent and character of woodland during this shift in heath vegetation was unchanged, suggesting that the woodland was located on valley slopes and combes and around the upland fringes.

The use of multiple sites has allowed a better understanding of the spatial dimensions of woodland clearance and survival during the early Bronze age to the late Iron Age. The evidence from Long Breach suggests that woodland persisted in and around the valley draining to the east of Molland Common. However, the data from Gourte Mires show woodland clearance around the southern edge of Molland Common at 3560±60 B.P. (2120-1730 B.C.). The data from the higher blanket mire sequences on Exmoor similarly indicate a regional increase in woodland clearance during this period. The vegetation then shows remarkable continuity through time until the later Iron Age, when intensive woodland clearance is recorded at 2230±70 B.P. (410-90 B.C.). This clearance fits an increasing body of evidence for regional woodland clearance across western and northern Britain during the mid-late Iron Age. In contrast to the evidence from Gourte Mires and Long Breach, the data from Ansteys Combe suggest that woodland persisted within the steeper-sided valley contexts draining to the south of Molland Common. It is likely that these landscape contexts would have been suitable for management of woodland as a resource, either for timber, domestic use or charcoal production for industrial uses.

From the later Iron Age through to the early Medieval period, the agricultural system around Molland Common appears to be pastoral, and there are no phases of scrub or woodland regeneration, clearly indicating that there was no cessation of activity around the upland fringe of Exmoor. This continued until around 1000 A.D., when a significant shift to a mixed arable/pastoral regime is indicated from the Molland sites, although the data from Long Breach suggest that pastoral activities probably were more dominant towards the higher, central part of the study area. This pattern continued until well into the post-Medieval period, and most likely represents some form of convertible husbandry on the upland area. The data from the sites have demonstrated that the vegetation at the upland fringe

was and is not homogenous, but most likely has been a mosaic of different vegetation communities since the earlier Neolithic.

References

Andersen, S.T. (1978). Identification of wild grass and cereal pollen. Danmarks Geologiske Undersøgelse Årbog, 1978, 69-92

Andrew, R. (1984). A practical pollen guide to the British flora. Quaternary Research Association, Cambridge

Beckett, S.C., Hibbert, F.A. (1979). Vegetational change and the influence of prehistoric man in the Somerset Levels. New Phytologist, 83, 577-600

Bennett, K.D. (1994). Annotated catalogue of pollen and pteridophyte spore types. Unpublished report, Department of Plant Sciences, University of Cambridge

Brown, A.G. (1999). Characterising prehistoric lowland environments using local pollen assemblages. Quaternary Proceedings, 7, 585-594

Caseldine, C.J. (1999). Archaeological and environmental change on Prehistoric Dartmoor – current understandings and future directions. Journal of Quaternary Science, 14, 575-583

Caseldine, C.J., Hatton, J. (1993). The development of high moorland on Dartmoor: fire and the influence of Mesolithic activity on vegetation change. In: Chambers, F.M. (ed) Climate change and human impact on the landscape. Chapman and Hall, London, pp 119-132

Chambers, F.M., Mauquoy, D., Todd, P.A. (1999). Recent rise to dominance of *Molinia caerulea* in environmentally sensitive areas: new perspectives from palaeoecological data. Journal of Applied Ecology, 36, 710-733

Dumayne, L., Barber, K. (1994). The impact of the Romans on the environment of northern Britian: pollen data from three sites close to Hadrian's Wall. The Holocene, 4, 165-173

Dumayne-Peaty, L., Barber, K. (1998). Late Holocene vegetational history, human impact and pollen representativity variations in northern Cumbria, England. Journal of Quaternary Science, 13, 147-164

Edwards, K.J. (1979). Palynological and temporal inference in the context of prehistory, with special reference to the evidence from lake and peat deposits. Journal of Archaeological Science, 6, 255-270

Edwards, K.J. (1999). Palynology and people: observations on the British record. Quaternary Proceedings, 7, 531-544

Edwards, K.J., MacDonald, G.M. (1991). Holocene palynology: II. Human influence and vegetation change. Progress in Physical Geography, 15, 364-391

Faegri, K., Kaland, P.E., Krzywinski, K. (1989). Textbook of pollen analysis (4th edn). John Wiley and Sons, Chichester

Fleming, A. (1979). The Dartmoor reaves: boundary patterns and behaviour patterns in the second millennium B.C. Proceedings of the Devon Archaeological Society, 37, 115-131

Fleming, A. (1988). The Dartmoor Reaves. Batsford, London

Fleming, A. (1994). The Reaves revisited. Proceedings of the Devon Archaeological Society, 52, 63-74

Fox, H.S.A. (1991). Farming practice and techniques, Devon and Cornwall. In: Miller, E. (ed.) The Agrarian History of England and Wales, vol 3, 1348-1500. Cambridge University Press, Cambridge, pp 303-323

Francis, P.D., Slater, D.S. (1990). A record of vegetation and land use change from upland peat deposits on Exmoor. Part 2: Hoar Moor. Somerset Archaeology and Natural History Society Proceedings, 134, 1-25

Francis, P.D., Slater, D.S. (1992). A record of vegetation and land use change from upland peat deposits on Exmoor. Part 3: Codsend Moor. Somerset Archaeology and Natural History Society Proceedings, 136, 9-28

Fyfe, R.M., Brown, A.G., Coles, B.J. (in press). Mesolithic to Bronze Age vegetation change and human activity in the Exe Valley, Devon, UK. Proceedings of the Prehistoric Society, 70

Fyfe, R.M., Brown, A.G., Cook, N. (submitted). A new high-resolution late-Holocene palaeoecological and palaeoclimatological record for Exmoor, south west England. The Holocene

Hatcher, J. (1988). New settlement: south west England. In: Hallam, H.E. (ed.) The Agrarian History of England and Wales, vol 2, 1042-1350. Cambridge University Press, Cambridge, pp 234-244

Henderson, C.G., Weddell, P.J. (1994). Medieval settlements on Dartmoor and in west Devon: the evidence from excavations. Proceedings of the Devon Archaeological Society, 52, 119-140

Hester, A.J., Baillie, G.J. (1998). Spatial and temporal patterns of heather use by sheep and red deer within natural heather/grass mosaics. Journal of Applied Ecology, 35, 772-784

Jacobsen, G.L., Bradshaw, R.H. (1981). The selection of sites for palaeoecological studies. Quaternary Research, 16, 80-96

Jowsey, P.C. (1966). An improved peat sampler. New Phytologist, 65, 245-248

Lamb, H.H. (1982). Climate, history and the modern world. Methuen, London and New York

Leah, M.D., Wells, C.E., Huckerby, E., Stamper, P. (1998). The Wetlands of Shropshire and Staffordshire. Lancashire Imprints, Lancaster

Mackay, A.W., Tallis, J.H. (1994). The recent history of the forest of Bowland, Lancashire. New Phytologist, 128, 571-584

Mellars, P. (1976). Fire ecology, animal populations and man: a study of some ecological relationships in prehistory. Proceedings of the Prehistoric Society, 42, 15-45

Moore, P.D., Merryfield, D.L., Price, M.D.R. (1984). The vegetation and development of blanket mires. In: Moore, P.D. (ed) European Mires. Academic Press, London, pp 203-235

Moore, P.D., Webb, J.A., Collinson, M.E. (1991). Pollen analysis. Blackwell, Oxford

Odgaard, B.V. (1992). The fire history of Danish heathland areas as reflected by pollen and charred particles in lake sediments. The Holocene, 2, 218-226

Palmer, S.C.F., Hester, A.J. (2000). Predicting spatial variation in heather utilization by sheep and red deer within heather/grass mosaics. Journal of Applied Ecology, 37, 616-631

Parker, A.G., Goudie, A.S., Anderson, D.E., Robinson, M.A., Bonsall, C. (2002). A review of the mid-Holocene elm decline in the British Isles. Progress in Physical Geography, 26, 1-45

Peglar, S.M. (1993). The mid-Holocene *Ulmus* decline at Diss Mere, Norfolk, UK: a year-by-year pollen stratigraphy from annual laminations. The Holocene, 3, 1-13

Peglar, S.M., Birks, H.J.B. (1993). The mid-Holocene *Ulmus* fall at Diss Mere, South-East England – disease and human impact? Vegetation History and Archaeobotany, 2, 61-68

Pennington, W. (1965). The interpretation of some Post-glacial vegetational diversities at different Lake District sites. Proceedings of the Royal Society, B161, 310-340

Pennington, W. (1970). Vegetation history in the north-west of England: a regional synthesis. In: Walker, D., West, R.G. (eds) Studies in the vegetational history of the British Isles. Cambridge University Press, Cambridge, pp 41-79

Pennington, W., Haworth, E.Y., Bonny, A.P., Lishman, J.P. (1972). Lake sediments in northern Scotland. Proceedings of the Royal Society, B264, 191-294

Prentice, I.C. (1985). Pollen representation, source area and basin size: towards a unified theory of pollen analysis. Quaternary Research, 23, 76-86

Ralston, I. (1999). The Iron Age: Aspects of the Human communities and their environments. Quaternary Proceedings, 7, 501-512

Riley, H., Wilson-North, R. (2001). The Field archaeology of Exmoor. English Heritage, Swindon

Rodwell, J.S. (1992). British Plant Communities 3: grasslands and montane communities. Cambridge University Press, Cambridge

Scaife, R.G. (1988). The *Ulmus* decline in the pollen record of South East England and its relationship to early agriculture. In: Jones, M. (ed) Archaeology and the flora of the British Isles. Oxford University Committee for Archaeology Monograph no 14, Oxford, pp 21-33

Simmons, I.G. (1964). Pollen diagrams from Dartmoor. New Phytologist, 63, 165-180

Simmons, I.G. (1996). Changing the Face of the Earth. Blackwell, Oxford

Simmons, I.G., Innes, J.B. (1987). Mid-Holocene adaptations and later Mesolithic forest disturbance in Northern England. Journal of Archaeological Science, 14, 385-403

Simmons, I.G., Innes, J.B. (1996). Disturbance phases in the mid-Holocene vegetation at North Gill, North York Moors: form and process. Journal of Archaeological Science, 23, 183-191

Simmons, I.G., Rand, J.I., Crabtree, K. (1983). A further pollen analytical study of the Blacklane peat section on Dartmoor, England. New Phytologist, 94, 655-667

Sims, R.E. (1978). Man and vegetation in Norfolk. In: Limbrey, S., Evans, J.G. (eds) The effect of man on the landscape: the lowland zone. Council for British Archaeology Research Report, Oxford, pp 57-62

Skinner, C., Brown, A.G. (1999). Mid Holocene vegetation diversity in eastern Cumbria. Journal of Biogeography, 26, 45-54

Smith, A.G., Cloutman, E.W. (1988). Reconstruction of Holocene vegetation history in three dimensions at Waun-Fignen-Felen, and upland site in South Wales. Philosophical Transactions of the Royal Society, B322, 159-219

Smith, K., Coppen, J., Wainwright, G.J., Beckett, S. (1981). The Shaugh Moor project: third report, settlement and environmental investigations. Proceedings of the Prehistoric Society, 47, 205-273

Stuiver, M., Reimer, P.J. (1993). Extended ^{14}C database and a revised CALIB radiocarbon calibration program. Radiocarbon, 35, 215-230

Sugita, S. (1993). A model of pollen source area for an entire lake surface. Quaternary Research, 39, 239-244

Sugita, S. (1994). Pollen representation of vegetation in Quaternary sediments: theory and method in patchy vegetation. Journal of Ecology, 82, 879-898

Sugita, S. (1998). Modelling pollen representation of vegetation. In: Gaillard, M.J., Berglund, B.E., Frenzel, B., Huckriede, U. (eds) Quantification of land surfaces cleared of forests during the Holocene, Paläoklimaforschung/Palaeoclimate Research 27, Gustav Fischer, Stuttgart, pp 1-16

ter Braak, C.J.F. (1987). CANOCO – a FORTRAN program for canonical community ordination by [partial] [detrended] [canonical] correspondence analysis, principle components analysis and redundancy analysis. Agricultural Mathematics Group, Wageningen

Tipping, R. (1994). The form and fate of Scotland's woodlands. Proceedings of the Society of Antiquities of Scotland, 124, 1-54

Tipping, R. (1995). Holocene evolution of a lowland Scottish landscape: Kirkpatrick Fleming. II. Regional vegetation and land-use change. The Holocene, 5, 83-96

Todd, P.A. (1996). The MAFF *Molinia* study: control of purple moorgrass (*Molinia caerulea* (L.) Moench) in heather (*Calluna vulgaris*) moorland after reduction in sheep grazing. In: Phillips, J. (ed) The Heather Trust Annual Report. Heather Trust, Kippen, pp 13-16

Turner, J. (1964). The anthropogenic factor in vegetational history. I. Tregaron and Whixall Mosses. New Phytologist, 63, 73-82

Turner, J. (1970) Post-Neolithic disturbance of British vegetation. In: Walker, D., West, R.G. (eds) Studies in the vegetational history of the British Isles. Cambridge University Press, Cambridge, pp 97-116

van Geel, B., Buurman, J., 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, 451-460

Vuorela, I. (1970). The indication of farming in pollen diagrams from Southern Finland. Acta Botanica Fennica, 87, 1-40

Wimble, G., Wells, C.E., Hodgkinson, D. (2000). Human impact on mid- and late Holocene vegetation in south Cumbria, UK. Vegetation History and Archaeobotany, 9, 17-30

Fig. 1. Map showing the location of the study area on the southern fringes of Greater Exmoor, and other sites mentioned in the text (1=Moles Chamber, 2=The Chains, 3=Hoar Moor, 4=Codsend Moor). The inset map indicates the location of Exmoor in Britain
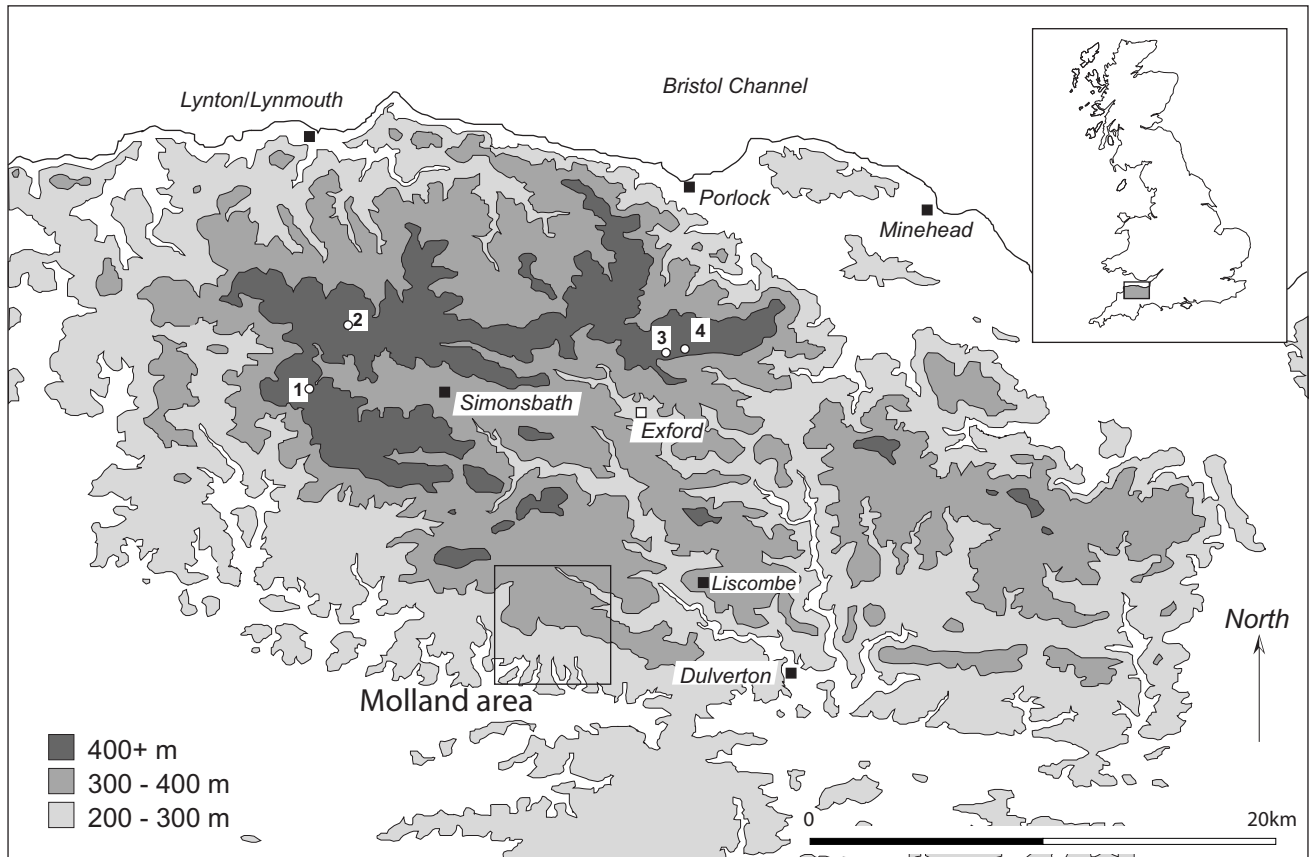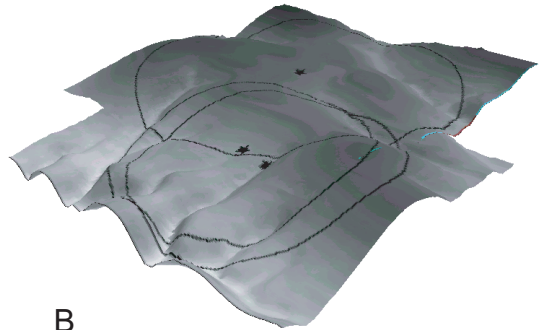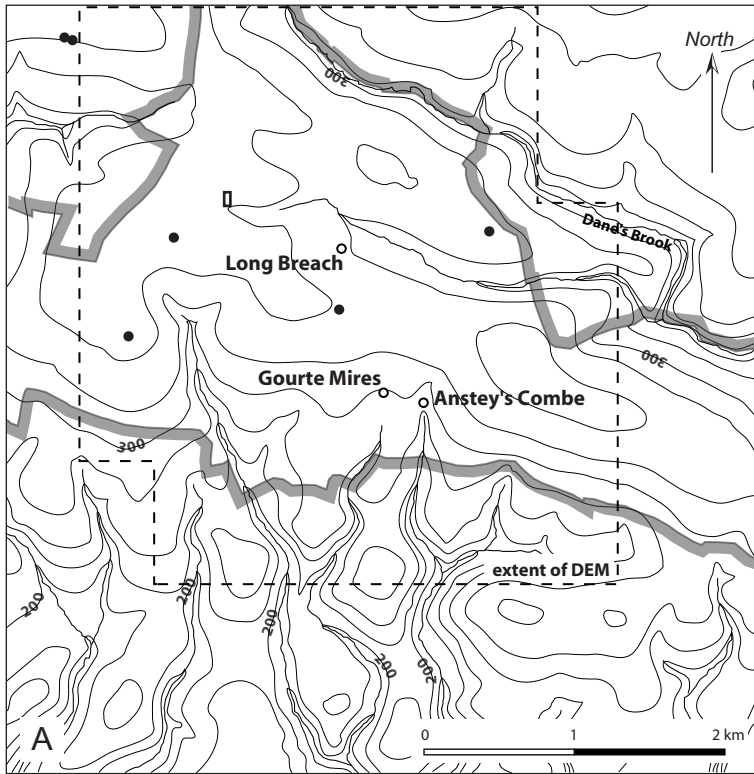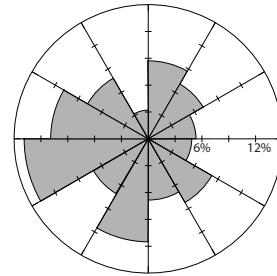
Fig. 2. A: Map of coring sites in the study area, with filled circles indicating Bronze Age barrows and open rectangle a stone setting. Shading indicates extent of modern enclosure. B: Digital elevation model of Molland Common showing topographic location of sites. C: Wind direction frequency diagram, Liscombe, Exmoor, for 1993-2000

Fig. 3. Age-depth curves for sample cores: A: Gourte Mires; B: Long Breach; C: Anstey's Combe, including loss-on-ignition, stratigraphy and Pinus curve

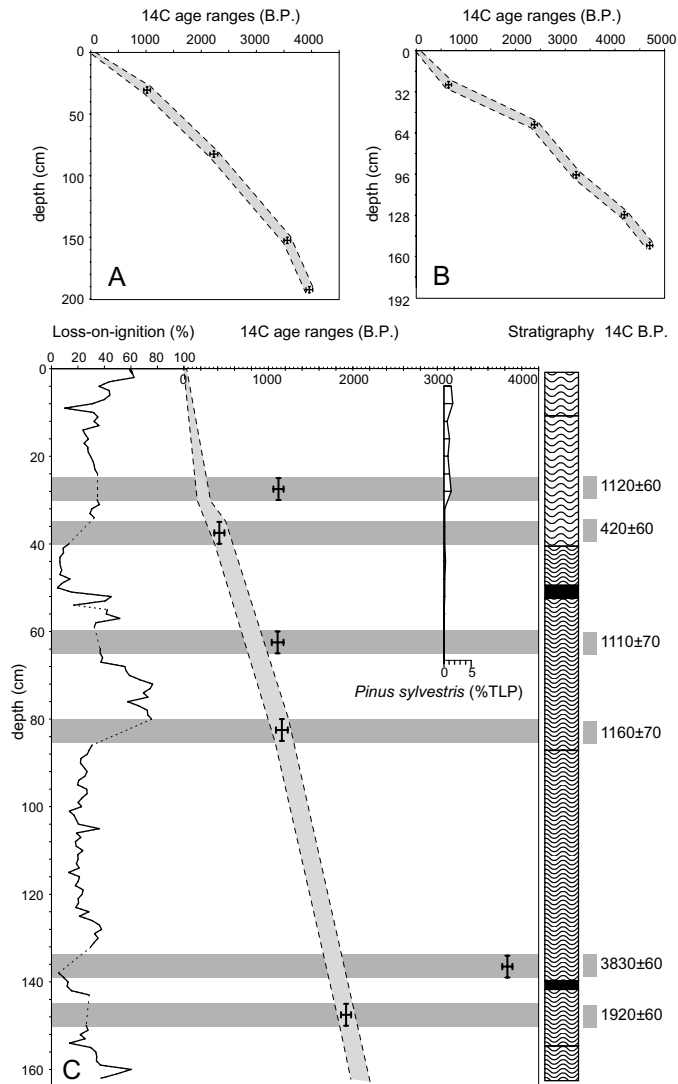Fig. 4. Transects showing stratigraphy of three sites: A: Long Breach; B: Ansteys Combe; C: Gourte Mires. Note different vertical and horizontal scales between sites

Fig. 5. Percentage based (%TLP) pollen diagram from Long Breach, Molland Common, Exmoor, showing all identified pollen and spore taxa. Charcoal is represented in two size classes as concentration data. Rare taxa (<1% TLP) are indicated by +

Fig. 6. Percentage based (%TLP) pollen diagram from Gourte Mires, Molland Common, Exmoor, showing all identified pollen and spore taxa. Charcoal is represented in two size classes as concentration data. Rare taxa (<1% TLP) are indicated by +

Fig. 7. Percentage based (%TLP) pollen diagram from Ansteys Combe, Molland Common, Exmoor, showing all identified pollen and spore taxa. Charcoal is represented in two size classes as concentration data. Rare taxa (<1% TLP) are indicated by +
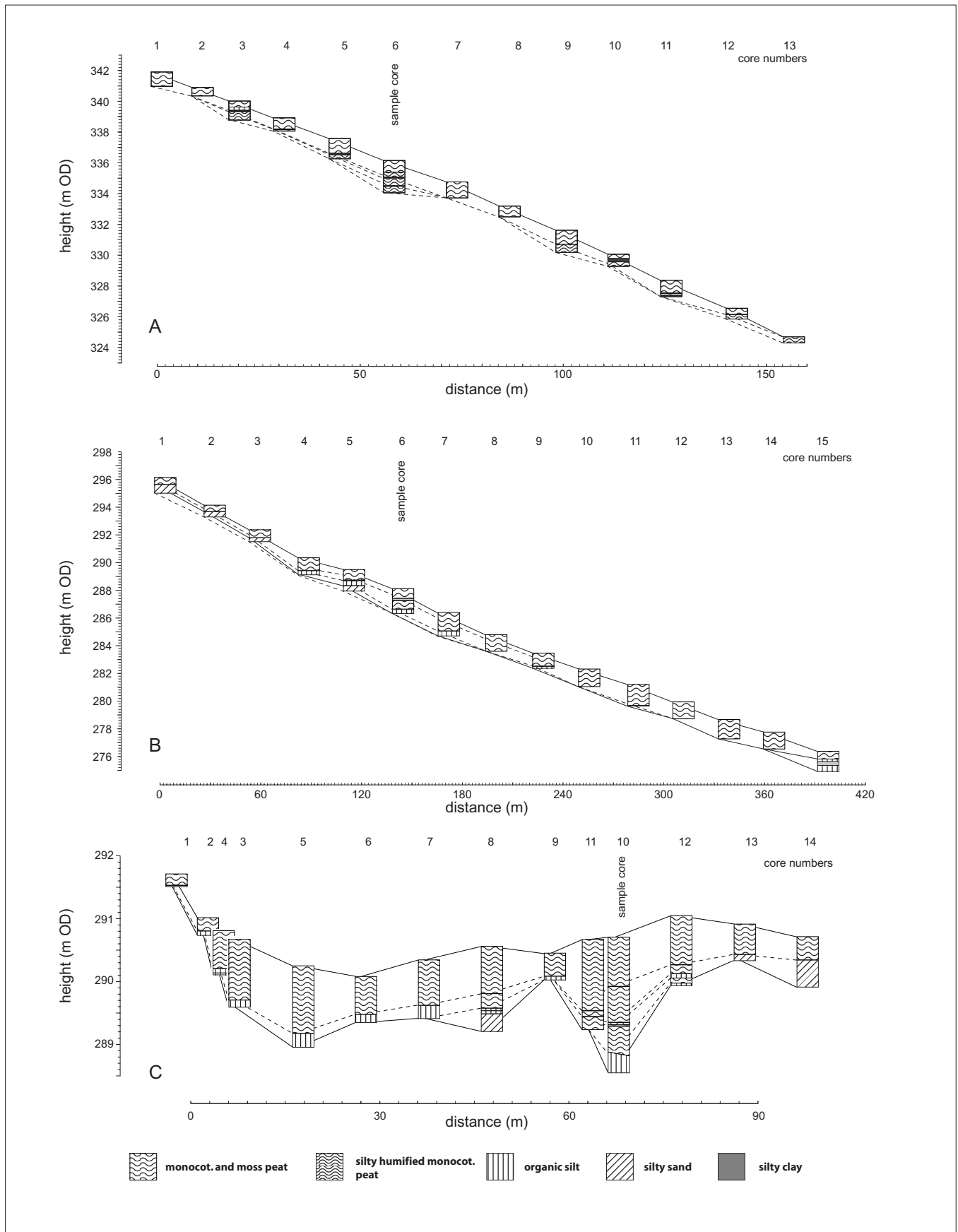
Fig. 8. A: Species scores, PCA analysis, combined data (Gourte Mires and Long Breach).
Eigenvalues: axis 1: 0.515; axis 2: 0.218. B: First axis sample scores against sample age
(uncalibrated), PCA analysis, combined data (Gourte Mires and Long Breach).
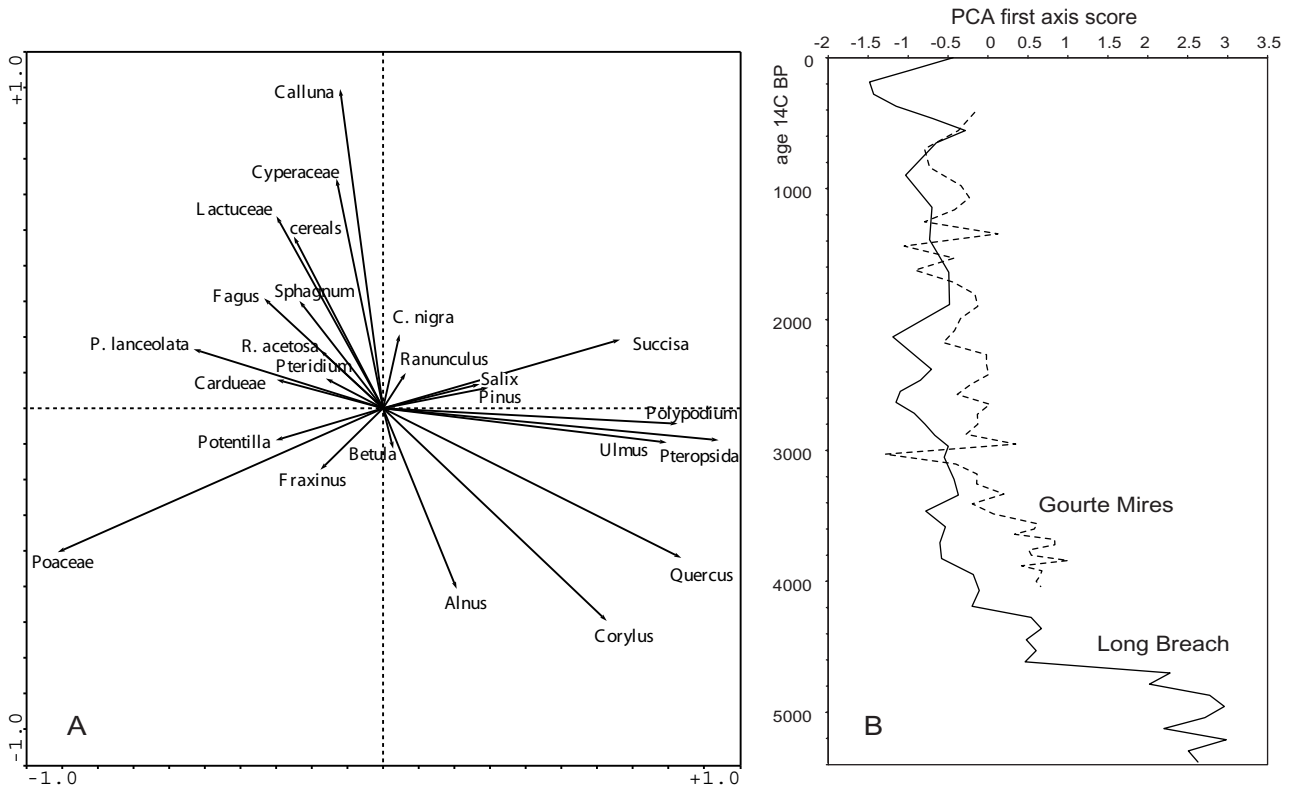
Table 1. Results of AMS radiocarbon dating

Sample Code	Depth	Lab Code	Age ^{14}C B.P.	Calibrated Age Range (2s)
LONG BREACH				
LBMC5	24-29	Wk-10624	650±60	A.D. 1270-1420
LBMC4	55-60	Wk-10623	2380±60	770-370 B.C.
LBMC3	94-99	Wk-10622	3220±60	1630-1320 B.C.
LBMC2	125-130	Wk-10621	4190±60	2900-2580 B.C.
LBMC1	149-154	Wk-10620	4700±60	3640-3360 B.C.
GOURTE MIRES				
GM4	28-33	Wk-10619	1020±60	A.D. 890-1170
GM3	80-85	Wk-10618	2230±70	410-90 B.C.
GM2	150-155	Wk-10617	3560±60	2120-1730 B.C.
GM1	190-195	Wk-10616	3960±60	2630-2280 B.C.
ANSTEYS COMBE				
AC5	25-30	Wk-10614	1120±60	A.D. 770-1202
AC4	35-40	Wk-10613	420±60	A.D. 1410-1640
AC6	60-65	Wk-10615	1110±70	A.D. 720-1040
AC3	82-87	Wk-10612	1160±70	A.D. 680-1020
AC2	134-139	Wk-10611	3830±60	2470-2060 B.C.
AC1	145-150	Wk-10610	1920±60	50 B.C.–A.D. 240

Table 2. PCA species-scores for first two axis, combined analysis, Long Breach and Gourte Mires.

Axis 1 (eigenvalue=0.515)		Axis 2 (eigenvalue=0.218)	
Pollen taxa	Axis score	Pollen taxa	Axis score
Poaceae	-0.895	*Corylus*	-0.5836
P. lanceolata	-0.5131	*Alnus*	-0.4902
Fagus	-0.3207	*Quercus*	-0.4104
Lactuceae	-0.2897	Poaceae	-0.3949
Potentilla	-0.2832	*Fraxinus*	-0.1616
Cardueae	-0.2822	*Betula*	-0.0979
Cereals (undiff.)	-0.2434	*Ulmus*	-0.0933
Sphagnum	-0.233	Pteropsida	-0.0866
Fraxinus	-0.1626	*Potentilla*	-0.0839
R. acetosa	-0.1621	*Polypodium*	-0.041
Pteridium	-0.1455	*Pinus*	0.0551
Cyperaceae	-0.1256	*Salix*	0.0622
Calluna	-0.1176	*Pteridium*	0.0767
Betula	0.0244	Cardueae	0.0768
C. nigra	0.0424	*Ranunculus*	0.0856
Ranunculus	0.0538	*R. acetosa*	0.1524
Alnus	0.1998	*P. lanceolata*	0.1599
Salix	0.2554	*Succisa*	0.1881
Pinus	0.2775	*C. nigra*	0.1893
Corylus	0.613	*Sphagnum*	0.2866
Succisa	0.648	*Fagus*	0.2974
Ulmus	0.7779	Cereals (undiff.)	0.4663
Polypodium	0.808	Lactuceae	0.5222
Quercus	0.8213	Cyperaceae	0.6257
Pteropsida	0.9228	*Calluna*	0.8763