

APPENDIX 1: POLLEN ANALYSIS

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Two monoliths, one from Cutacre and the other from the Kingsway Business Park, were subjected to pollen analysis. The Cutacre monolith was from a possible palaeochannel (**1305**) at Wharton Hall, which contained just under 0.5 m of organic silty clays underlain by woody deposits (*Ch 3, p 38*), whilst that from Kingsway was extracted from a deposit of peat close to Lower Moss Side Farm, which was over 1 m deep and overlay a sequence of silts and clays (*Ch 2, p 19*). The material from Cutacre has been dated to the medieval period, whilst that from Kingsway dates to the late Mesolithic and late Neolithic periods (*Appendix 2*).

Methodology

Volumetric samples (1 cc) were taken from each monolith sub-sample, and one tablet containing a known number of *Lycopodium* spores was added so that pollen concentrations could be calculated (Stockmarr 1971). The samples were prepared using a standard chemical procedure (method B of Berglund and Ralska-Jasiewiczowa 1986), using HCl, NaOH, sieving, HF, and Erdtman's acetolysis, to remove carbonates, humic acids, particles greater than 170 µm, silicates, and cellulose, respectively. The samples were then stained with safranin, dehydrated in tertiary butyl alcohol, and the residues mounted in 2000 cs silicone oil. Slides were examined at a magnification of x400 by counting pollen along equally spaced traverses. A minimum of 300 pollen grains was counted, including pollen of trees, shrubs, and herbs, in the total land pollen count. Pollen identification was made following the keys of Moore *et al* (1991), Faegri *et al* (1989), and a small modern-reference collection. Andersen (1979), Tweddle *et al* (2005), and Joly *et al* (2007) were referenced for the identification of cereal grains, while plant nomenclature follows Stace (2010). Charcoal particles greater than 5 µm were also recorded (Peglar 1993). Non-pollen palynomorph (NPP) identification and taxonomy follow van Geel (1978) and van Geel

and Aptroot (2006). Non-pollen palynomorphs are prefixed by HdV (corresponding to their listing in the NPP catalogue in the Hugo de Vries laboratory, University of Amsterdam, The Netherlands).

Calculation and Presentation of Results

The pollen data from both the Cutacre and Kingsway monoliths were used to compile percentage diagrams using the computer programs TILIA and TGView (Grimm 1991-2011). The percentage values are based on a pollen sum of total land pollen (trees, shrubs, cereal-types, and herbs (TLP)), but excludes ferns and aquatic taxa, as well as *Sphagnum*-moss spores, fungal spores, algae, and other non-pollen palynomorphs. All palynomorphs excluded from the pollen sum are expressed as a percentage of the pollen sum plus the group sum in which they belong. Microcharcoal values are expressed as a percentage of the pollen sum plus the charcoal counts, while non-pollen palynomorphs (NPP) are expressed as a percentage of the pollen sum plus the NPP counts. Taxa representing rare occurrences are recorded with a plus sign (pollen count sheets and the residues of prepared samples have been placed in the respective site archives).

Lithology

A summary of the lithology of each monolith was compiled. In the Wharton Hall palaeochannel (*Ch 3, p 38*), this comprised a thin, wood-rich organic deposit (**1304**), which was overlain by 0.37 m of silty clays, with sand and organic fragments (**1001**). This was dated to the late sixteenth- or early seventeenth century and was a marsh deposit.

The lithological sequence at Kingsway comprised a lower layer of grey clay, approximately 0.1 m thick, overlain by a silty wood peat, approximately 0.35 m

thick. A distinctive, 0.01 m thick, charcoal layer was present within the silty wood-peat deposit. Two thin organic silt deposits (0.02 m and 0.04 m thick) were present within the overlying peat, which was itself in excess of 1 m thick.

Dating

Several samples were subjected to radiocarbon dating (see *Appendix 2* for details). However, following advice from SUERC, only one of the radiocarbon assays from the Wharton Hall palaeochannel is considered reliable for dating the pollen sequence. This assay dated humic acid, within a sample of organic clay at a depth of 0.39-0.4 m, to cal AD 770-990 (1139±30 BP; SUERC-58092).

Results

The Wharton Hall palaeochannel

The pollen, non-pollen palynomorphs, and microcharcoal data from the Wharton Hall palaeochannel have been zoned. Four main zones have been distinguished (Cu-a to Cu-d; Fig 121).

Pollen zone Cu-a (0.46-0.36 m)

The lowest zone (Cu-a) is distinguished from that overlying it (Cu-b; *below*) by the dominance of oak pollen (*Quercus*). Other trees and shrubs present include alder (*Alnus*) and hazel-type (*Corylus avellana*-type), with fewer counts of willow (*Salix*), birch (*Betula*), pine (*Pinus*), lime (*Tilia*), holly (*Ilex*), ivy (*Hedera*), and heather (*Calluna*). The most commonly recorded herbs are grasses (Poaceae), followed by lesser counts for ribwort plantain (*Plantago lanceolata*), aster-type (Asteraceae, a large group comprising plants such as daisies, fleabanes, and thistles), sedges (Cyperaceae), cereal-type, meadowsweet (*Filipendula*), and dandelion-type (*Taraxacum*-type).

A wide range of herb pollen at this level includes occurrences of nettles (*Urtica*-type), dead-nettles (*Lamium*-type), sheep's sorrel (*Rumex acetosella*), common sorrel (*Rumex acetosa*), common knapweed (*Centaurea nigra*), mints (*Mentha*-type), the bedstraw family (Rubiaceae), the pea family (Fabaceae, a wide group including taxa such as vetches, peas, and clovers), and the cabbage family (Brassicaceae, another large group including plants such as rocket, garlic mustard, and cresses). Fern spores, including monolet ferns (Pteropsida), bracken (*Pteridium*), and polypody ferns (*Polypodium vulgare*), as well as *Sphagnum*-moss spores, were recorded. Pollen of the aquatic plant, lesser bulrush (*Typha angustifolia*), was

rare. Relatively few fungal spores were recorded, although reworked carboniferous miospores were also present. Moderate amounts of microcharcoal were also recorded.

Interpretation

The pollen data suggest that, although some wet and damp areas existed locally, the palaeochannel had largely filled when the material in the monolith was deposited. Grassland and oak woodland were close to the site, the summary curve for trees/shrubs, crops, and herbs showing just under 40% tree cover (mostly oak, but with lesser quantities of alder, hazel-type, and a range of other trees and shrubs, including willow, which has a preference for damp ground (Stace 2010)). The herb flora was dominated by grasses, but with a diverse range of herbs, such as docks, sedges, bedstraw, cinquefoils, mints, common knapweed, daisy-types, and dandelion-types. Of these, many have a preference for wet areas, for example sedges and bedstraw (*ibid*), but many may grow in a wide variety of habitats, including hedgerows, field edges, footpaths, and ruderal communities. The abundance of pollen of grasses and ribwort plantain suggests that the area may have been used for pastoral activity (Behre 1981; Tipping 2002).

Cereal-type pollen was also recorded, the pollen dimensions suggesting the presence of grains of barley and wheat/oats, assuming that these were not wild grasses (Andersen 1979). The consistent occurrence of cereal-type pollen suggests that either arable crops were being grown locally or perhaps crop processing was occurring in the vicinity. There is also evidence for burning, based on moderate counts for microcharcoal. An early medieval date of cal AD 770-990 (1139±30 BP; SUERC-58092) was derived from the humic-acid fraction of the organic clay, at a depth of 0.39-0.40 m.

Pollen zone Cu-b (0.36-0.20 m)

An increase in alder pollen and decreases in oak pollen distinguish Cu-b. Values for grass pollen also remained high. The herb pollen assemblage was similar to that from Zone Cu-a (*above*), but values for fern spores increased. Rare occurrences of the aquatic plants bulrush (*Typha latifolia*) and lesser bulrush were recorded. A peak in values of microcharcoal particles was present at 0.28 m, coincident with a peak in the occurrence of the fungal spore *Coniochaeta xylariispora* (HdV-6). The relative abundance of fungal spores was greater and the range slightly more diverse than in the lower zone (Cu-a), spores, including *Cercophora* (HdV-112), *Chaetomium* (HdV-7A), *Podospora* (HdV-368), *Sordaria* (HdV-55), and *Sporomiella* (HdV-113), being consistently recorded in small numbers.

Interpretation

A change in lithology from a wood-rich deposit to one of silty clays was coincident with the palynological evidence in this zone, where there was a major drop in oak pollen. Oak may have been cleared and used for burning, this latter suggestion being supported by a microcharcoal peak at 0.28 m. The presence of dead wood in the vicinity was also supported by a peak in fungal spores that host on dead deciduous wood (Innes *et al* 2006), including oak (*Coniochaeta xylariispora* HdV-6), also at 0.28 m. At the same point as values of oak declined, pollen values for alder increased significantly, suggesting the development of alder-carr communities at the site. Pollen counts for hazel-type plants suggest that scrub expanded (perhaps into cleared areas) and an increase in the numbers of fern spores may suggest that these also occupied areas that had been cleared of oak trees. Pollen of ribwort plantain was consistently present within the zone, suggesting grazing (Tipping 2002), which may also be inferred from the range of fungal spores known to host on animal dung (*eg Sporomiella* (HdV-113), *Cercophora* (HdV-112), *Chaetomium* (HdV-7A), *Podospora* (HdV-368), and *Sordaria* (HdV-55)). Cereal-type pollen was present, but in very small numbers in the lower part of the zone, becoming slightly more abundant within the upper part, suggesting possible small-scale arable cultivation, or nearby crop processing.

Pollen zone Cu-c (0.20-0.8 m)

Zone Cu-c is characterised by consistently high values of alder pollen and a significant reduction in the pollen of grasses. Values for hazel-type pollen remain low but consistent, while those for oak appear to have recovered a little through the zone. Of interest is a slight expansion in values for the pollen of holly. The pollen count for ribwort plantain showed a decrease through the zone, but that for cereal-type pollen was marginally greater than in the previous or subsequent zones. The diversity of herb pollen remained similar to that in the lower zones (Cu-a; *p* 290), including, in addition, pollen of knotgrass (*Polygonum aviculare*). Monolete fern spores continued to occur consistently, but values for polypody ferns decreased through the zone. Microcharcoal counts remained moderately high, but fungal spores showed a decrease in both numbers and diversity. There was a slight increase in both deteriorated grains and reworked carboniferous miospores at 0.14 m.

Interpretation

The palynofloral changes demonstrate a reduction in grass pollen and a further increase in alder pollen. The relative abundance of holly suggests that the climate was generally warmer than before, as this shrub is known to be thermophilous (Godwin 1994). Values for cereal-type pollen show slight increases

when compared to the previous zone (Cu-b; *p* 290), suggesting that either arable cultivation or crop processing was taking place in the vicinity. Although knotgrass has been identified on all sorts of open ground (Stace 2010), it has also been recorded in association with cereal growth (Behre 1981) and cultivated land (Gaillard 2007), and was present within this zone. Values for ribwort plantain dropped through the zone and the fungal spores that host on animal dung also showed a decrease, perhaps suggesting less pastoral activity than previously.

Pollen zone Cu-d (0.08-0.02 m)

Rising values for grass pollen serve to distinguish this uppermost zone from the previous one (Cu-c; *above*). Pollen counts for ribwort plantain increased in the uppermost sample and those for cereal-type pollen decreased to nothing at the top of the zone. The occurrence of tree and shrub pollen remained similar to that in Zone Cu-c, but with a reduction in values for holly. Spores of bracken were particularly common within the topmost sample at 0.2 m. The fungal-spore assemblage was much reduced, although spores of *Cercophora* (HdV-112) were still present. Reworked carboniferous miospores were also present, and moderate amounts of microcharcoal were recorded.

Interpretation

Alder pollen decreased slightly as grasses increased, suggesting a further expansion of open areas relative to alder carr. Meadow plants, or those of hedgerows and waysides, continued to flourish, as indicated, for example, by pollen of daisy-types, dandelion-types, sedges, cinquefoils, buttercups, and bedstraw. The records for cereal-type pollen declined to absence within this zone, suggesting a cessation in cereal cultivation and/or processing on-site. Values for ribwort plantain increased slightly, suggesting pastoral activity. This was further supported by a consistent presence of the fungal spore *Cercophora* (HdV-112), which hosts primarily on animal dung (van Geel and Aptroot 2006).

Kingsway: Moss Side Farm peat monolith

The pollen, non-pollen palynomorph, and microcharcoal results are presented on the TILIA diagram (Fig 122).

Zone KWa (1.84-1.745 m)

The arboreal assemblage was dominated by hazel-type pollen, with values reaching up to 80%. Also present among the tree and shrub community were pollen grains of alder, birch, willow, pine, and oak. Rare pollen grains of elm (*Ulmus*), heather, ivy, and honeysuckle (*Lonicera*) were also recorded. In the herb community, pollen of grasses and meadowsweet were predominant, while sedges,

thistles (*Cirsium*-type), enchanter's-nightshades (*Circaea*-type), cinquefoils (*Potentilla*-type), and devil's-bit scabious (*Succisa pratensis*) were also present. Monolete fern spores (Pteropsida) and *Sphagnum*-moss spores were commonly recorded. Microcharcoal was also present in amounts less than 20%.

Interpretation

The lithology of the basal grey clay was present throughout the zone and probably represents a waterlogged layer upon which peat communities began to develop. The pollen data suggest hazel-type scrub dominated the local environment, although some of this may have been pollen of *Myrica gale* (bog-myrtle), which is known to occur on wet moorland and heathland, bogs, and fens (Stace 2010). The common occurrence of willow and meadowsweet, plants that grow preferentially in wet and damp places (*ibid*), supports the interpretation of the palaeoenvironment. *Sphagnum*-moss spores were also suggestive of peat or boggy areas.

Pollen of herbs such as grasses, sedges, thistles, and devil's-bit scabious suggests that small openings may have existed on the moor. The high values of microcharcoal and fern spores are of interest as the relative abundance of the former may be indicative of burning events, possibly of an anthropogenic nature. If correct, this would relate to late Mesolithic activity in this area, at some stage prior to *c* 5500 cal BC (*below*). Burning could have produced open areas, which may have allowed an increase in ferns and a relative diversity of herbs to flourish. Burning could also have initiated mineral inwash, possibly resulting from the erosion of the thin moorland soils, which had become destabilised as a result of fires. The fern spores may have been derived from this mineral inwash, or may be indicative of the existence of open areas, within which fern growth had taken hold.

Zone KWb (1.745-1.54 m)

A very clear decline in the pollen of hazel-type flora, coinciding with an equally clear increase in alder pollen, defines Zone KWb. The pollen curves for oak, birch, and pine showed a slight increase relative to the previous zone (KWa; *p* 292). In comparison to the underlying zone, the pollen of herbs was less diverse, the most consistently occurring herb being devil's-bit scabious. Fern spores were represented by reduced numbers of monolete spores, in comparison with the underlying zone, as well as occurrences of spores of polypody ferns and bracken. Values for microscopic charcoal remained generally about 10% through the zone, but dropped to being virtually absent at the top. The fungal spore *Gelasinospora* (HdV-1) was present.

Interpretation

The pollen assemblage indicated a palaeoenvironment invaded and dominated by alder, suggesting development of damp alder-carr, with a much reduced presence of hazel-type/bog-myrtle on the moor. Immediately above the transition from the basal grey clay to the peat, a late Mesolithic date of 5620-5380 cal BC (6545±50 BP; SUERC-7974) was obtained at 1.71-1.72 m (*Appendix 2*). This is consistent with the asynchronous advance and spread of alder in upland areas of the north of England (Innes *et al* 2011). The local spread of alder was often accompanied by charcoal (Smith and Cloutman 1988), and charcoal layers can coincide with the arrival of new woody taxa, as if burning stimulated or accelerated woodland succession (Innes *et al* 2011). As is the case at Kingsway, charcoal sometimes occurs at the base of peat deposits; thus, burning could have triggered peat formation, by vegetation removal and increasing ground wetness (*ibid*). A thin charcoal layer has been identified within the peat stratigraphy in this zone (Fig 121) and a late Mesolithic date of 5470-5110 cal BC (6305±50 BP; SUERC 7973) has been obtained from charcoal at 1.635-1.645 m (*Appendix 2*).

The continuous presence of microscopic charcoal, with values peaking at just under 20%, provides evidence of fires and burning, direct evidence of burning coming from the occurrence of several specimens of the fungal spore, *Gelasinospora* HdV-1, which has been associated with microcharcoal and charred plant remains (Innes and Blackford 2003). Such burning may have resulted in the expansion of peat on the moor, the developing peat being bordered by alder-carr vegetation. The pollen data suggest that hazel scrub was being burnt, consistent with a decrease in the curve for hazel-type pollen. No microcharcoal was present towards the top of the zone, and values for hazel-type appeared to recover, suggesting possible regeneration of hazel scrub on the moor.

Zone KWc (1.54-1.185 m)

Zone KWc is distinguished by an expansion of oak pollen, to peak values of 40%. With the exception of birch pollen, which also showed an increase in numbers, the curves for alder, hazel, and pine all decreased in pollen values. Lime (*Tilia*) and ash (*Fraxinus*) also appeared for the first time. Heather pollen became more consistently present towards the top of the zone, and herb pollen was more diverse than in the previous zone (KWb), and included grasses, cinquefoils, the bedstraw family, cow-wheat (*Melampyrum*), and docks/sorrels (*Rumex*). Fern spores were commonly recorded and *Sphagnum*-moss spores were present in small numbers throughout the zone. The fungal spore, *Cercophora* HdV-112, was also consistently recorded. Microcharcoal values recovered to a small peak of around 10%.

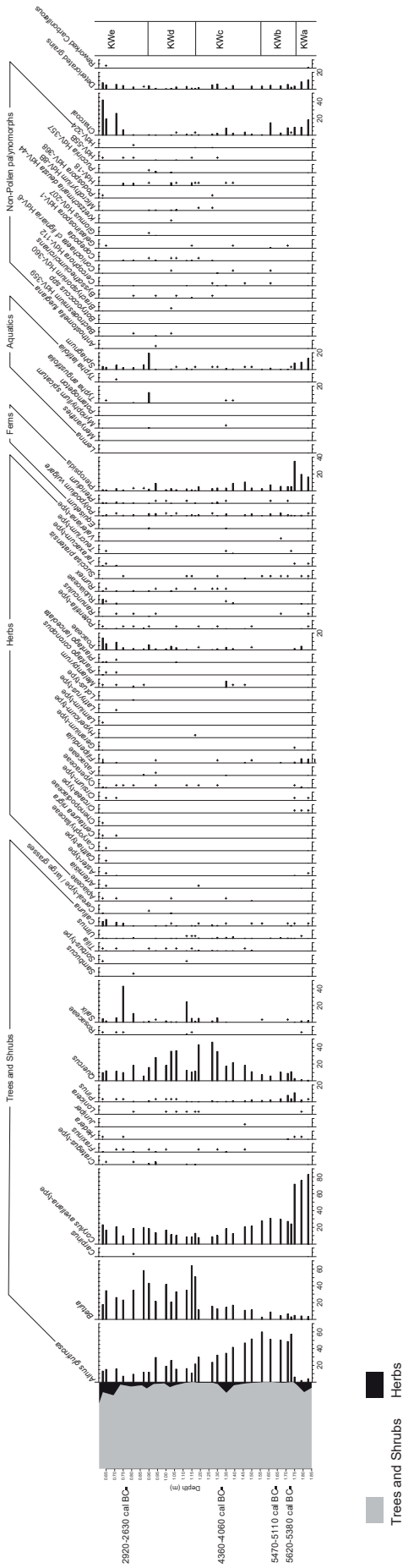


Figure 122: Pollen diagram for the monolith from the Lower Moss Side Farm peat deposit, Kingsway

Interpretation

Decreasing values in pollen of alder and hazel-type were mirrored by an increase in birch and particularly oak, which peaked at more than 40% towards the top of the zone. The presence of pollen of a more diverse herb community suggests the possible presence of open areas in or adjacent to woodland. Of interest is the presence of pollen of cow-wheat, the curve showing up as a small peak within this zone. A radiocarbon date of 4360-4060 cal BC (5425±50 BP; SUERC 7972; Appendix 2) indicates sediments of late Mesolithic age at 1.32 m, just above the cow-wheat pollen peak. Cow-wheat is usually taken as an indicator of the opening of woodland canopies on acid soils (Simmons and Innes 1996; Innes and Blackford 2003) and has been associated with woods, scrub, and heathland (Stace 2010). Pollen of heather, which is known from heaths, moors, bogs, and open woodland, often on peaty soil (*ibid*), was consistently present. Both cow-wheat and heather appear to grow in areas that have been subjected to fire (Simmons and Innes 1996; Innes et al 2004), and a small charcoal peak was also evident within the middle of this zone, providing evidence of fires in the vicinity. In addition, bracken also occurs in disturbed habitats, especially burnt and grazed areas (Behre 1981), and this was continuously present at Kingsway, from the point at which cow-wheat reached its greatest abundance.

Overall, the pollen data in this zone suggest a probable clearance event, reducing both alder and hazel-type/myrtle scrub and allowing open areas supporting grasses and herbs, such as docks/sorrels, meadowsweet, cinquefoils, and cow-wheat, to develop. Following the clearance, oak woodland expanded to record values at the top of the zone. It is interesting that, throughout this zone, the fungal spore *Cercophora* HdV-112 was sporadically identified. This is coprophilous or can occur on decaying wood, but the presence of *Cercophora* may also be used as an indicator for animal dung in the surrounding area (van Geel and Aptroot 2006). It may have been that late Mesolithic communities utilised fire as a method of clearing space, to encourage animals to browse, though grazing by wild animals could have promoted the development of open areas in or adjacent to the woodland (Moore 2001). Comparable late Mesolithic clearance activity has also been noted in the central Pennines at Soyland Moor (Williams 1985), where a peak in cinquefoils, accompanied by the continuous presence of cow-wheat and a decrease in hazel-type, was dated to c 5950-5200 cal BC (*op cit*, 90).

Zone KWd (1.185-0.92 m)

A distinct increase in birch pollen characterises KWd. Values for alder pollen dropped in comparison with the underlying zone (KWc; p 293), though hazel-type pollen remained largely unchanged, but values for oak

fluctuated from an initial drop to recover through the zone. A peak in willow was recorded in the lower part of the zone and hawthorn (*Crataegus*-type) was present sporadically, while grasses dominated the herb assemblage, with occurrences also of sedges, docks/sorrels, cinquefoils, and devil's-bit scabious. Fern spores and moss spores were also present. A diverse range of non-pollen palynomorphs was recorded, the most significant types being HdV-18, *Microthyrium* HdV-8B, *Byssothecium circinans*, and *Copepoda* HdV-28. Microcharcoal counts were very low.

Interpretation

The zone is marked by a very clear expansion of birch pollen, with reductions continuing in alder, hazel-type, and an initial reduction in values of oak pollen from 40% to 10%. The expansion of birch may be due to the ease with which it was able to spread into gaps created by the decline of other deciduous trees, as it is a fast-growing, light-demanding tree and a colonist of open ground (Atkinson 1992). Both downy birch and silver birch are native trees/shrubs and form woods on light, mostly acid soils, with downy birch favouring wetter and more peaty soils, especially in upland areas (Stace 2010). A peak of willow pollen within the lower part of the zone suggests the development of wet areas, mirroring the regeneration of woody vegetation following burning episodes that has been documented at Soyland Moor, in the central Pennines (Williams 1985).

A very weak record for elm pollen is apparent in the pollen diagram. It may be that the soils were already too poor or had deteriorated on the moor to enable these trees to grow in any substantial numbers, as they prefer rich clay soils (Parker et al 2002). It is likely, but unclear, that the early Neolithic Elm Decline occurred within this zone, as the already low values for elm pollen declined even further to barely present and were associated with sporadic occurrences of both ribwort plantain and cereal-type pollen, accompanied by a slight expansion of grasses. The elm decline is dated to around 3800-4000 BC (c 5000 BP) in the UK (*ibid*).

At Chat Moss, to the south-west, at Nook Farm 3 (Hall *et al* 1995), pollen from the oldest zone (NF3a, 0.55-0.41 m) showed sporadic occurrences of elm and ribwort plantain, but no records of cereal-type pollen, a similar situation to that recorded in Zone KWc and above, in that an alder dominance was replaced by an abundance of birch. Whilst this activity has not been precisely dated at either site, a date from some 0.10 m higher at Nook Farm 3, had a range of 3629-3207 cal BC (4760±60 BP; GU5273), placing this material in the early Neolithic period. The interpretation of the pollen sequence at Nook Farm is that a damp alder-carr was replaced by birch woodland as a result of burning (*ibid*).

Zone KWe (0.92-0.63 m)

Zone KWe is distinguished by a decrease in oak and alder pollen, and a gradual increase in hazel-type pollen. The birch-pollen curve fluctuated, but the general trend, following an initial increase, was one of decreasing values overall. A peak in willow pollen of up to 40% occurred within the middle of the zone, while the upper part is characterised by a gradual increase in heather pollen. The grass pollen curve expanded towards the top and a range of other herbs included pollen of the pinks family (Caryophyllaceae), thistles, sedges, cow-wheat, and ribwort plantain. Fern spores were present in small numbers throughout the zone, and values for *Sphagnum*-moss spores decreased. Pollen of the aquatic plant, the lesser bulrush (*Typha angustifolia*), also had a peak occurrence within the lower part of the zone. Although virtually absent within this lower part, microcharcoal counts increased to 40% at the top.

Interpretation

Light-demanding trees and shrubs, such as birch and hazel-type (Gaillard 2007), dominated the vegetation, along with oak, alder, ash, hawthorn, honeysuckle, and ivy. Wet areas can be assumed from an abundance of willow pollen, which peaked in the middle of the

zone, as well as lesser bulrush, which particularly occurred in the lower part. This has been dated to the late Neolithic period, 2920-2630 cal BC (4230±60 BP; SUERC7971; Appendix 2). An expansion of grass pollen, increasing towards the top of the zone, is indicative of the continuing opening up of the landscape. The pollen curve for heather increased towards the top of the profile and, together with cow-wheat pollen, may indicate the growth of these plant types following fires, and the development of acid moorland at the site (Innes and Blackford 2003; Blackford *et al* 2006). The increase in values for microcharcoal particles provides supporting evidence for burning. The diversity of herb pollen, including taxa such as devil's-bit scabious, ribwort plantain, cinquefoils, the bedstraw family, and docks/sorrels, which are representative of wet meadows, heaths, and pastures (Behre 1981; Stace 2010), may suggest the possible use of the land for pasturing animals (Behre 1981).

Occasional grains of cereal-type pollen may support the occurrence of limited arable cultivation on the moor. Cereal-type pollen included that of both wild and cultivated grasses (Andersen 1979), the two being often difficult to separate, as the dimensions overlap (*ibid*; Tweddle *et al* 2005; Joly *et al* 2007).