APPENDIX 16: POLLEN AND NON-POLLEN PALYNOMORPHS

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Following an initial phase of assessment, archaeological deposits from four of the CNDR sites were subjected to pollen analysis (*cf* OA North 2011a; 2011b). These came from Stainton West, Parcel 32, Knockupworth, and an area examined during the watching brief. Samples were examined from a potential Bronze Age ditch (***50081***, Knockupworth; *Ch 11*), close to Hadrian's Wall, which was probably still open in the Roman period (*Ch 13*); a pre-Roman buried soil (***50072***, Knockupworth; *Ch 11*) sealed beneath the north Vallum mound; a deposit of laminated turf (***51026***, Knockupworth; *Ch 13*), dating to the Iron Age, which was probably used in the construction of the Turf Wall; a putative medieval ditch (***32131***, Parcel 32; *Ch 14*); and a medieval soil (***200106***) that had filled the ditch of the later Neolithic henge (*Ch 14*).

The site forming the focus for analysis was, however, Stainton West, where, given its nature and significance, numerous pollen sub-samples were analysed, mainly from deposits contained within the *Principal palaeochannel*. The aim was to analyse deposits where pollen was seen at assessment stage to be well preserved and which could be related to the stratigraphic sequence within the channel, taking into consideration lateral variations and the complexities associated with the lower and upper parts of the sequence. In an attempt to correlate human activity with the pollen sequences, the analysis focused on sections where the wooden tridents had been found (*Ch 8*), as well as features associated with clear human activity, principally Burnt Mound 2 (*Ch 11*).

Quantification

Initially, 174 sub-samples from 42 monoliths were assessed from the *Principal palaeochannel* (OA North 2011b). Based on this, 11 monoliths were selected for analysis, mostly from Bays B, V, F, D, and O, though one came from Burnt Mound 2 (Fig 641). From these monoliths, 275 sub-samples were analysed (Table 295).

The main pollen reference section was close to the northern end of the excavated palaeochannel (Bay B, monoliths 70222/71155). This comprised a monolith (70222) extracted from the middle of Bay B, with a second (71155) from underlying Bay V. Together, these sampled the deep accumulation of organic deposits in this part of the channel, including those associated with one of the wooden tridents (Trident 1; *Ch 8*). These two monoliths overlapped, to ensure that no deposit was missing from the combined section. Further to the south-west, two other monoliths (70225 and 71158) were also extracted from Bay B/V, to sample those deposits not present in the main reference section. In addition, the upper deposit from the north-eastern part of Bay B was analysed (monolith 70219), again to enable the examination of pollen within deposits that were not present in the main reference section.

Two monoliths (70252 and 70250), from the middle and eastern side of Bay F towards the southern end of the excavated palaeochannel, were analysed to provide coverage of sediment sequences in this part of the channel. Similarly, at the far northern end, a monolith (70507) from the south-west part of Bay O was analysed, which sampled more recent accumulations than those in Bays B, D, and F. In this instance, it was anticipated that analysis would provide pollen records that could be added to the data from Bay B, to extend the pollen sequence and provide, in turn, insights into the more recent palaeoenvironmental history of the site. Selected pollen data from monolith 70513, from the north-eastern part of Bay O, focused on deposits present only there.

Of the remaining monoliths analysed, one (70296) was from Bay D, analysis focusing on pollen that had accumulated prior to, and following, the deposition of the second wooden trident (Trident 2; *Ch 8*). The last monolith (70235) analysed was derived from Burnt Mound 2 and it was anticipated that this would provide some information on the environment that existed at the time of its use, during the last two centuries of the third millennium BC (*Ch 11*).

In total, 38 sub-samples from 17 monoliths were initially assessed for pollen from the other sites (OA North 2011a; *above*). On the basis of this, 40 sub-samples were selected for analysis (Table 296).

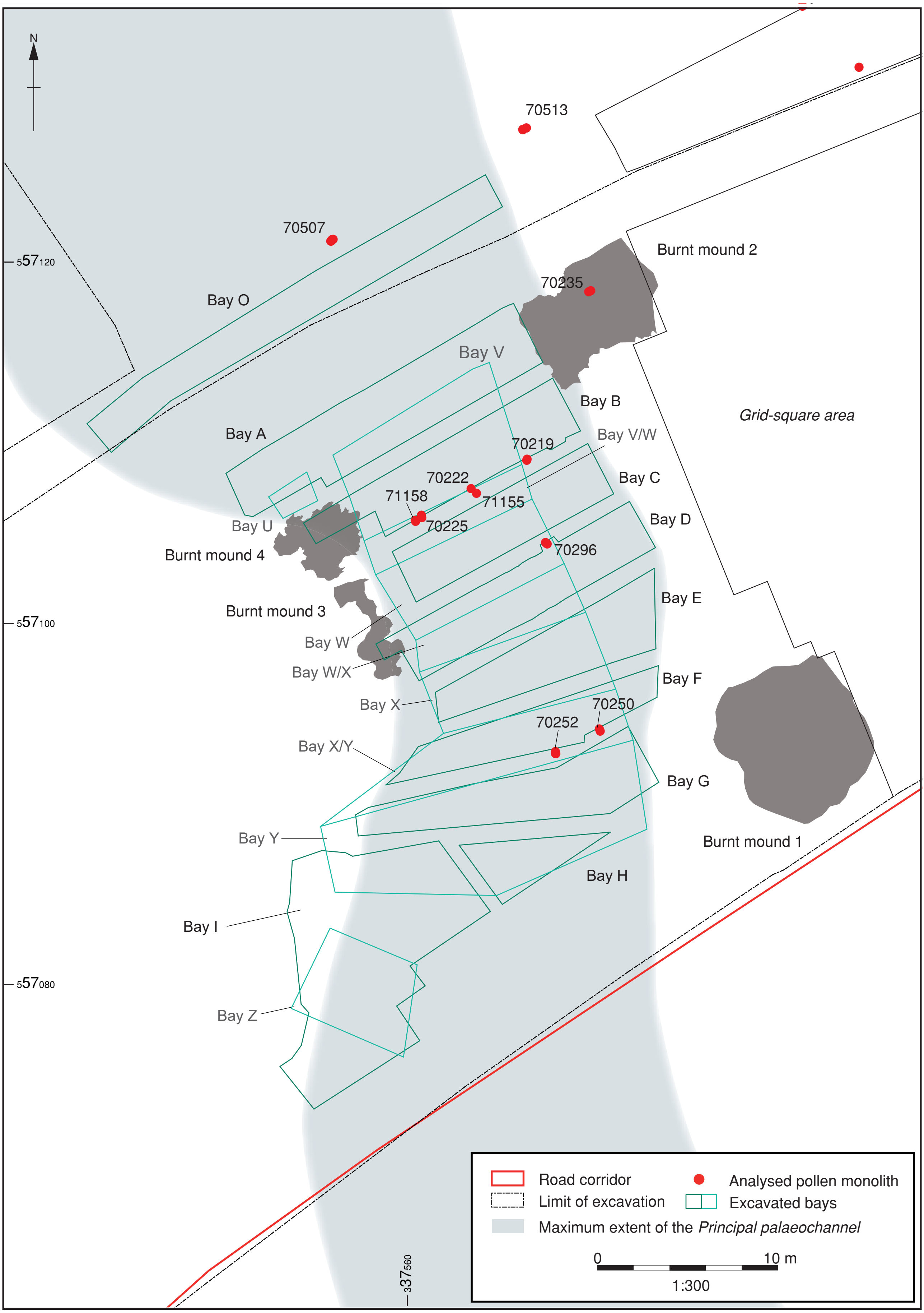


Figure 641: Pollen monoliths analysed from Stainton West

Bay/feature	Monolith	Monolith location	Trident locations	Depth analysed (m)	Number of sub-samples analysed
Bay B	70222	Centre of bay	Trident 1	0.02-1.06	53
	70225	Towards south-west of bay		0.32-1.06	29
	70219	Towards north-east of bay		0.08-0.12	3
Bay D	70296	Centre of bay	Trident 2	0.20-0.46	14
Bay F	70250	Edge (east) of bay		0.22-0.76	28
	70252	East of centre in bay		0.04-0.70	34
Bay O	70507	Edge (south) of bay		0.12-1.08	49
	70513	Edge (north) of bay		0.22-0.46	13
Bay V	71155	Centre of bay		0.02-0.30	15
	71158	Towards south-west of bay		0.02-0.48	24
Burnt Mound 2	70235	On eastern edge of channel adjacent to Bay A		0.04-0.28	13
				Total	***275***

Table 295: Sub-samples analysed for pollen from the Principal palaeochannel *at Stainton West*

Methodology

Sub-samples from each monolith were taken 0.02 m apart, to determine major changes in the palaeoenvironmental sequence, such as clearance events and the Elm Decline. Volumetric samples (1 cc) were taken from each 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 total of between 300 and 500 pollen grains was counted, depending on richness and preservation of pollen.

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. Plant nomenclature follows Stace (2010). Charcoal particles greater than 5 μm were also recorded (Peglar 1993), and non-pollen palynomorph (NPP) identification and taxonomy follow van Geel (1978) and van Geel and Aptroot (2006). NPP are prefixed by HdV (corresponding to their listing in the NPP catalogue in the Hugo de Vries laboratory, University of Amsterdam, Netherlands).

Calculation and Presentation of Results

Pollen data have been presented as percentage diagrams using the computer programs TILIA-GRAPH and TG-View (Grimm 1991-2011). For the Stainton West pollen diagrams, the percentage values are based on a pollen sum of total land (trees, shrubs, crops, and herbs) pollen (TLP), but excludes ferns and aquatic taxa, as well as *Sphagnum*-moss spores, fungal spores, algae, and other non-pollen palynomorphs. For the pollen diagrams from the other three sites, fern spores are included in the TLP sum. 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. NPP

Site	Sample No	Feature	Depths (m)	Number of sub-samples analysed
Parcel 32	32046	Ditch ***32131***	0.26-0.80	15
Knockupworth	50000	Buried soil ***50072***	0.07-0.23	5
	50013	Ditch deposits ***50081***	0.12-0.48	10
	51023	Turf deposits ***51026***	0.10	1
'Henge Field'	250006/7	Henge ditch ***200108***	0.40-1.36	9
			Total	***40***

Table 296: Sub-samples analysed for pollen from Parcel 32, Knockupworth, and the henge monument

(inclusive of fungal spores) are expressed as a percentage of the pollen sum plus the NPP counts. Counts for dinoflagellate cysts (or dinocysts), which are the cysts of dominantly marine plankton (but some forms are tolerant of less saline conditions), are expressed as a percentage of the pollen sum plus the dinocyst count. Taxa representing rare occurrences are recorded with a plus sign, whilst deteriorated grains are displayed on the pollen diagram and include crumpled, broken, concealed, or corroded examples. Pollen grains, positively identified as reworked Carboniferous miospores, are also indicated on the pollen diagram. For each diagram, context numbers are displayed on the lithology column, and interpreted pollen zones and relevant lithological entities are also shown. Abbreviations have been used to denote each stratigraphic entity. Pollen count sheets and the residues of prepared samples form part of the site archive, with raw pollen counts having been exported from TILIA-GRAPH (*ibid*) and stored as digital data on the CNDR Finds Database.

Taphonomy and Interpretation

The approach adopted was to explore several possible interpretations for the taphonomy of the pollen assemblages and to use supporting site data (*ie* waterlogged plant remains (*Appendix 17*), charred plant remains (*Appendix 18*), wood (*Appendix 13*), and soil micromorphology (*Appendix 19*), as well as published research data, to aid the interpretation. However, there are several taphonomic processes and interpretative problems inherent in the application of palynological analysis in sediments from fluvial and estuarine settings relevant to Stainton West, and these have implications for palaeoenvironmental reconstruction (Nayling and Caseldine 1997).

The taphonomic processes leading to the accumulation and preservation of pollen in alluvial sediments are complex and pollen may derive from a variety of sources, possibly representing airborne pollen; pollen derived from pastoral and arable environments; from fen-carr woodlands; from aquatic and mire communities; from wet meadows or from grassland areas subject to flooding either by freshwater, brackish, or marine water; contemporary pollen from either upstream or downstream, or both; that eroded from older alluvial sediments; and derived from anthropogenic activities, such as coppicing or pollarding, or as a result of animal trampling, or beaver activity (*ibid*). More generally, the productivity, dispersal, and germination of seeds can also skew the fossil record, due to natural factors, such as dispersal by animals and birds. Despite these difficulties, valuable palaeoenvironmental data can be obtained from alluvial deposits and palaeochannel sequences, especially in an archaeological setting, when layered deposits are available for analysis. This pollen analysis is of particular value, as regularly spaced samples through continuously deposited sediments provide a relatively coherent picture of palaeoenvironmental change.

There are also some complications in the use of certain taxa, such as cereal-type pollen, as this includes material from both wild and cultivated grasses (Poaceae; Andersen 1979). Moreover, the parameters for cereal identification for barley (*Hordeum* sp), in particular, overlap significantly with those for wild grasses such as sweetgrass (*Glyceria* sp; Joly *et al* 2007). However, it may be that, with care, it is possible to distinguish between many wild taxa and the cultivated genera, barley, oats (*Avena* sp), rye (*Secale* sp), and wheat (*Triticum* sp; Tweddle *et al* 2005). This separation is important, as wild grasses are found in maritime, wetland, and waste-ground habitats (*ibid*), whereas cultivated grasses are indicators of arable farming and, as such, their presence or absence allows for the interpretation of anthropogenic land-use. This is especially pertinent when there is an absence of supporting plant macrofossil evidence or incomplete archaeological evidence.

Results: Stainton West

At Stainton West, the pollen data provide a continuous stratigraphic history of vegetation change. The oldest pollen sequences (Late Mesolithic to Neolithic) were present in Bays B/V, F, and D, whilst younger pollen sequences (later Neolithic to Bronze Age) were present within Bays B, D, F, O, and Burnt Mound 2. The pollen sequences from these individual monoliths allowed for the construction of five main pollen superzones (CNDR 1-5) for the palaeochannel and adjacent area. These were created by identifying and correlating similar pollen assemblages across the bays (through a consideration of the biostratigraphy of each monolith), and correlated assemblages were then dated using radiocarbon assay (Table 297).

Pollen superzones

CNDR 1

The earliest superzone comprises the *Mesolithic organic deposit* (*Ch 3*), the *Mesolithic alluvium*, and the *Mesolithic/Neolithic alluvium* (*Ch 6*) stratigraphic units and was present across the *Principal palaeochannel*, in Bays B (monoliths 70222/71155 and 70225/71158) and F (monoliths 70250 and 70252). It is characterised by the dominance of tree pollen, in particular hazel-type (*Corylus avellana*-type), oak (*Quercus* sp), and elm (*Ulmus* sp), but, unusually, relatively little alder (*Alnus glutinosa*). A series of plant macrofossils was radiocarbon dated (Table 298), which suggests that it

Pollen superzones/ stratigraphic unit	Bay B/V Monoliths 70225/71158	Bay B Monolith 70222/71155	Bay F Monolith 70252	Bay F Monolith 70250	Bay D Monolith 70296	Bay O Monolith 70507	Bay O Monolith 70513	Bay B monolith 70219	Burnt Mound 2 Monolith 70235
CNDR 5: Middle Bronze Age or younger (BA/IAA)						Grasses/sedges			
CNDR 4: Early Bronze Age (land-surface ***70486***; BAA; Burnt Mound 2)						Alder/grasses (correlation)	Alder/grasses (correlation)		Alder/grasses Radiocarbon assays SUERC-32714 SUERC-42015
CNDR 3: later Neolithic and Chalcolithic (LNOD; CA)		Alder/hazel/oak Radiocarbon assays SUERC-44745 SUERC-44746 SUERC-47189 SUERC-47188	Alder carr Radiocarbon assays SUERC-44768 SUERC-44767		Alder/hazel/ oak Radiocarbon assays SUERC-44785 SUERC-44786	Alder/hazel/ oak		Alder/hazel/ oak (correlation)	
CNDR 2: earlier Neolithic (ENOD; ENA)		Alder rise Elm Decline Demise Radiocarbon assays SUERC-44742 SUERC-44737 SUERC-44738 SUERC-48334 Elm Decline (start) Radiocarbon assays SUERC-44735 SUERC-44736 SUERC-44733 SUERC-44734	Elm Decline Radiocarbon assays SUERC-44765 SUERC-44766	Alder rise Elm Decline Demise (correlation) Elm Decline (start) (correlation)	Alder rise Elm Decline Demise Radiocarbon assays SUERC-44784 SUERC-44783 Elm Decline Radiocarbon assays SUERC-47197 SUERC-47198				
CNDR 1: Later Mesolithic (MOD; MA; M/NA)	Hazel/oak/elm Radiocarbon assays SUERC-47186 SUERC-47187 SUERC-44754 SUERC-44753 SUERC-44747 SUERC-44748	Hazel/oak/elm Radiocarbon assays SUERC-47190 SUERC-47191 SUERC-44743 SUERC-44744	Hazel/oak/elm Radiocarbon assays SUERC-44764 SUERC-44762	Hazel/oak/ elm (correlation)					

Key: MOD = *Mesolithic organic deposit*; MA = *Mesolithic alluvium*; M/NA = *Mesolithic/Neolithic alluvium*; ENO = *Earlier Neolithic organic deposit*; ENA = *Earlier Neolithic alluvium*; LNO = *Later Neolithic organic deposit*; CA = *Chalcolithic alluvium*; BAA = *Bronze Age alluvium*; BA/IAA = *Bronze Age/Iron Age alluvium*
Note: Correlations based on pollen assemblages that have been radiocarbon dated by plant macrofossils or charcoal taken from the monoliths analysed for palynology

Table 297: Correlation of the pollen superzones at Stainton West

Entity	Monolith	Context	Laboratory code	Radiocarbon date BP	$\delta^{13}C$ (‰)	Calibrated date range (95%)	*Posterior density estimate* (95% confidence)	Plant macrofossil	Comment
Mesolithic organic deposit	71158	***71129*** (group ***71097***)	SUERC-47186	6346±39	-27.5	5470-5220 cal BC	*5470-5220 cal BC*	Immature hazelnut (*Corylus avellana*)	Residual item? (*Terminus post quem*)
			SUERC-47187	6207±39	-29.7	5300-5050 cal BC	*5290-5050 cal BC*	Hazel roundwood	
		71089 (group ***71096***)	SUERC-44754	6237±35	-29.1	5310-5060 cal BC	*5210-5000 cal BC*	Alder/hazel (*Alnus/ Corylus*) roundwood twig **77017**	
			SUERC-44753	6142±35	-30.3	5220-4490 cal BC	*5310-5060 cal BC*	Hazelnut (*Corylus avellana*)	
	70225	***70226*** (group ***70228***)	SUERC-44747	6065±35	-26.2	5060-4840 cal BC	*5190-4890 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-44748	5959±35	-26.0	4940-4720 cal BC	*4990-4870 cal BC*	Indeterminate twig **77006**	-
Mesolithic alluvium	70252	***70345***	SUERC-44764	5093±35	-28.8	3970-3790 cal BC	*4320-4040 cal BC*	Hazelnut (*Corylus avellana*)	-
			SUERC-44762	5379±35	-27.4	4340-4060 cal BC	*4040-3910 cal BC*	Blackthorn-type (*Prunus* sp) seeds	
Mesolithic/ Neolithic alluvium	70222	***70317*** (group ***70302***)	SUERC-47190	6005±39	-27.8	5000-4790 cal BC	*5000-4790 cal BC*	Hazelnut (*Corylus avellana*)	Residual item? (*Terminus post quem*)
			SUERC-47191	5802±39	-28.6	4770-4540 cal BC	*4730-4530 cal BC*	Elm (*Ulmus* sp) twig **77001**	
			SUERC-44743	5301±35	-24.5	4240-4000 cal BC	*4250-4040 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-44744	5443±35	-27.7	4360-4230 cal BC	*4360-4170 cal BC*	Elm (*Ulmus* sp) twig **77005**	

Note: The dated plant macrofossils were derived from the analysed pollen monoliths

Table 298: Radiocarbon dates for pollen superzone CNDR 1, Stainton West

spanned the late sixth and fifth millennia BC (setting aside dates from potentially residual and intrusive materials; *Appendix 20*).

CNDR 2

Above this was a superzone (CNDR 2), comprising the *Earlier Neolithic organic deposit* and the *Earlier Neolithic alluvium* stratigraphic units (*Ch 8*), characterised by declining values for elm pollen. Within the UK, the extent and magnitude of such declines (Elm Decline) vary from site to site (Parker *et al* 2002), though, significantly, detailed pollen analysis at Stainton West has permitted the identification of a local Elm Decline sequence. This was composed of an initial decline in elm pollen values (Elm Decline (ED)), followed by the point at which elm values declined to absence, or merely presence only (Elm Decline Demise (EDD)). The expansion of alder pollen is another event characteristic of this superzone (*Ch 8*).

In Bay B (monoliths 70222/71155), the start of the Elm Decline appears in the latest part of the *Earlier Neolithic organic deposit*, whilst the demise (EDD) occurred within the *Earlier Neolithic alluvium*. Similarly, in Bay D (monolith 70296), although this demise was initially thought to occur within the *Earlier Neolithic organic deposit*, detailed stratigraphic analysis indicates that these events also occurred within the *Earlier Neolithic alluvium* (*Ch 8*). Declining elm-pollen values were also detected in the *Earlier Neolithic organic deposit* and *Earlier Neolithic alluvium* in Bay F, whilst in one monolith (70250), the demise occurred in the *Earlier Neolithic alluvium*.

Superzone CNDR 2 has been radiocarbon dated using plant macrofossils from the monoliths analysed for pollen (Table 299). These indicate that this pollen zone spans the early and mid-fourth millennium BC.

CNDR 3

The third superzone comprises the *Later Neolithic organic deposit* and the *Chalcolithic alluvium* stratigraphic units, as well as a deposit of alluvium contained in a possible Chalcolithic-age reactivation channel (*Ch 11*). It is characterised by the consolidation of alder on the floodplain and the relatively consistent presence of hazel-type and oak pollen. These palynological events were again seen in both organic deposits and alluvium, being present in Bay B (monoliths 70222 and 70219), Bay D (monolith 70296), Bay F (monolith 70252), and Bay O (monolith 70507).

The age of this superzone has been established by the modelled radiocarbon ages of CNDR 2 (*above*) and CNDR 4 (Burnt Mound 2; *below*), although several plant macrofossils, from contexts analysed for pollen, have also provided radiocarbon dates between *3360-3170 cal BC* (*SUERC-44785*) and *2220-2060 cal BC* (*SUERC-44746*; Table 300). In addition, plant macrofossils, probably from the Chalcolithic reactivation channel, have been dated to *2410-2190 cal BC* (*SUERC-44768*) and 1500-1300 cal BC (3142±35 BP; SUERC-44767); the latter date is, however, probably derived from intrusive material (*Appendix 20*).

CNDR 4

The fourth superzone is characterised by the expansion of alder and grasses, but was confined to deposits associated with Burnt Mound 2 (*Ch 11*), and also several from Bay F (monolith 70252) and Bay O (monoliths 70507 and 70513), within the *Bronze Age alluvium*, buried land-surface ***70486***, and the earlier part of *Bronze Age/Iron Age alluvium*. Chronological modelling (*Ch 1*; *Appendix 20*) suggests that the first use of Burnt Mound 2 dates to *2150-2030 cal BC* (*'First Burnt Mound 2'*), whilst its last use occurred in *2140-1980 cal BC* (*'Last Burnt Mound 2'*). The latest deposit in this sequence was the *Bronze Age/Iron Age alluvium*, which sealed the last burnt mound (Burnt Mound 3) at Stainton West (*Ch 11*). Chronological modelling suggests that the use of Burnt Mound 3 occurred between *1730-1520 cal BC* (*'Start Burnt Mound 3'*), and *1610-1370 cal BC* (*'End Burnt Mound 3'*). The dating evidence therefore indicates that this superzone spans the very end of the third millennium BC and, at least, the earlier part of the second millennium BC.

CNDR 5

This uppermost superzone was identified in two monoliths (70507 and 70513) from Bay O, which largely sampled sediments associated with a buried subsoil. It comprises an expansion of grasses and sedges, and a drastic reduction in alder pollen. This material has not been dated, but it is possible that it could have formed in the second half of the second millennium BC, or possibly later.

Detailed pollen data

Detailed pollen data are presented in terms of the excavated bays, and are arranged in stratigraphic order from oldest to youngest. The results for each monolith analysed are presented as pollen (percentage) diagrams and these are zoned, where appropriate. The zones are initially described and then interpreted, under the relevant superzone designation (CNDR 1-5; *above*), followed by the zone label, depth (core depth and height above Ordnance Datum (OD)), and stratigraphic unit or units.

Bay B: 70222/Bay V: 71155

Monoliths 70222 and 71155 were extracted from the centre of Bay B and the stratigraphically earlier Bay V. The monoliths overlapped and sampled the *Basal sands and gravels* and most of the overlying stratigraphic units present in the *Principal palaeochannel*, apart from

Entity	Monolith	Context	Laboratory code	Radiocarbon date BP	$\delta^{13}C$ (‰)	Calibrated date range (95%)	*Posterior density estimate* (95% confidence)	Plant macrofossil	Comment
Earlier Neolithic organic deposit	70222	***70308*** (group ***70301***)	SUERC-44735	4976±35	-27.3	3930-3650 cal BC	*3930-3740 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-44736	5036±35	-30.0	3950-3710 cal BC	*3930-3740 cal BC*	Alder (*Alnus glutinosa*) twig **77002**	
			SUERC-44733	4973±35	-25.9	3920-3650 cal BC	*3930-3720 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-44734	5028±35	-28.5	3950-3710 cal BC	*3930-3720 cal BC*	Alder (*Alnus glutinosa*) twig **77000**	
	70252	***70346*** (group ***70301***)	SUERC-44765	4972±35	-25.5	3920-3650 cal BC	*3900-3690 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-44766	4973±35	-27.7	3920-3650 cal BC	*3790-3660 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-44768	3867±35	-29.5	2470-2200 cal BC	*2410-2190 cal BC*	Alder (*Alnus glutinosa*) twig **77009**	From Chalcolithic reactivation channel
			SUERC-44767	3142±35	-28.2	1500-1300 cal BC	-	Alder (*Alnus glutinosa*) twig **77008**	Intrusive item
	70296	***70315*** (lower fraction)	SUERC-47197	4801±39	-25.2	3660-3380 cal BC	*3710-3650 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-47198	4909±39	-26.6	3770-3640 cal BC	*3710-3650 cal BC*	Elm (*Ulmus* sp) roundwood **77015**	
Earlier Neolithic alluvium		***70315*** (upper fraction)	SUERC-44783	4769±35	-30.6	3650-3380 cal BC	*3640-3490 cal BC*	Alder (*Alnus glutinosa*) twig **77014**	
			SUERC-44784	4775±35	-30.8	3650-3380 cal BC	*3640-3520 cal BC*	Alder (*Alnus glutinosa*) twig **77012**	
	70222	***70187*** (group ***70135***)	SUERC-44742	4978±35	-31.7	3930-3660 cal BC	*3690-3640 cal BC*	Alder (*Alnus glutinosa*) twig **77004**	Residual item?
			SUERC-44737	4526±35	-24.2	3370-3090 cal BC	-	Hazelnut (*Corylus avellana*)	Residual item?
			SUERC-44738	4688±35	-30.4	3630-3360 cal BC	*3640-3420 cal BC*	Alder wood	
			SUERC-48334	4730±34	-27.5	3640-3370 cal BC	*3620-3370 cal BC*	Hazelnut (*Corylus avellana*)	

Note: The dated plant macrofossils were derived from the analysed pollen monoliths

Table 299: Radiocarbon dates for pollen superzone CNDR 2, Stainton West

Entity	Monolith	Context	Laboratory code	Radiocarbon date BP	$\delta^{13}C$ (‰)	Calibrated date range (95%)	*Posterior density estimate* (95% confidence)	Plant macrofossil	Comment
Later Neolithic organic deposit	70296	***70314*** (group ***70300***)	SUERC-44785	4534±35	-26.4	3370-3100 cal BC	*3360-3170 cal BC*	Hazelnut (*Corylus avellana*)	
			SUERC-44786	4478±35	-29.1	3350-3020 cal BC	*3360-3170 cal BC*	Indeterminate twig **77013**	
	70222	***70307*** (group ***70300***)	SUERC-47188	3693±39	-24.3	2200-1960 cal BC	*2290-2110 cal BC*	Hazelnut (*Corylus avellana*)	At interface between *Later Neolithic organic deposit* and *Chalcolithic alluvium*
			SUERC-47189	3758±39	-26.4	2300-2030 cal BC	*2290-2110 cal BC*	Hazel (*Corylus avellana*) roundwood charcoal	
Chalcolithic alluvium		***70306*** (group ***70299***)	SUERC-44745	4530±35	-24.2	3370-3100 cal BC	*3370-3100 cal BC*	Hazelnut (*Corylus avellana*)	Residual? (*Terminus post quem*)
			SUERC-44746	3750±35	-25.9	2290-2030 cal BC	*2220-2060 cal BC*	Hazel (*Corylus avellana*) charcoal	
Alluvium in Chalcolithic-age reactivation channel	70252	Interface between deposit ***70346*** (group ***70301***) and ***70307***	SUERC-44767	3142±35	-28.2	1500-1300 cal BC	-	Alder (*Alnus glutinosa*) twig **77008**	Intrusive item
			SUERC-44768	3867±35	-29.5	2470-2200 cal BC	*2410-2190 cal BC*	Alder (*Alnus glutinosa*) twig **77009**	From Chalcolithic reactivation channel

Note: The dated plant macrofossils were derived from the analysed pollen monoliths

Table 300: Radiocarbon dates for pollen superzone CNDR 3, Stainton West

Monolith	Depth (m)	Altitude (m OD)	Context	Entity	Description of sediments
70222	0-0.18	+8.92-8.74	***70306***	*Chalcolithic alluvium*	Peaty clay, rich in plant detritus
	0.18-*c* 0.23	+8.74-8.69	***70307***	*Later Neolithic organic deposit*	Peaty clay, plant detritus, some wood
	0.23-0.40	+8.69-8.52	***70187***	*Earlier Neolithic alluvium*	Peaty clay, very woody, herbaceous debris and hazelnut fragments. Large wood chunk at 0.37 m
	0.40-0.48	+8.52-8.44	***70187***		Silt with some large wood pieces (*eg* at 0.48 m, detrital?)
	0.48-*c* 0.63	+8.44-8.29	***70308***	*Earlier Neolithic organic deposit*	Peaty silty clay, very wet; lots of wood fragments and plant remains. Hazelnuts (*Corylus avellana*)
	0.63-0.80	+8.29-8.12	***70317***)	*Mesolithic/Neolithic alluvium*	Peaty clay with abundant plant detritus
	0.80-1.07	+8.12-7.85	?***70059***	*Mesolithic alluvium/ Mesolithic organic deposit*	Dark grey mottled clay with charcoal fragments
Monoliths overlap by 0.80 m					
71155	0-0.21	+8.12-7.91	***71091***	*Mesolithic organic deposit*	Brown humic sandy clay with occasional plant detritus and charcoal
	0.21-0.28	+7.91-7.84	***71140***		Mixed transitional layer between brown humic sandy clay above and grey/ orange clay below
	0.28-0.43	+7.84-7.69	***71142***)		Pale orange sandy clay with organic inclusions
	0.43-0.50	+7.69-7.62	***71001***	*Basal sands and gravels*	Orange sand

Table 301: Continuous stratigraphy for monoliths 70222 and 71155, Bays B and V, Stainton West

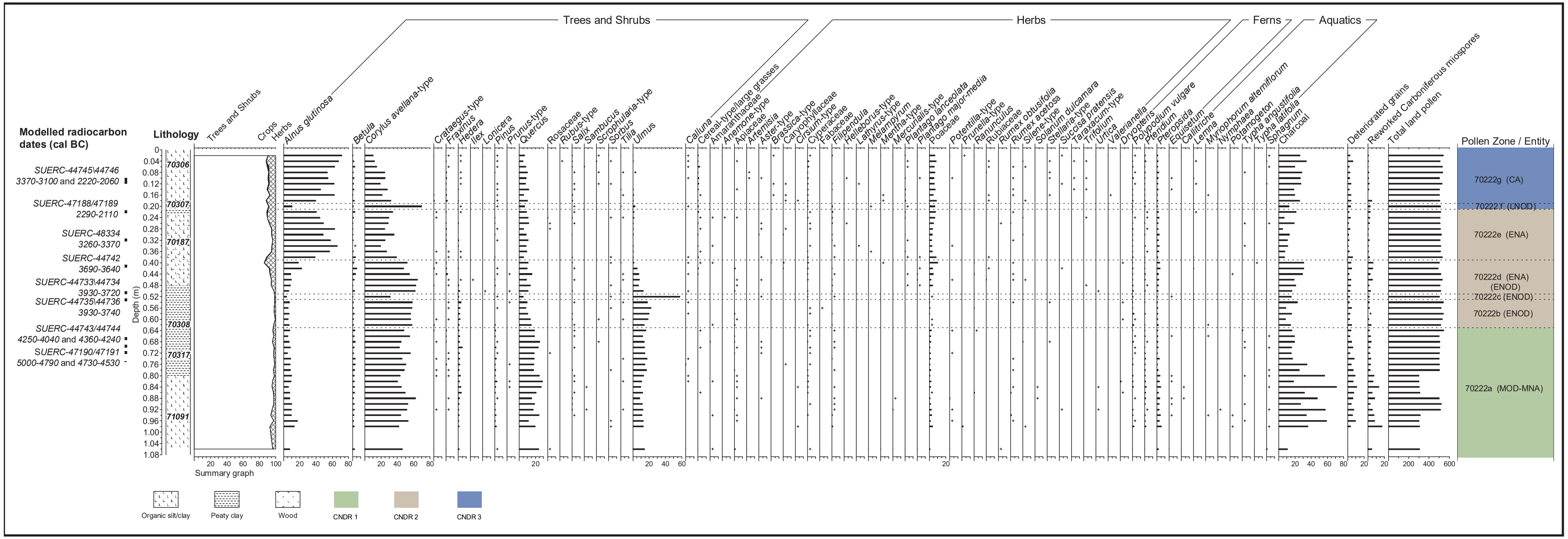
those post-dating the *Chalcolithic alluvium* (Table 301). Together, therefore, they produced valuable pollen data, effectively a master sequence, relevant to pollen superzones CNDR1-3, allowing insights into the Late Mesolithic, Neolithic, and Chalcolithic landscapes in the vicinity of the channel.

CNDR 1: Zone 70222a (1.06-0.63 m; 7.86-8.29 m OD). Mesolithic organic deposit and Mesolithic/Neolithic alluvium: hazel thickets

Arboreal taxa dominate the assemblage, with the main contributors being hazel-type, oak, and elm (*Ulmus* sp). Other tree and shrub pollen includes alder, birch (*Betula* sp), and ivy (*Hedera helix*), with occurrences of pine (*Pinus* sp) and willow (*Salix* sp; Fig 642). Of the dryland and pasture taxa, grass pollen is low, but has a consistent presence, and rare cereal-type/large grass-pollen grains are present. The wood-rot fungal spores, *Coniochaeta xylarispora* (HdV-6) and *Kretzschmaria deusta* (HdV-44), are the most common and consistently recorded within this zone (Fig 643). Microcharcoal values are higher in the lower part of the zone, with lower counts present from 0.74 m (8.18 m OD).

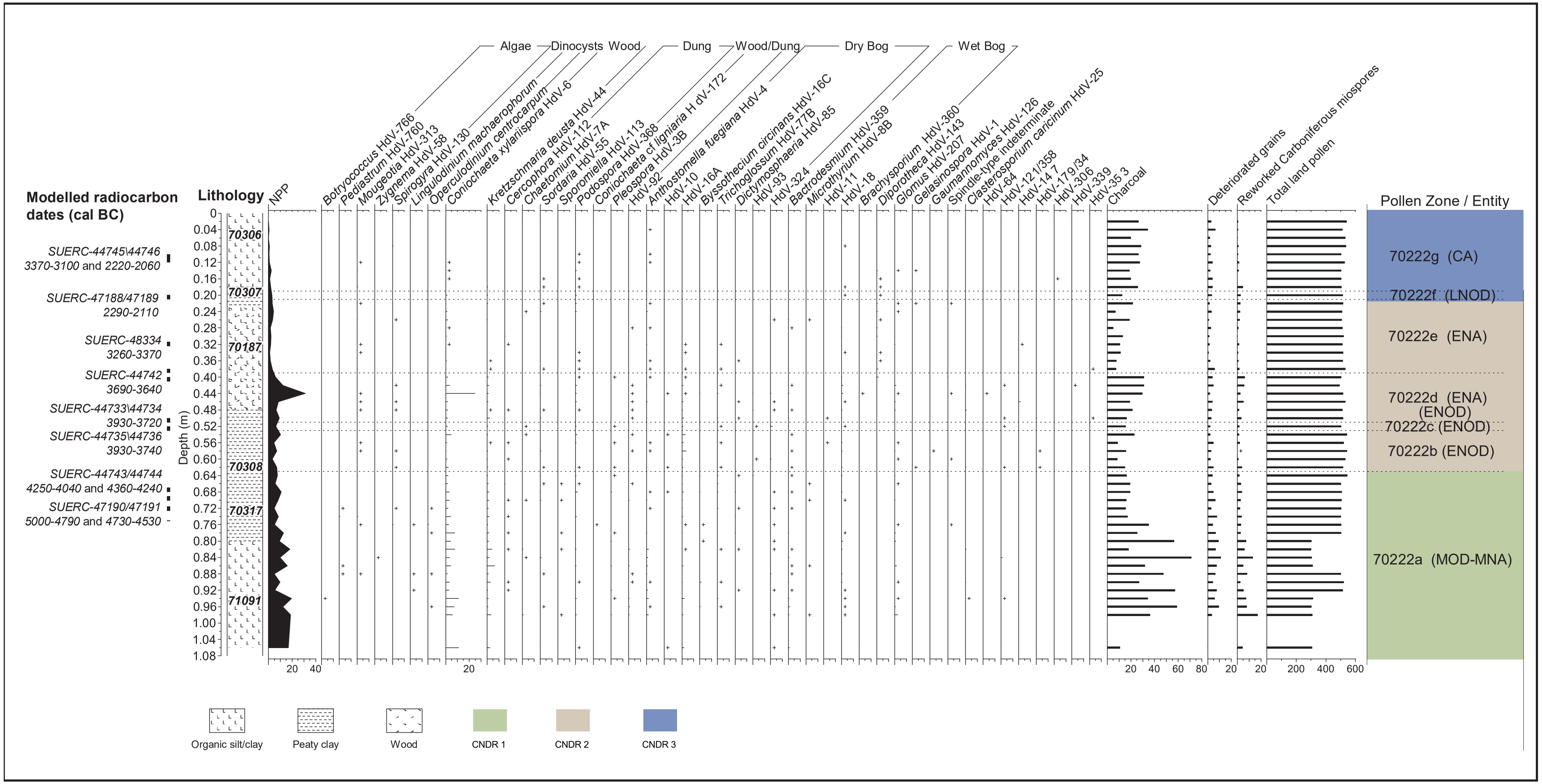
The data suggest that the floodplain at this time was dominated by hazel woodland, probably growing on the drier parts (*cf* Brown 1988), possibly surrounded by mixed oak and elm woodland. The pollen indicates that there was very little alder present and the dominant tree types comprise light-demanding trees and shrubs (*eg* hazel-type), as well as those tolerant of shade (*eg* elm and oak; Gaillard 2007). Although dominantly wooded, openings are indicated by the records for grasses, sedges (Cyperaceae), common sorrel (*Rumex acetosa*), and cinquefoils (*Potentilla*-type), as well as fern spores, including polypodies (*Polypodium vulgare*), bracken (*Pteridium aquilinum*), and undifferentiated monolete spores (Pteropsida). Thus, there was likely to have been limited woodland disturbance, which led to the creation of small, open areas that may have been used by grazing animals.

Any alder grains present may represent a regional source, or potentially small numbers of alder trees growing in wetter areas within the floodplain. There is some evidence to support the existence of such wetter areas, based on the occasional occurrence of pollen of aquatic taxa, such as lesser bulrush (*Typha angustifolia*), as well as *Sphagnum*-moss spores. Freshwater algae (*Pediastrum* (HdV-760) and *Botryococcus* (HdV-766)) were also recorded sporadically, providing additional evidence for aquatic habitats. Occurrences of dinoflagellate cysts, including the marine taxon



Key: MOD= *Mesolithic organic deposit*; MNA= *Mesolithic/Neolithic alluvium*; ENOD= *Earlier Neolithic organic deposit*; ENA= *Earlier Neolithic alluvium*; LNOD= *Later Neolithic organic deposit*; CA= *Chalcolithic alluvium*

Figure 642: Pollen percentage diagram for monolith 70222/71155, Bay B, Stainton West



Key: MOD= *Mesolithic organic deposit*; MNA= *Mesolithic/Neolithic alluvium*; ENOD= *Earlier Neolithic organic deposit*; ENA= *Earlier Neolithic alluvium*; LNOD= *Later Neolithic organic deposit*; CA= *Chalcolithic alluvium*

Figure 643: Non-pollen palymorph percentage diagram for monolith 70222/71155, Bay B, Stainton West

Operculodinium centrocarpum and the estuarine taxon *Lingulodinium machaerophorum*, may represent a weak-saline influence (possibly caused by tidal surges) within the channel at this time. It would appear from the microcharcoal record that fire was used in this setting, perhaps as a tool to encourage browsing animals to the area. Microcharcoal may have resulted from regional and/or local events, as well as being the product of natural fires, although extensive natural fires are thought to occur infrequently in deciduous woodlands (Rackham 1986; Moore 2001).

Fungal spores such as *Chaetomium* (HdV-7a), *Sporomiella* (HdV-113), and *Cercophora* (HdV-112) indicate possible herbivore grazing (van Geel and Aptroot 2006). *Cercophora* (HdV-112) has been used as an indication for animal dung in the surroundings (*ibid*), while *Sporomiella* (HdV-113) spores are considered a reliable proxy for faunal biomass (*ibid*). *Glomus* (HdV-207) points to some ground disturbance/erosion (Anderson *et al* 1984). Of greater significance is the occurrence of relatively substantial numbers of the fungal spores *Coniochaeta xylariispora* (HdV-6) and *Kretzschmaria deusta* (HdV-44), both of which are woodland types and are associated with its demise and decay, through any process that increased the number of injured or dying trees (Innes *et al* 2006). Palaeoecologically, many of the Holocene woodlands in the British Isles contained abundant dead wood (Whitehouse 2006; Whitehouse *et al* 2014). However, *Kretzschmaria deusta* (HdV-44) has been found in pollen assemblages from the Netherlands, in proximity to human habitation dated to the later Mesolithic period (Adema 2002), and thus the significant wood-rot fungi values suggest trees under stress, which could also be linked to Mesolithic woodland management (Innes *et al* 2006). At Stainton West, whilst there is strong evidence from the *Mesolithic organic deposit* for the presence of beaver, there is also evidence for the apparent human working of large oak timbers and for oak and elm-felling debris (*Appendix 13*). This appears to provide direct evidence for such woodland management.

Of the two radiocarbon dates, from plant macrofossils towards the top of the zone (*Appendix 20*), elm wood is dated to *4360-4170* cal *BC* (*SUERC-44744*) at 0.68-0.69 m (8.24-8.23 m OD), whilst a hazelnut, at 0.67-0.68 m (8.25-8.24 m OD), produced a date of *4250-4040 cal BC* (*SUERC-44743*). These dates support the pollen spectra in indicating a Late Mesolithic age for this zone. Reworking of Carboniferous miospores may suggest some recycling or mixing of sediments, as a result of erosion in this fluvial location.

CNDR 2: Zone 70222b (0.63-0.53 m; 8.29-8.39 m OD). Earlier Neolithic organic deposit (part): expansion of elm

Zone 70222b is similar to the material below it, but exhibits a reduction in oak and an expansion of elm; hazel-type and alder curves remain similar to those in Zone 70222a. The fact that other tree-pollen values, such as those for hazel and elm, are seen to increase, or at least remain stable, suggests that the decline in oak may be a product of relative-pollen percentages, or may possibly indicate that oak close to the river was intentionally selected and felled by the local community. Grass pollen is present in very small quantities; wood-rot fungal spores are also present, but in lower numbers than previously.

CNDR 2: Zone 70222c (0.53-0.51 m; 8.39-8.41 m OD). Earlier Neolithic organic deposit (part): elm peak

The single sample shows a dramatic expansion of elm pollen, such that it represents 58% of the total land pollen count. This expansion appears to be mostly at the expense of hazel-type frequencies, but the pollen of other tree types (*eg* alder and oak) is also reduced.

The expansion of elm is a significant event, the sudden abundance of pollen within the profile surely reflecting increased production. Although the reasons for a massive increase in elm pollen is not entirely certain, it could have been created if a tree was standing on the site, through the dropping of pollen-rich anthers. However, if these were the source of the pollen, the clumping of pollen grains might be expected; this was not seen on the analysed slide. Given this, another possibility may have been human intervention, such as tree coppicing, pollarding, or girdling, which would result in enhanced flowering and consequent pollen production (Innes *et al* 2006); significantly, some of the elm roundwood (stake **76229** and roundwoood **76524**) from the *Earlier Neolithic organic deposit* exhibits evidence for coppicing (*Appendix 13*). Beavers also encourage tree growth, by the coppicing of trees, which creates thin, long stems that are dragged into the channel to create dams or lodges (Coles 2006), and the roundwood assemblage from the *Earlier Neolithic organic deposit* provides firm evidence for the presence of beaver activity (*Appendix 13*). The increase in elm pollen is offset by a decrease in that of hazel and oak.

Several modelled radiocarbon dates have been obtained from plant macrofossils from this section (*Appendix 20*). An alder twig and hazelnut shell at 0.53-0.5 m (8.39-8.40 m OD) produced a date of *3930-3740* cal *BC* (*SUERC-44735/6*), whilst at 0.52 m (8.40 m OD), an alder twig and a hazelnut shell provided a date of *3930-3720 cal BC* (*SUERC-44733/4*).

CNDR 2: Zone 70222d (0.51-0.39 m; 8.41-8.53 m OD). Earlier Neolithic organic deposit (part) and Earlier Neolithic alluvium (part): the Elm Decline

In zone 70222d, elm-pollen values dropped drastically and continued to decline; between 0.50 m (8.42 m OD) and 0.40 m (8.52 m OD), the values in elm declined by 11.5%. This fall is mirrored by an expansion of hazel-type pollen. The curve for grass pollen is consistent and rising from the beginning of the zone. The curves for ribwort plantain (*Plantago lanceolata*) and cereal-type pollen grains are more or less continuous from 0.48 m (8.44 m OD) and 0.44 m (8.48 m OD) respectively. A peak expansion of the fungal spore *Coniochaeta xylarispora* (HdV-6) at 0.44 m (8.48 m OD) and an increase in numbers of *Kretzschmaria deusta* (HdV-44) were also recorded. Charcoal values, although initially low, appeared to rise throughout this zone.

A step-wise decline in elm is indicated, coincident with the start of the curve for ribwort plantain. Cereal-type pollen is consistently present from 0.44 m. As has been extensively documented in the pollen records of the Elm Decline (for instance, at Burnfoothill Moss, Dumfriesshire; Tipping 1995a), evidence for more open pastureland and cultivation becomes apparent in the pollen record, though prior to this, other indicators of changing woodland structure include evidence for increased openness in the canopy cover. The pollen of ash (*Fraxinus excelsior*), a tree which takes advantage of open spaces (Forestry Commission 1994), is present sporadically, but becomes consistently present after the Elm Decline. Hawthorn (*Crataegus*) is also known to colonise open ground rapidly (Muir 2005, 50) and the pollen is sporadically present both before and after the Elm Decline; hawthorn fruits are present in the plant macrofossil assemblage in both the *Earlier Neolithic organic deposit* and *Earlier Neolithic alluvium* stratigraphic units (*Appendix 17*). The consistent occurrence of ivy, especially prior to the Elm Decline, is interesting; its representation may imply an increased population of dead host trees (Garbett 1981), or may possibly indicate an opportunistic presence in more open woodland.

At Stainton West, the start of both the Elm Decline and the Elm Decline Demise are well dated. Specifically, Trident 1, associated with the *Earlier Neolithic organic deposit*, from the vicinity of monolith 70222 (*Ch 8*), has been dated to the *3900-3660 cal BC* (*SUERC-26379*), this date correlating well with the start of the Elm Decline (*Appendix 20*). A date from an alder twig (*3690-3640 cal BC*; *SUERC-44742*) at 0.40 m (8.52 m OD) indicates the lower boundary of the Elm Decline Demise, whilst dates from a second alder twig and a hazelnut shell, at 0.38-0.39 m (8.54-8.53 m OD), bracket its upper boundary. That alder twig produced a date of *3640-3420* cal *BC* (*SUERC-44738*), whilst the hazelnut was dated to 3370-3090 cal BC (4526±35 BP; SUERC-44737); however, it is likely that the hazelnut is intrusive (*Appendix 20*). Taken together, these dates suggest that the start of the trend in the decline of elm pollen (as derived from the constraining dates from the elm peak immediately prior to this event; *above*) occurred in *3940-3730 cal BC* (*'Elm peak immediately prior to Elm Decline B'*). Chronological modelling (*Ch 1*; *Appendix 20*) also places the appearance of cereal-type pollen at *3870-3670 cal BC* (*'Cereal-type pollen B'*) and ribwort plantain at *3930-3710 cal BC* (*'Ribwort plantain B'*). The chronological and pollen data therefore show that the site may have been exploited agriculturally over several generations in the Early Neolithic period, possibly for *c* 300 years, causing change in vegetation and some opening up of the landscape. Debris indicating the felling of elm, oak, hazel, and hawthorn-type (Maloideae) trees is also present in the *Earlier Neolithic organic deposit* (*Appendix 13*).

Within Cumbria, the Elm Decline has been dated at Blea and Blelham Tarns to 3944-3643 cal BC (4965±70 BP; SRR-16) and 3773-3521 cal BC (4856±57 BP; SRR-261) respectively (Parker *et al* 2002). Older dates include those from Williamson's Moss for the first of a two-step decline, with a second and more pronounced Elm Decline dated to 3900-3370 cal BC (4850±80 BP; SRR-3068; Bonsall *et al* 1989; Tipping 1994a). A date of 4450-3940 cal BC (5340±120 BP; K-1057) has also been obtained for the upland site at Barfield Tarn (Pennington 1970; 1975). Closer to Stainton West, Burnfoothill Moss, Dumfriesshire, and Solway Moss, Cumbria, two of the Solway's lowland mosses, have produced radiocarbon dates for this event. At Solway Moss, cereal-type pollen from above the Elm Decline was dated to 3350-2890 cal BC (4400±80 BP; GU-5313), although another cereal-type grain, from an adjacent, duplicate monolith, occurring immediately above the level of the Elm Decline, was dated to 4036-3780 cal BC (5110±60 BP; GU-5275), which may perhaps relate to early cereal cultivation (Hodgkinson *et al* 2000, 109-10, 322). At Burnfoothill Moss on the northern shore of the Solway Firth, a date of 3700-3510 cal BC (4820±45 BP; SRR-3755) has been obtained for the Elm Decline (Tipping 1995a; Parker *et al* 2002).

CNDR 2: Zone 70222e (0.39-0.21 m;8.53-8.71 m OD). Earlier Neolithic alluvium (part): spread of alder

As numbers of elm-pollen grains continued to dwindle to zero, hazel-type pollen values also drop, but alder pollen is seen to increase dramatically. Microcharcoal values also plummet throughout the zone, with the exception of the samples at 0.26 m (8.66 m OD) and 0.22 m (8.70 m OD).

This zone corresponds broadly to a lithological change (initiated in Zone 70222d; *above*) from dominantly organic-rich sediments to siltier, less organic, alluvial sediments (*Earlier Neolithic alluvium*), with some detrital wood. This lithological change may reflect a rejuvenation of the channel caused by natural events, perhaps flooding, expressed in the pollen assemblages by a significant and sustained rise in alder. The record suggests that the appearance of the floodplain had now altered, with dominantly alder and reduced hazel-type vegetation covering the area, with some oak woodland, and pine and ash stands, possibly on higher ground, such as the river terraces. The stability of alder on the floodplain suggests the community became the dominant tree species, probably because of waterlogging, since alder has the ability to survive flooding and a rise in the local watertable, by the production of (adventitious) roots from non-root tissues, such as a stem or a leaf (Brown 1988).

The ultimate dominance by alder may relate to changes in the floodplain conditions, such as increasing soil stability and decreasing free drainage, and may be indicative of terrestrialisation of the palaeochannel. Clearances within the floodplain would now appear to have been sustained, although still at a low level, with a continuous-pollen curve for grasses, and continuous curves for both ribwort plantain and cereal-type pollen. The transition to an alder-dominated floodplain has been dated at Stainton West to the earlier Neolithic period (*Appendix 20*). Alder wood produced a date of *3640-3420* cal *BC* (SUERC-44738) at 0.38-0.39 m (8.54-8.53 m OD) and a hazelnut from the same depth returned a date of 3370-3090 cal BC (4526±35 BP; SUERC-44737), though this date is considered too young, since a hazelnut at 0.34 m (8.58 m OD) was dated to *3620-3370* cal *BC* (*SUERC-48334*). The switch of dominance between hazel-type pollen and that of alder has also been dated in Bay D, 70296b, at depths of 0.36-0.38 m (8.52-8.50 m OD; SUERC-44784) and 0.34-0.35 m (8.54-8.53 m OD; SUERC-44783). The combined dating evidence therefore suggests that the mid-fourth millennium BC witnessed the replacement of hazel-type pollen with that of alder on the floodplain.

CNDR 3: Zone 70222f (0.21-0.19 m;8.71-8.73 m OD). Later Neolithic organic deposit

A peak in hazel-type pollen at the expense of alder defines this zone. The apparent swing from an alder-dominated floodplain to one dominated by hazel could possibly be attributed to a lowering of the watertable, resulting in temporary drier conditions. Alternatively, the peak in hazel-type pollen may have been a result of the deposition of hazel catkins within the channel, creating an over-representation of this in the record. Radiocarbon dates from *Later Neolithic organic deposit* **70307** suggest a Chalcolithic/Early Bronze Age date, a hazelnut fragment and hazel charcoal being dated to *2290-2110* cal *BC* (*SUERC-47188/9*; *Appendix 20*). However, these items were found at the interface (0.22 m; 8.70 m OD) between this deposit and the overlying *Chalcolithic alluvium* (***70306***), and as such probably date the later deposit (*below*).

CNDR 3: Zone 70222g (0.19-0.02 m;8.73-8.90 m OD). Chalcolithic alluvium: dominance of alder

The uppermost zone shows dominant alder pollen, with hazel and oak. Dryland/pasture-herb flora, inclusive of grasses, ribwort plantain, and cereal-types, is consistently recorded, while charcoal values reach relatively high proportions.

Hazel-type pollen values continue to decline, perhaps in response to rising values for alder, the latter indicative of a wetter landscape. High values for charcoal suggest burning, and it may be that hazel was being intentionally cleared on the floodplain rather than, or as well as, oak on the terraces. Such clearances would have created open areas for pasture and/or cultivation. Fungal spores provide a little evidence for burning (*Gelasinospora* HdV-1) and for animal grazing (*Podospora* HdV-368; van Geel and Aptroot 2006). Algal taxa, indicative of freshwater environments, are also present (*eg Mougeotia* HdV-313). Hazel charcoal (from 0.10 m; 8.82 m OD; deposit ***70306***) returned a Chalcolithic/Early Bronze Age date of *2220-2060* cal *BC* (*SUERC-44746*), but a hazelnut from the same deposit/depth was dated to *3370-3100* cal *BC* (*SUERC-44745*), though it is thought that this was residual (*Appendix 20*). Two other items, recovered from the interface between this deposit and the underlying *Later Neolithic organic deposit* (***70307***; *above*), probably derive from this deposit and provide Chalcolithic/Early Bronze Age dates of *2290-2110* cal *BC* (*SUERC-47188/9*).

Bay B: 70225/Bay V: 71158

Monoliths 70225 and 71158 were extracted from the south-western portion of Bay B and the underlying Bay V, *c* 1.8 m distant from monoliths 70222/71155. These two monoliths overlapped, to provide a continuous sequence, which, as with the adjacent monoliths, sampled most of the major stratigraphic units in the *Principal palaeochannel*, descending down from the *Chalcolithic alluvium* to the *Mesolithic organic deposit* (Table 302). Notably though, the *Earlier Neolithic organic deposit* was not present in this section of the channel, with the *Mesolithic alluvium* being instead sealed by the *Earlier Neolithic alluvium*. Moreover, one part of monolith 70225 sampled an alluvial deposit (***70225***, part of the *Mesolithic alluvium*) with very poor pollen survival, meaning that this section of the sequence was unsuitable for analysis. In addition, no detailed analysis was completed on that part of the monolith which sampled the deposits overlying the *Mesolithic alluvium* (the *Later Neolithic organic deposit* and *Chalcolithic alluvium*), with suitable pollen data for these stratigraphic units being gathered from the other monoliths extracted from Bay B (70222; *above*; 70219).

CNDR 1: Zone 7, 0225a (1.54-1.39 m; 7.40-7.55 m OD). Mesolithic organic deposit (part): hazelnut thickets

The curve for hazel-type pollen expanded in Zone 70225a, while those for oak and elm declined towards the top of the zone (Fig 644). Other tree- and shrub

Monolith	Depth (m)	Altitude (m OD)	Context	Entity	Description of sediments
70225	0-0.10	+8.94-8.84	***70306***	*Chalcolithic alluvium*	Peaty clay with herbaceous debris
	0.10-0.21	+8.84-8.73	***70307***	*Later Neolithic organic deposit*	Peaty clay, darker and wetter than above, with plant and wood fragments
	0.21-0.35	+8.73-8.59	***70187***	*Earlier Neolithic alluvium*	Grey clay/silt with wood and plant fragments; charcoal present
	0.35-0.76	+8.59-8.18	***70225***	*Mesolithic alluvium*	Tan silty-clay loam with some organic inclusions
	0.76-0.88	+8.18-8.06	***70267***		Grey/green silt/clay with some fine sand
	0.88-1.08	+8.06-7.87	***70226***	*Mesolithic organic deposit*	Soft, organic clay/silt with plant fragments. Charcoal layer from 1.06-1.07 m
Monoliths overlap by 0.02 m					
71158	0-0.12	+7.89-7.77	***71131***	*Mesolithic organic deposit*	Dark brown soft peaty clay with plant debris, wood, and charcoal fragments
	0.12-*c* 0.33	+7.77-7.56	***71089***		Brown/black peaty silty clay with common woody material, including a large wood chunk from 0.25-0.28 m, and hazelnuts (*Corylus avellana*)
	0.33-0.49	+7.56-7.40	***71129***		Pebble layer from 0.33-0.34 m; then clay layer followed by coarse-fine yellow/grey sand. Fining upwards sequence with 'flood' event at top. Detrital wood at 0.39-0.44 m
	0.49-0.55	+7.40-7.34	-	-	Sediment missing

Table 302: Continuous stratigraphy for monoliths 70225 and 71158, Bays B and V, Stainton West

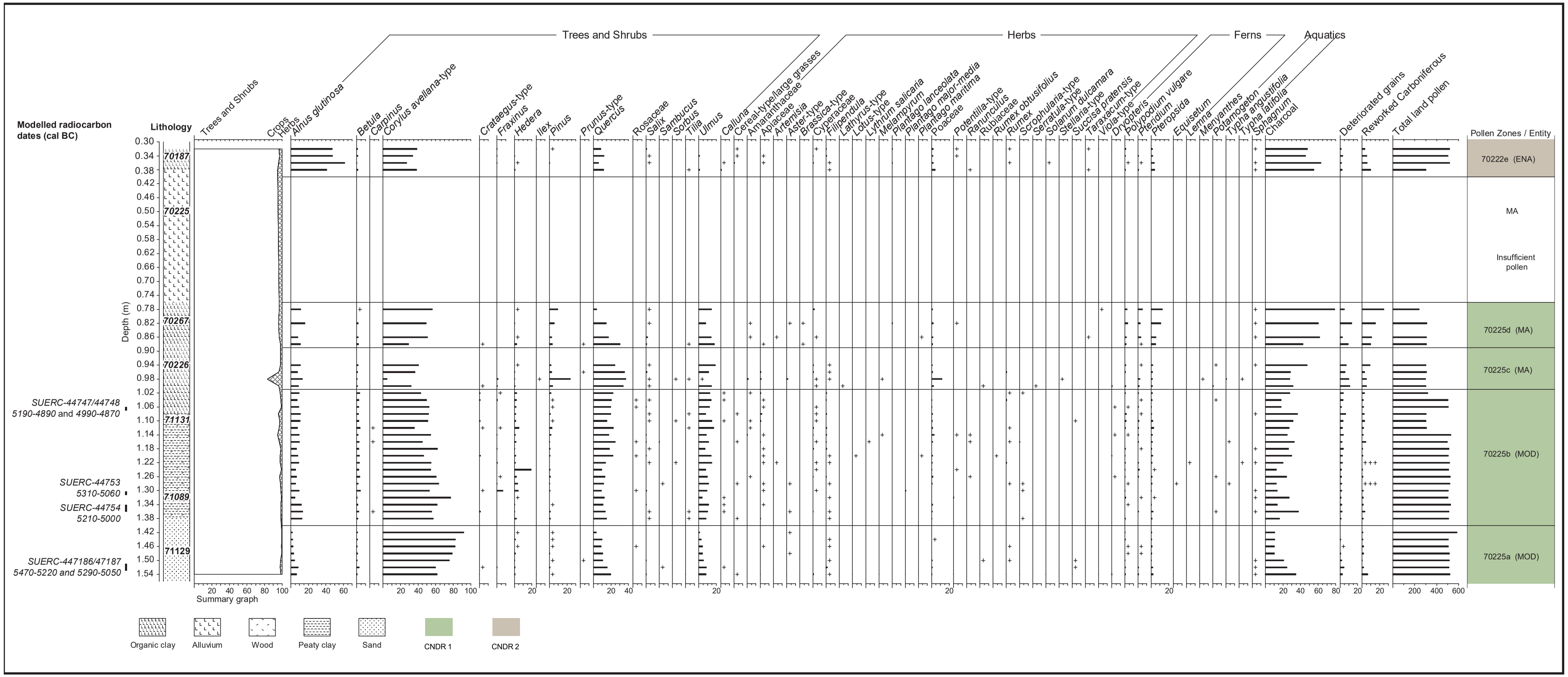
pollen include alder, birch, hawthorn, ash, ivy, pine, heather (*Calluna*), and willow. The herb flora is not diverse, though occurrences of sedges and grasses are visible, as well as meadowsweet (*Filipendula*), docks/sorrels (*Rumex*), daisy-types (*Aster*-type), devil's bit scabious (*Succisa pratensis*), and the carrot family (Apiaceae). This latter type represents a wide-ranging group, including cow parsley (*Anthriscus sylvestris*), wild carrot (*Daucus carota*), wild celery (*Apium graveolens*), and marshworts (*Apium*-type). Fern spores include common polypody and bracken, while *Sphagnum*-moss spores are also present. NPP are relatively diverse and include the fungal spores *Coniochaeta xylariispora* (HdV-6), *Glomus* (HdV-207), *Kretzschmaria deusta* (HdV-44), and the alga *Spirogyra* (HdV-130; Fig 645). Microcharcoal counts are relatively low.

The data suggest that hazel scrub was the dominant vegetation type on the floodplain at this time. The arboreal pollen suggests typical Mesolithic lowland woodlands with common oak and elm, as well as smaller amounts of birch, ash, and pine. Very low numbers of alder-pollen grains were recorded, and damp or wet areas must have existed locally, or in the wider area, to support some alder stands. The algal taxon *Spirogyra* (HdV-130) is known to live in stagnant, shallow water pools (van Geel 1978), providing further evidence for some wetter areas.

The very few herbs suggest the presence of only natural openings in the hazel scrub, which might have been caused by animal movements or plant habitation. The reduction in both elm and oak pollen through this zone may be a consequence of over-representation of hazel-type pollen in the percentage diagram, and the reduction is not coincident with the consistent appearance of ribwort plantain, cereal-type pollen, or grass pollen, and is therefore thought unlikely to represent an early assault on deciduous woodlands.

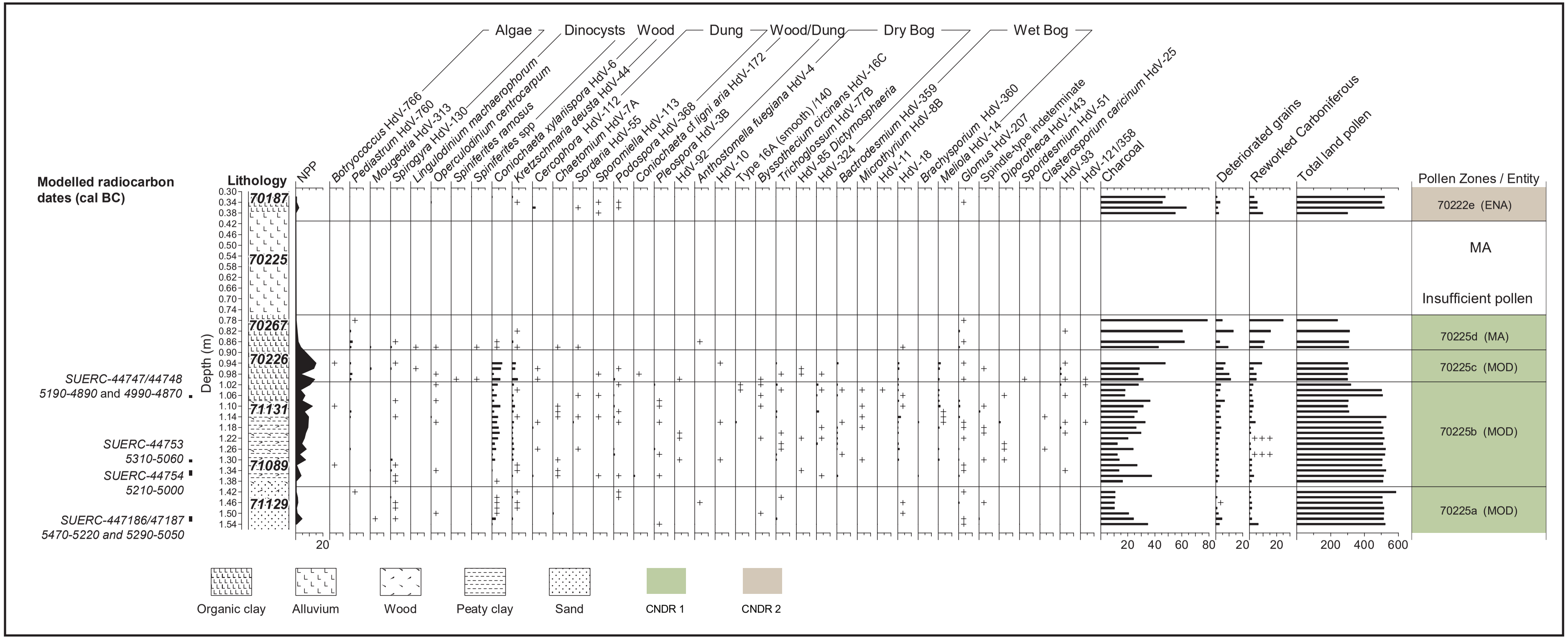
Of interest are the fungal spores *Glomus* (HdV-207), *Coniochaeta xylariispora* (HdV-6), and *Kretzschmaria deusta* (HdV-44). The former is associated with disturbed ground and the other two are indicators for decaying deciduous wood, especially elm and oak (*ibid*). These may therefore suggest disturbance to the woodland, perhaps from animals browsing, but may also indicate the presence of diseased or damaged trees (Innes *et al* 2006). The rare occurrence of dinocysts suggests the channel may have been prone to extreme tidal events.

CNDR 1: Zone 70225b (1.39-1.01 m; 7.55-7.93 m OD). Mesolithic organic deposit (part): mixed woodland
The data from this zone share much in common with the underlying Zone 70225a (*above*), but are distinguished by a relatively small reduction in hazel pollen and a small but sustained increase in alder, with the curve



Key: MOD= *Mesolithic organic deposit*; MA= *Mesolithic alluvium*; ENA= *Earlier Neolithic alluvium*

Figure 644: Pollen percentage diagram for monolith 70225/71158, Bay B, Stainton West



Key: MOD= *Mesolithic organic deposit*; MA= *Mesolithic alluvium*; ENA= *Earlier Neolithic alluvium*

Figure 645: Non-pollen palymorph percentage diagram for monolith 70225/71158, Bay B, Stainton West

for this increasing from 1.38 m (7.56 m OD), being present in relatively robust numbers at *c* 10% TLP. In addition, values for ash, initially, and then ivy, show brief peak occurrences before returning back to lower values. An increase in the diversity of tree and shrub types was also noted, with the presence of the pollen of lime (*Tilia*), rowan (*Sorbus*), elder (*Sambucus*), and wild roses (Rosaceae). The herb pollen and spore counts are similar to those in Zone 70225a (*above*), but, in contrast, aquatic plants and freshwater algae are present in small numbers, pondweed (*Potamogeton*), lesser bulrush, bulrush, and duckweed (*Lemna*), and spores of horsetails (*Equisetum*) being represented. Among the NPP assemblages, freshwater algae include occurrences of *Botryococcus* (HdV-766) and *Pediastrum* (HdV-760). A few occurrences of the dinoflagellate cyst *Operculodinium centrocarpum* were also noted. The assemblage of fungal spores is more diverse than in the earlier zone and, in addition to the dominant taxa, *Coniochaeta xylariispora* (HdV-6) and *Kretzschmaria deusta* (HdV-44), it includes several examples of *Cercophora* (HdV-112), as well as isolated occurrences of *Chaetomium* (HdV-7A) and *Coniochaeta ligniaria* (HdV-172).

The pollen record indicates an environment still dominated by hazel scrub, but with significant stands of oak and elm forming elements of the woodland mosaic. There is evidence for slight increases in wetter local areas, based on the pollen of aquatic plants and freshwater algae, as well as a small expansion of alder, suggesting some alder trees may have been present locally. Alternatively, alder may have comprised a regional element of the pollen profile, representing an alder-carr environment at some distance from the floodplain. However, it is worth noting that the main alder expansion at Stainton West was not visible until much later and did not occur within the Mesolithic sections analysed for pollen. Significantly, this seems at odds with some other north Cumbrian sites, such as Scaleby Moss (Walker 1966), where a large expansion in alder has been dated to between *c* 6500 cal BC and *c* 6000 cal BC (7700-7150 BP), with the beginning of the alder rise being dated there to 6490-5920 cal BC (7361±146 BP; Q-167; Godwin and Willis 1959), the dates being similar to those from several sites in lowland England (Hodgkinson *et al* 2000).

There is also a suggestion that the channel area may have been within reach of weak marine influences based on occurrences of the dinocyst *Operculodinium centrocarpum* throughout the zone. Interestingly, there are occurrences of pollen of the goosefoot family (Amaranthaceae) at the same level. Although members of the goosefoot family have a wide distribution, some types are used to suggest proximity to marine influence (Long *et al* 1998).

The presence of sporadic cereal-type grains throughout this zone may possibly represent large grass pollen, as the evidence for disturbance indicators is very low. However, consistent low values for grasses and members of the carrot family were recorded, along with intermittent records for docks/sorrels and mugwort, which may suggest some ruderal growth. Microcharcoal is also present, but in relatively modest amounts.

The abundance of the fungal spores *Coniochaeta xylariispora* (HdV-6) and *Kretzschmaria deusta* (HdV-44) suggests the presence of damaged or diseased deciduous woodland (van Geel 1978; Innes *et al* 2006). The assemblage of fungal spores also includes specimens of *Cercophora* (HdV-112), *Chaetomium* (HdV-7A), *Coniochaeta ligniaria* (HdV-172), *Sporomiella* (HdV-113), *Sordaria* (HdV-55A/B), and *Podospora* (HdV-368), all coprophilic forms associated with animals and people (Blackford and Innes 2006), providing support for herbivore grazing probably occurring nearby. It may have been that small numbers of Mesolithic people used the area for the movement of animals, and subsequent pathways through the hazel scrub opened up in response to such use. The *Mesolithic organic deposit* contains evidence for beaver activity, as well as evidence for the anthropogenic working of large oak timbers and the felling of elm and oak (*Appendix 14*).

Dates from plant macrofossils indicate a Late Mesolithic age for the start of organic accumulation. A hazelnut, at 1.34-1.35 m (7.60-8.59 m OD), returned a date of *5210-5000* cal *BC* (*SUERC-44754*) and a further date from waterlogged wood, at 1.31-1.33 m (7.63-7.61 m OD), provided a date of *5310-5060* cal *BC* (*SUERC-44753*).

CNDR 1: Zone 70225c (1.01-0.89 m; 7.93-8.05 m OD). Mesolithic organic deposit (part): expansion of oak

As the values for hazel pollen decreased slightly throughout the zone, the values for oak pollen appear to increase. Values for elm remain similar, with the exception of the sub-sample at 0.98 m (7.96 m OD), where oak and pine pollen values rise at the expense of hazel and elm, but then followed by the recovery of both hazel and elm. Other tree and shrub types include birch, hawthorn, ash, ivy, pine, and willow. The herb pollen is fairly poor in diversity, but includes consistent grasses, and sedges, the carrot family, docks/sorrels, and meadowsweet were all recorded. Fern spores are present, as well as pollen of aquatic taxa, notably pondweed and lesser bulrush.

The NPP assemblages include occurrences of the freshwater algae *Botryococcus* (HdV-766) and *Pediastrum* (HdV-760). Sporadic occurrences of marine indicators, the dinoflagellate cysts *Operculodinium* *centrocarpum* and species of *Spiniferites*, were recorded, as well as *Lingulodinium machaerophorum*, which is known to tolerate estuarine conditions (Edwards and Andrle 1992). Fungal spores are diverse, the most significant being *Coniochaeta xylariispora* (HdV-6) and *Kretzschmaria deusta* (HdV-44). Microcharcoal values rise through the zone, and levels of reworked Carboniferous miospores also increase.

The arboreal pollen assemblages indicate fluctuating hazel scrub, but with significant stands of oak and elm. Alder would have been present in damper locations, and may represent either local or regionally derived pollen. Of interest is the temporary reduction in elm and hazel-type pollen, offset by increasing pine and grass. It is possible that the higher levels of grass may indicate a greater incidence of open areas in the woodland, but the once-off increased levels of pine imply increased aerial or waterborne transport of these saccate grains, possibly derived from more regional vegetation. Freshwater algae, including *Botryococcus* sp (HdV-766), and the pollen of aquatic taxa, such as bulrush and lesser bulrush, are present. The algal taxa *Spirogyra* (HdV-130) and *Mougeotia* (HdV-313) provide further evidence for the presence of shallow, stagnant water. There is also some evidence for weak marine influences based on rare occurrences of the dinocysts *Operculodinium centrocarpum* and species of *Spiniferites*, assuming these taxa are *in situ*. The occurrence of the dinocyst *Lingulodinium machaerophorum* is interesting, as this taxon is known to exist in estuarine conditions (Edwards and Andrle 1992).

CNDR 1: Zone 70225d (0.89-0.78 m; 8.05-8.16 m OD). Mesolithic alluvium (part): evidence for erosion

This zone is distinguished primarily by the fall in oak pollen, the abundance of microcharcoal, and the significant increase in the reworking of older Carboniferous pollen and spores. Ferns spores also increase throughout the zone. However, it should be noted that the interval at 0.76-0.38 m (8.18-8.56 m OD; deposit ***70225***) did not contain sufficient pollen for analysis.

The high values for microcharcoal and decreasing pollen counts for oak, in particular, may indicate its clearance, allowing the spread of light-demanding hazel scrub on the floodplain. Closer to the channel, the continuous presence of *Pediastrum* (HdV-760) is indicative of fresh- to brackish-water conditions (Batten 1996). The occurrences also of rare dinoflagellate cysts suggest the influence of very weak marine conditions, although *Lingulodinium machaerophorum* is known to be tolerant of estuarine conditions (Edwards and Andrle 1992). High counts for Carboniferous miospores suggest that older material was being recycled and may provide evidence for an erosive event within the channel. The abundant microcharcoal at this point may also have been deposited as a result of renewed alluviation.

The sediments and the palynomorphs contained within are indicators of the palaeoenvironment prior to the deposition of a thick blanket of alluvial material (deposit ***70225***), thought to have been deposited as a result of river rejuvenation, following sea-level rise, possibly at the end of the Mesolithic period (*Ch 6*). Soil micromorphology indicates that ***70225*** represents a probable boundary between a terrestrial soil and material from the river, and the small amounts of burnt sand and charcoal may testify to nearby Mesolithic occupation (*Appendix 19*).

CNDR 2: Zone 70225e (0.38-0.32 m; 8.56-8.62 m OD). Earlier Neolithic alluvium: alder carr

The arboreal pollen is dominated by alder, hazel-type and oak pollen also being very common; the numbers of pollen grains of birch, ash, elm, willow, ivy, heather, and lime are present, but generally low. Grass was the most common herb-type recorded, and a range of other herb taxa include sedges, dandelion-types (*Taraxacum*-type), meadowsweet, buttercups, cinquefoils, ribwort plantain, docks/sorrels, and possible cereal-type pollen. *Sphagnum*-moss spores are present and other spores comprise common polypody, bracken, and monolete ferns. Reworking of Carboniferous pollen grains is common. A single dinocyst, *Operculodinium centrocarpum*, was identified at 0.34 m (8.60 m OD). Fungal spores are few, but include examples of *Cercophora* (HdV-112) and *Sporomiella* (HdV-113), while microcharcoal values are moderate to high.

The data suggest that alder carr may have become established on the floodplain, bordered perhaps by hazel-type scrub and mixed-deciduous woodland, which may have occupied drier areas of the floodplain and the river terraces. There is evidence that small openings existed, based on the presence of herb pollen, including grasses, docks/sorrels, and cinquefoils; these openings may have been created either by animals or people. The presence of a few cereal-type grains in association with disturbance indicators, such as ribwort plantain, may support the presence of people actively using the environment for small-scale cultivation. The rare occurrence of the fungal spores *Cercophora* (HdV-112), *Sporomiella* (HdV-113), and *Podospora* (HdV-368), which are largely coprophilic, suggests the possible presence of animals in the local environment (Blackford and Innes 2006). Microcharcoal particles may have been derived from both local and regional sources as a result of deliberate burning; however, the incidence of natural fires, although unlikely, cannot be dismissed (Rackham 1986; Moore 2001). The dominance of alder carr on, or adjacent to, the palaeochannel, and the coincident fall in hazel pollen, is an event seen throughout the monoliths. In Bay B (70222/71155) this transition has been dated to the mid-fourth millennium BC, based on plant macrofossils (*Appendix 17*), whilst plant macrofossils from Bay D have also produced similar dates.

Bay B: 70219

The single monolith was extracted from Bay B, *c* 1.8 m north-west of the central monoliths (70222/71155) extracted from this bay, and the underlying Bay V. As monolith 70219 was positioned on the sloping edge of the *Principal palaeochannel*, the full sequence of channel deposits was slightly curtailed in this area, and hence the monolith sampled the underlying *Basal sands and gravels*, and its sealing channel deposit, which in this area was the *Mesolithic alluvium* (hence the earlier *Mesolithic organic deposit* was not present in this part of the channel; Table 303). Above the Mesolithic alluvium, the monolith sampled most of main stratigraphic units, up to and including the *Bronze Age alluvium*, although the *Earlier Neolithic alluvium* was missing in this part of the channel. However, as good pollen data relevant to the Late Mesolithic and Neolithic periods were available from the other monoliths from this bay (70222/71155; 70225/71158), pollen analysis focused on the upper channel deposits, specifically the *Chalcolithic alluvium* and *Bronze Age alluvium*.

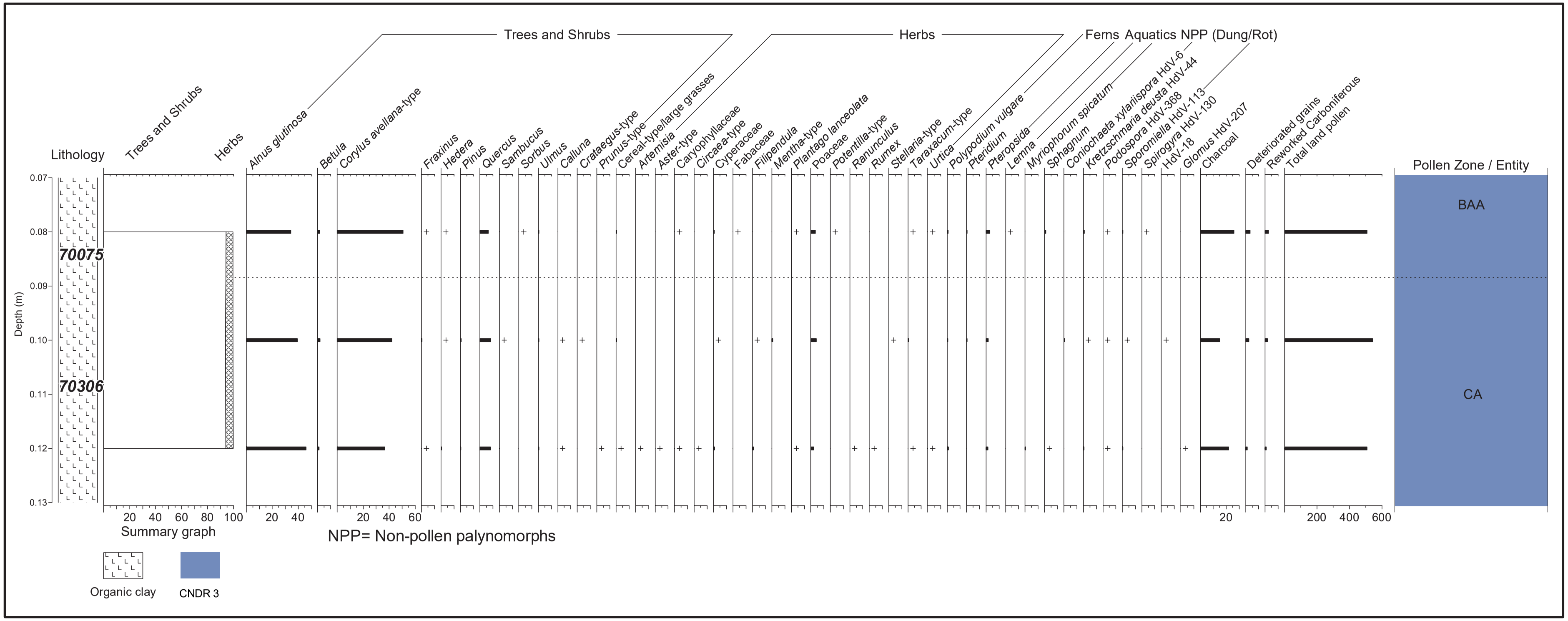
CNDR 3: unzoned pollen diagram (0.08-0.12 m; 8.82-8.78 m OD) Chalcolithic alluvium and Bronze Age Alluvium

Although this monolith contained a small section of the *Bronze Age Alluvium* (0.08-0.09 m; 8.82-8.81 m OD), the majority relates to the *Chalcolithic alluvium* (deposit ***70306***; *Ch 11*). The data show a post-Elm Decline assemblage, with very little difference in any of the three sub-samples (Fig 646). Almost equal amounts of alder and hazel-type pollen were recorded, other tree and shrub pollen including significant quantities of oak, with lesser values for birch, elm, ash, ivy, hawthorn, rowan, elder, and blackthorn-type (*Prunus* sp). The herb assemblage comprises predominantly grasses, with sedges, cereal-type, ribwort plantain, meadowsweet, docks/sorrels, nettles (*Urtica*), buttercups (Ranunculaceae), daisy-type, dandelion-type, cinquefoils, mints (*Mentha*-type), peas and vetches (Fabaceae), and pinks (Caryophyllaceae). Spores include common polypody, bracken, and monolete ferns, while *Sphagnum*-moss spores were present in two of the sub-samples (at 0.12 m (8.78 m OD) and 0.08 m (8.82 m OD)), and pollen grains of the aquatic water milfoil (*Myriophyllum spicatum*) and duckweed were recorded at 0.12 m (8.78 m OD) and 0.8 m (8.82 m OD) respectively. Small numbers of fungal spores were recorded, including *Glomus* (HdV-207), *Kretzschmaria deusta* (HdV-44), *Coniochaeta xylariispora* (HdV-6), and *Sporomiella* (HdV-113). Small amounts of microcharcoal were also present in all three sub-samples.

The data indicate a largely wooded landscape, with alder occupying wetter carr-type vegetation on and/or adjacent to the floodplain, or within the infilled channel, and hazel-type pollen, representing drier, scrub vegetation possibly also on, or near to, the floodplain. Mixed deciduous woodlands existed, at least regionally, mostly oak woods, but with ash, birch, and a little elm also present. Hawthorn, ivy, and possibly rowan and blackthorn were additional components of the woodland; woodland herbs include willowherbs (*Circaea*-type), known to grow in woody or shady areas (Stace 2010). Most of the herb pollen recorded is associated with open damp meadow/pastureland and/or disturbed ground, such as grasses, ribwort plantain, daisy-types, dandelion-types, and nettles (Behre 1981), while sedges and meadowsweet are indicative of wetter habitats (Stace 2010), which

Depth (m)	Altitude (m OD)	Context	Entity	Description of sediments
0-0.09	+8.9-8.81	***70075*** (group ***70075***)	*Bronze Age alluvium*	Mostly missing; brown/black crumbly dry peaty clay and plant detritus
0.09-0.13	+8.81-8.77	***70306*** (group ***70299***)	*Chalcolithic alluvium*	Brown/black crumbly dry peaty clay with common plant detritus
0.13-0.30	+8.77-8.60	***70307*** (group ***70300***)	*Later Neolithic organic deposit*	Wet brown/black peaty clay with wood and plant debris at 0.22 m and significant charcoal between 0.13 m and 0.2 m
0.30-0.53	+8.60-8.37	***70308*** (group ***70301***)	*Earlier Neolithic organic deposit*	Large chunks of wood in clay/sand matrix. Becoming coarser towards base of sequence, with increase in sand
0.53-0.68	+8.37-8.22	***70059*** (group ***70097***)	*Mesolithic alluvium*	Grey/green/yellow sand with clay and charcoal fragments
0.68-0.76	+8.22-8.14	***70078*** (group ***70098***)	*Basal sands and gravels*	Sticky grey-black silty clay, becoming red from *c* 0.71 m, with fine sand (Boulder Clay?)

Table 303: Stratigraphy for monolith 70219, Bay B, Stainton West



Key: CA= *Chalcolithic alluvium;* BAA= *Bronze Age alluvium*

Figure 646: Pollen and non-pollen palymorph percentage diagram for monolith 70219, Bay B, Stainton West

are supported by the occurrence of some aquatic plants. Small-scale cultivation is perhaps suggested by the occurrences of a few cereal-type pollen grains, although the dimensions of these may overlap with those of wild aquatic or marsh grasses, such as *Glyceria* (Andersen 1979; Tweddle *et al* 2005; Joly *et al* 2007). Overall, the pollen assemblages suggest a largely wooded floodplain, with small openings that may have been used for grazing animals and perhaps for some small-scale cultivation. Fungal spores, including the coprophilic *Sporomiella* (HdV-113) and *Podospora* (HdV-368), suggest the presence of an herbivore population (van Geel 1978).

Bay D: 70296

A single pollen monolith was analysed from Bay D. This was positioned slightly north-east of the centre of this bay and sampled a near continuous sequence of channel deposits, although in this part the *Mesolithic organic deposit* was absent, with the *Basal sands and gravels* being directly sealed by the *Mesolithic alluvium* (Table 304). Significantly, monolith 70296 was extracted from adjacent to Trident 2 (*Ch 8*), and, given this, the main focus for pollen analysis was the surrounding Neolithic channels deposits, in order to determine the nature of the Neolithic landscape and detect any anthropogenic pollen signatures reflecting clearance and/or early farming.

CNDR 2: Zone 70296a (0.46-0.41 m; 8.42-8.47 m OD). Earlier Neolithic organic deposit (part; deposit 70315 (lower fraction)): openings in the hazel woods/ declining elm

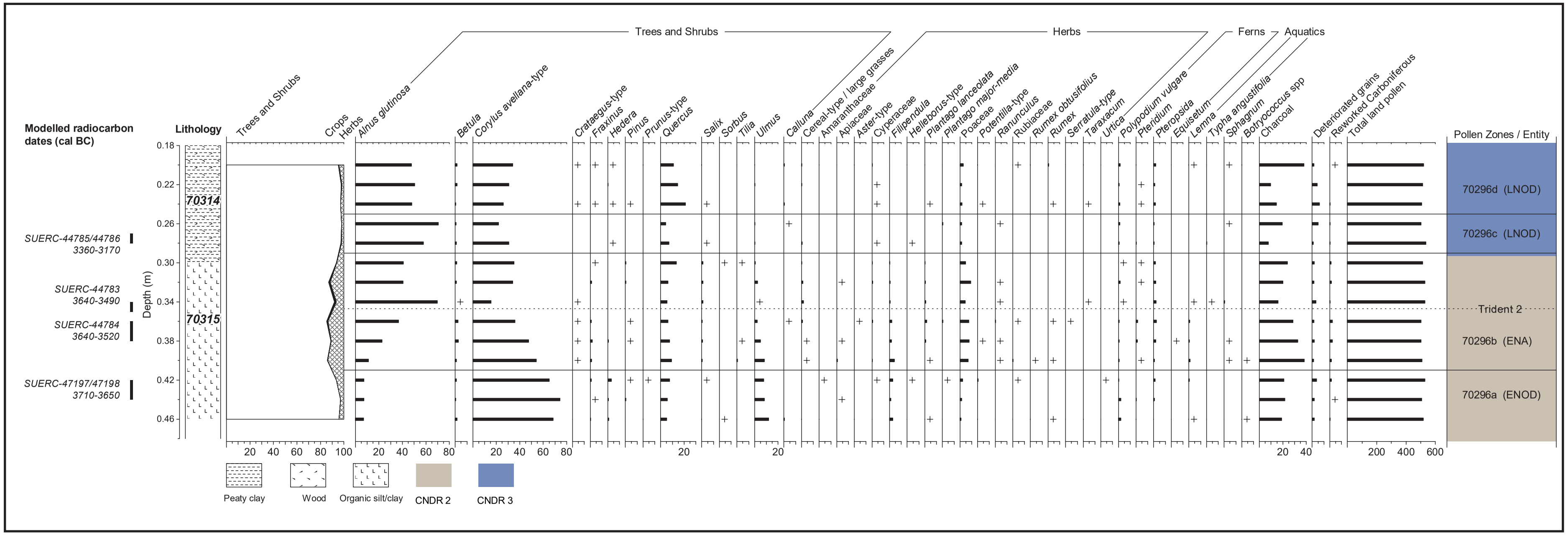
The lowest zone is dominated by tree and shrub pollen, notably hazel-type, with common frequencies of elm and oak, but less alder (Fig 647). The elm curve gradually declined from approximately 12% TLP at 0.46 m (8.42 m OD) to approximately 8% TLP at 0.42 m (8.46 m OD), while pollen of other tree and shrub types present include birch, ash, willow, ivy, and pine. Rare occurrences of rowan and blackthorn are also present. The herb pollen includes meadowsweet, grasses, sedges, bedstraw family (Rubiaceae), ribwort plantain, and docks/sorrels. Fungal spores include *Kretzschmaria deusta* (HdV-44) and *Coniochaeta xylariispora* (HdV-6; Fig 648). Small quantities of microcharcoal were recorded.

The assemblages demonstrate that the floodplain was dominated by hazel scrub, while mixed deciduous woodland, comprising predominantly elm and oak with a little ash, may have occupied other parts of the floodplain and floodplain terraces. Wetter areas may have been colonised by small alder stands (or alder pollen may have been derived from a regional source). The tree-pollen curves suggest declining values in elm, supported by a continuous curve for grass pollen and the sporadic presence of ribwort plantain; however, it was not possible to identify the start of the Elm Decline in this section. There may have been some small grassy openings supporting an herb population of meadowsweet, grasses, docks/sorrels, ribwort plantain, and sedges, suggesting small-scale disturbance to the hazel scrub. The cleared or disturbed areas may have been used for pasturing animals or to enhance browsing conditions, and thus could have resulted from anthropogenic activity on the floodplain, but may have been a result of natural events (such as fires or animal pathways). Chronological modelling estimates that these cleared areas existed by *3860-3540* cal *BC* (*'Ribwort plantain D'*; *Appendix 20*).

An adjacent monolith (70240) has been analysed at higher resolution (10 mm intervals), across the Mesolithic /Neolithic transition (Riley 2015). This shows a gradual decline of elm, associated with an increase in the pollen of disturbance indicators, including grasses, docks/sorrels, ribwort plantain, and other herbs (Fig 649). As the curve for elm pollen declined, a peak in values of hazel-type pollen was recorded, associated with a decrease in almost all

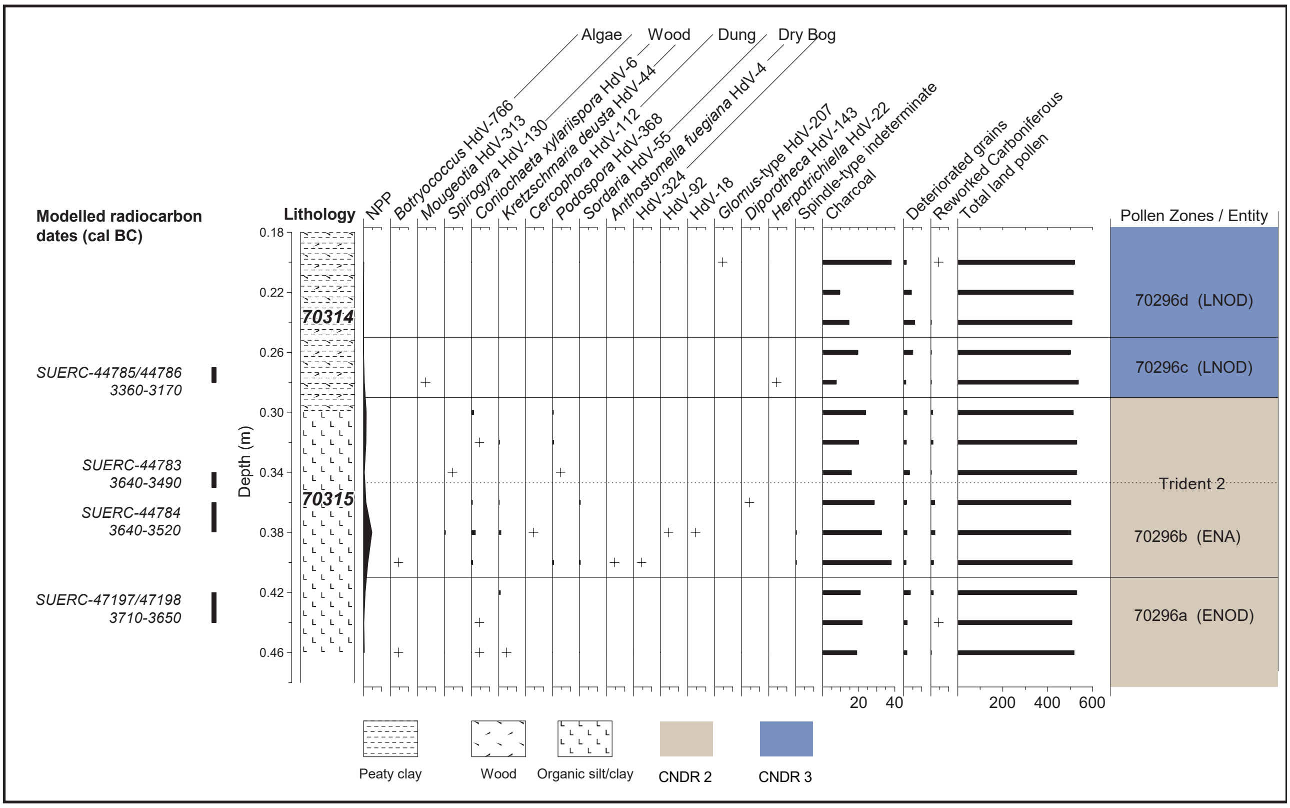
Depth (m)	Altitude (m OD)	Context	Entity	Description of sediments
0-0.06	+8.88-8.82	***70067***	*Bronze Age alluvium*	Pale grey clay
0.06-0.11	+8.82-8.77	***70313*** (group ***70299***)	*Chalcolithic alluvium*	Dark brown homogeneous clay
0.11-0.30	+8.77-8.58	***70314*** (group ***70300***)	*Later Neolithic organic deposit*	Organic clay/silt with plant and common wood debris
0.30-0.48	+8.58-8.40	***70315*** (upper and lower fraction)	*Earlier Neolithic alluvium/ Earlier Neolithic organic deposit*	Grey-brown organic clay
0.48-0.58	+8.40-8.30	***70093*** (group ***70097***)	*Mesolithic alluvium*	Grey/brown/red sand
0.58-0.60	+8.30-8.28	***70094*** (group ***70098***)	*Basal sands and gravels*	Red sand

Table 304: Stratigraphy for monolith 70296, Bay D¸ Stainton West



Key: ENOD= *Earlier Neolithic organic deposit;* ENA= *Earlier Neolithic alluvium;* LNOD= *Later Neolithic organic deposit*

Figure 647: Pollen percentage diagram for monolith 70296, Bay D, Stainton West



Key: ENOD= *Earlier Neolithic organic deposit*; ENA= *Earlier Neolithic alluvium*; LNOD= *Later Neolithic organic deposit*

Figure 648: Non-pollen palymorph percentage diagram for monolith 70296, Bay D, Stainton West

other pollen types, suggesting that a hazel-type catkin may have become incorporated within the deposits. A similar record was previously found in the pollen profiles from Bay F (70252). The data in monolith 70240 also record a greater incidence of plants of wet places (such as lesser bulrush and docks/sorrels) than seen in monolith 70296, perhaps suggesting slightly damper conditions at this more central location within Bay D. Interestingly, there is no record of cereal-type pollen, again possibly suggesting that ground conditions were too wet to support arable vegetation. Overall, the pollen record from monolith 70240 correlates well with those for the Elm Decline in Bays D (70296), F (70250), and B (70222/71155).

CNDR 2: Zone 70296b (0.41-0.29 m; 8.47-8.59 m OD). Earlier Neolithic alluvium (part; deposit 70315 (upper fraction)): Elm Decline Demise and clearance on the floodplain

The expansion of grasses at 0.4-0.3 m is significant and distinguishes this zone from those on either side. Elm-pollen values continued to decline gradually throughout this zone, culminating in its demise, the values, which had already begun to decline in the earlier zone (70296a; *above*), falling by 9.6% TLP over 0.1 m (from 0.46-0.36 m; 8.42-8.52 m OD) to less than 2.5% TLP at 0.36 m (8.52 m OD). There is also a notable decrease in hazel pollen and increase in alder, subsequent to the demise of elm. Pollen of birch, willow, and ash is consistently present and there are sporadic occurrences of hawthorn, rowan, and lime. Single occurrences of cereal-type pollen are present from 0.40 m (8.48 m OD), but became more common at 0.36-0.32 m (8.52-8.56 m OD), and likewise, single grain occurrences of ribwort plantain were recorded at 0.46 m (8.42 m OD) and 0.40 m (8.48 m OD), but the curve is continuous from 0.38 m (8.50 m OD). The fungal spore, *Cercophora* (HdV-112), is present at 0.38 m (8.50 m OD) and both *Coniochaeta xylariispora* (HdV-6) and *Kretzschmaria deusta* (HdV-44) were recorded at 0.42 m (8.46 m OD) and 0.38 m (8.50 m OD). Values for microcharcoal increase in the lower part of the zone.

The decline of elm pollen to barely present at 0.34 m (8.54 m OD) is coincident with a decrease in hazel-type pollen and expansion of grass. It also corresponds to a switch from a hazel-dominated floodplain to one dominated by alder carr, an event that is also seen in Bays B and F. Coincident with this, and subsequent to the elimination of elm, it would appear that some clearance of hazel occurred, as alder carr became dominant on the floodplain and in the channel areas, or, alternatively, environmental conditions became too wet on the floodplain for hazel to dominate the arboreal assemblage. The data, however, suggest clearance on the floodplain for the use of wood and perhaps also for animal grazing, and possibly for some cereal cultivation.

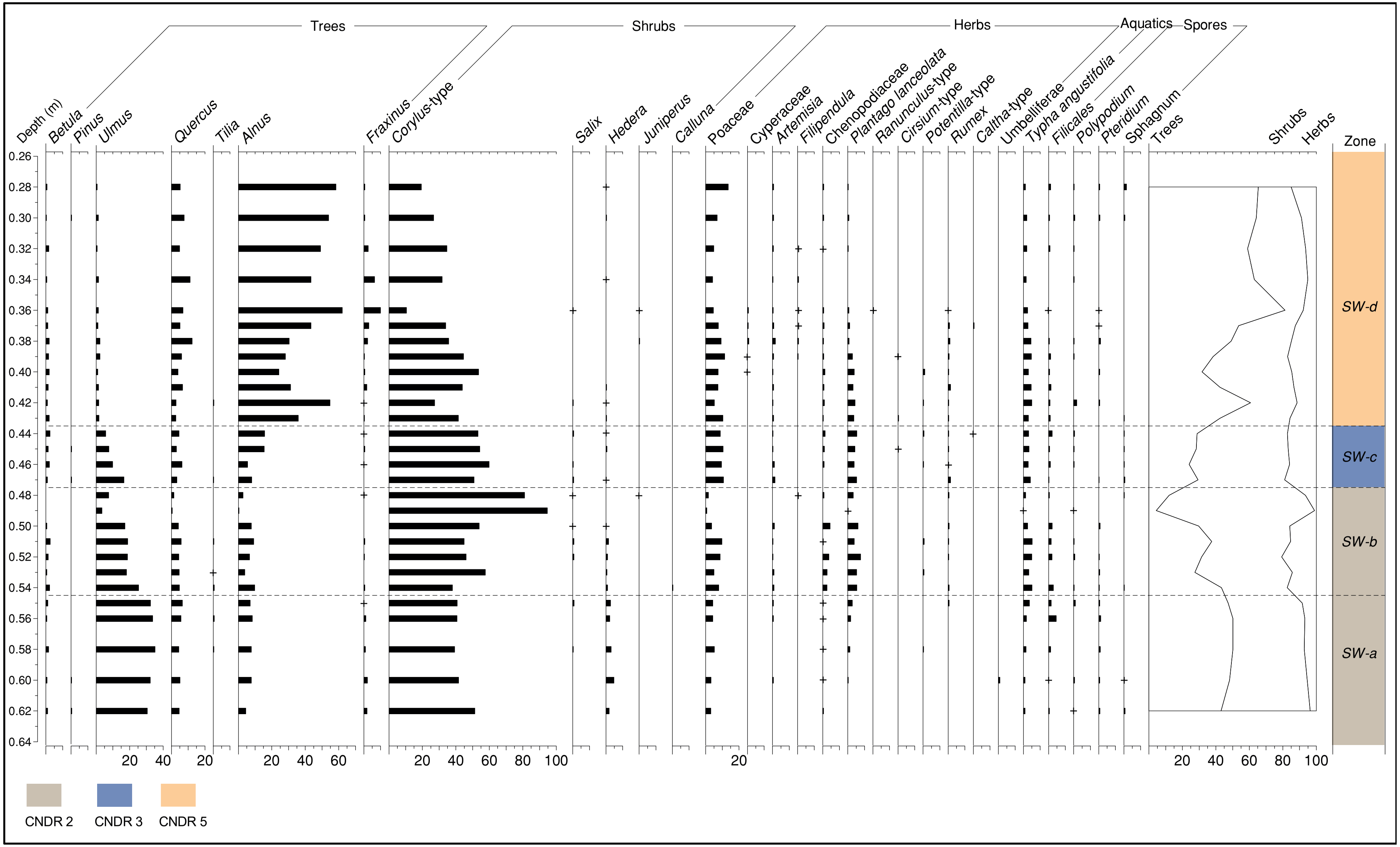


Figure 649: Pollen percentage diagram for monolith 70240, Bay D, Stainton West (courtesy of E Riley, Department of Geography, University of Durham)

The dimensions of the cereal-type pollen grains present at 0.36-0.32 m (8.52-8.56 m OD) suggest barley and also the wheat/oats group, indicating disturbance for arable cultivation. There is a possibility, however, that these grains may be attributable to wild grasses of wet habitats, such as sweetgrass (Andersen 1979) or other arable weeds (Tweddle *et al* 2005). Both cereal-type pollen and that of plants associated with wet meadows and pastures, for example, ribwort plantain (Behre 1981), are present throughout the main grass expansion, supporting the possible development of small areas suitable for arable cultivation.

The fungal spores, *Kretzschmaria deusta* (HdV-44) and *Coniochaeta xylariispora* (HdV-6), are known to occur on diseased or damaged deciduous wood (van Geel 1978; Innes *et al* 2006), and coprophilic fungal spores include low counts for *Sordaria* (HdV-55B), *Podospora* (HdV-368), and *Cercophora* (HdV-112); previous records of *Cercophora* (HdV-112) in relation to archaeological sites (Buurman *et al* 1995; Witte and van Geel 1985) show that this fungal spore can be used as a proxy for animal dung in the surroundings. Microcharcoal records show generally higher values within this clearance phase, in particular within the early part of the zone.

The palynological data provide evidence of a possibly short-lived, but distinctive, clearance event within the mid-fourth millennium BC. The demise in elm has been bracketed by dates, at 0.36-0.38 m (8.52-8.50 m OD), to *3640-3520* cal *BC* (*SUERC-44784*), and again at 0.34-0.35 m (8.54-8.53 m OD) to *3640-3490* cal *BC* (*SUERC-44783*); based on these, it is estimated that the Elm Decline Demise occurred in *3640-3510* cal *BC* (*'Elm Decline Demise D'*). It is within these deposits that the second wooden trident (Trident 2; *Appendix 13*) was found, at approximately 0.34 m (8.54 m OD), and oak sapwood from the trident has been dated to *3640-3370* cal *BC* (*SUERC-26660; Ch 8*). Chronological modelling has also provided estimates for the first occurrence of cereal-type pollen at *3690-3530* cal *BC (‘Cereal-type pollen D’*; *Appendix 20*).

CNDR 3: Zone 70296c (0.29-0.25 m; 8.59-8.63 m OD). Later Neolithic organic deposit (part): alder carr

The zone coincides with a lithological change from less organic clays and silts to peaty, more organic deposition. The pollen data show further expansion of the alder curve, as values for oak and hazel decline a little. Herb pollen is much reduced and only a few cereal-type grains are present, along with much lower values for grass than recorded in the earlier zone. Pollen of willow and sedges, and *Sphagnum*-moss spores, were recorded. The freshwater alga *Mougeotia* (HdV-313) is also present, while small quantities of microcharcoal were recorded.

There is less evidence for the presence of pasture and/or arable use of the floodplain than previously, and the area appears to have been largely abandoned to alder-carr expansion. The data suggest possible clearance of oak wood, which may have been growing on the floodplain or on the river terraces, and suggests that people may have been active in the area. This clearance event has been dated at 0.27-0.28 m (8.61-8.60 m OD) by plant macrofossils to the latter part of the fourth millennium BC; a hazelnut and a piece of alder from the same depth yielded a modelled date of *3360-3170* cal *BC* (*SUERC-44785/6*).

CNDR 3: Zone 70296d (0.25-0.20 m; 8.63-8.68 m OD). Later Neolithic organic deposit (part): alder carr and oak regeneration

The pollen curves for both alder and hazel indicate the dominance of these taxa in the local environment. The rising curve for oak suggests its local regeneration on drier terraces. Birch, hawthorn, ash, ivy, and elm were also recorded. A poorly diverse herb flora is present, including grasses, sedges, cinquefoil, docks/sorrels, dandelion-types, and bedstraw. Fern and *Sphagnum*-moss spores were recorded, while values for microcharcoal particles increase at the top of the zone.

The data suggest a largely forested lowland area of dominant alder carr, possibly with some hazel scrub, and grassy areas, which may have been produced by local herbivore grazing. Oak woods probably colonised other parts of the floodplain, or nearby terraces, along with some more hazel scrub, and trees or shrubs of more open habitats, such as ash and hawthorn. There is evidence for small-scale cultivation, assuming the cereal-type grains are representative of cultivated types rather than wild grasses (Andersen 1979; Tweddle *et al* 2005; Joly *et al* 2007). Microcharcoal is generally in relatively small numbers, though higher in the topmost sample. This may have been produced as a result of deliberate local/regional burning, but natural fires or lightning strikes, although unlikely, may also have occurred.

Bay F: 70250

Monolith 70250 was a comparatively short monolith extracted from the eastern side of Bay F. At this location, the two sequential Mesolithic-age channel deposits were sampled, along with the *Earlier Neolithic alluvium* and *Bronze Age alluvium*, with intervening *Earlier Neolithic organic deposit* and *Chalcolithic alluvium*, being absent in this part of the channel (Table 305). Pollen analysis, however, explicitly targeted those stratigraphic units dating to the Mesolithic and Neolithic periods.

Depth (m)	Altitude (m OD)	Context	Entity	Description of sediments
0-0.14	+8.89-8.75	***70077***	*Bronze Age alluvium*	Grey/light brown clay with charcoal flecks
0.14-0.38	+8.75-8.51	***70327*** (group ***70135***)	*Earlier Neolithic alluvium*	Slightly more organic grey/light brown clay with increase in charcoal fragments
0.38-0.75	+8.51-8.14	***70092*** (group ***70097***)	*Mesolithic alluvium*	Grey/light brown clay with charcoal
0.75-1.03	+8.14-7.86	***70273*** (group ***70228***)	*Mesolithic organic deposit*	Grey/brown sandy clay from 0.75-0.85 m; peaty clay band from 0.85-0.91 m; and grey/brown sandy clay from 0.91-1.03 m

Table 305: Stratigraphy for monolith 70250, Bay F, Stainton West

CNDR 1: Zone 70250a (0.76-0.43 m; 8.13-8.46 m OD). Mesolithic organic deposit (part) and Mesolithic alluvium: hazel thickets

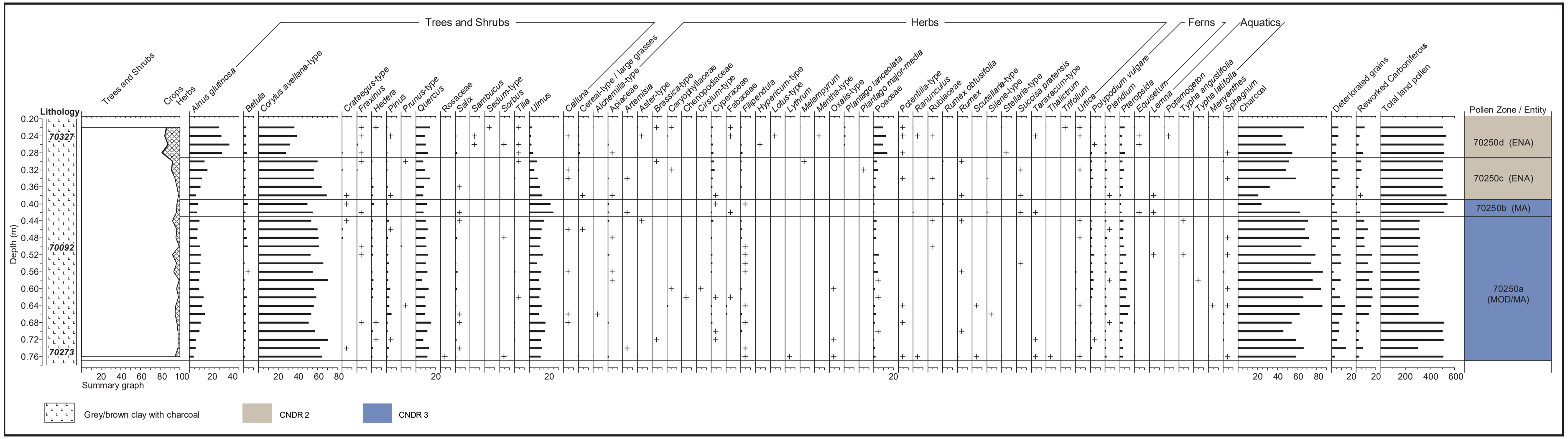
The data indicate an environment dominated by woodland vegetation (Fig 650), the most abundant component of the tree/shrub-pollen community being hazel-type, with approximately equal abundances of oak, elm, and alder. Various other tree and shrub types are also indicated from the pollen, including small numbers of birch, pine, ash, lime, and rowan, as well as hawthorn, ivy, willow, and heather. A range of herb pollen was recorded, the most common being grasses, but also sedges, meadowsweet, docks/sorrels, cinquefoils, and the carrot family. Pollen of aquatic plants, including bulrush and lesser bulrush, is sporadically present. Fern spores are strongly represented, including the consistent occurrence of bracken, common polypody, and undifferentiated monolete ferns, while *Sphagnum*-moss spores are also present throughout the zone, and the freshwater alga *Botryococcus* (HdV-766) is present in small numbers throughout (Fig 651), and fungal spores associated with decaying wood were regularly recorded, including *Kretzschmaria deusta* (HdV-44) and *Coniochaeta xylariispora (*HdV-6). Of additional interest is the occurrence of the dinoflagellate cyst *Operculodinium centrocarpum*. Microcharcoal counts remain high throughout the zone.

The overwhelming abundance of hazel-type pollen suggests that this was the dominant vegetation on the wooded floodplain at this time. The consistent occurrence of small numbers of alder grains suggests possible local stands of this tree, perhaps adjacent to the riverbank, as their roots can survive in water (Brown 1988), or the pollen may have been derived from regional alder-carr environments. Evidence for wetter areas is based on the regular recording of willow pollen, as well as occurrences of the freshwater alga *Botryococcus* (HdV-766) and *Sphagnum*-moss spores. Small grassy areas supporting damp-loving plants, such as meadowsweet and sedges, were also present. On drier ground, possibly on the river terraces, oak, elm, pine, and, to a lesser extent, lime, comprised mixed-deciduous woodland, with ash growing in openings in this. This assemblage is typical of Mesolithic woodlands, prior to the Elm Decline (Spikins 2000). That the river itself may have still been open to weak tidal influence is indicated by the occurrence of specimens of *Operculodinium centrocarpum*, most probably transported upstream.

The fungal spore *Glomus* (HdV-207) is an indicator of disturbed ground (van Geel 1978) and both *Kretzschmaria deusta* (HdV-44) and *Coniochaeta xylariispora* (HdV-6) suggest that decaying wood was present. Occasional grains of *Cercophora* (HdV-112), which is also coprophilous or can occur on decaying wood, are also present within the zone. The occurrence of this fungal spore has also been interpreted as an indication of animal dung in the surroundings (van Geel and Aptroot 2006). It is likely, therefore, that the river was being used by animals, the small grassy areas possibly corresponding to animal tracks through the hazel scrub. The abundance of microcharcoal may indicate deliberate and probably regular fires in the area, both locally and further afield. Natural fires may also have occurred, but this is unlikely (Rackham 1986; Moore 2001), and the microcharcoal record is too consistent for occasional, sporadic fires. It may be, however, that some of the microcharcoal was transported by fluvial activity prior to sedimentation.

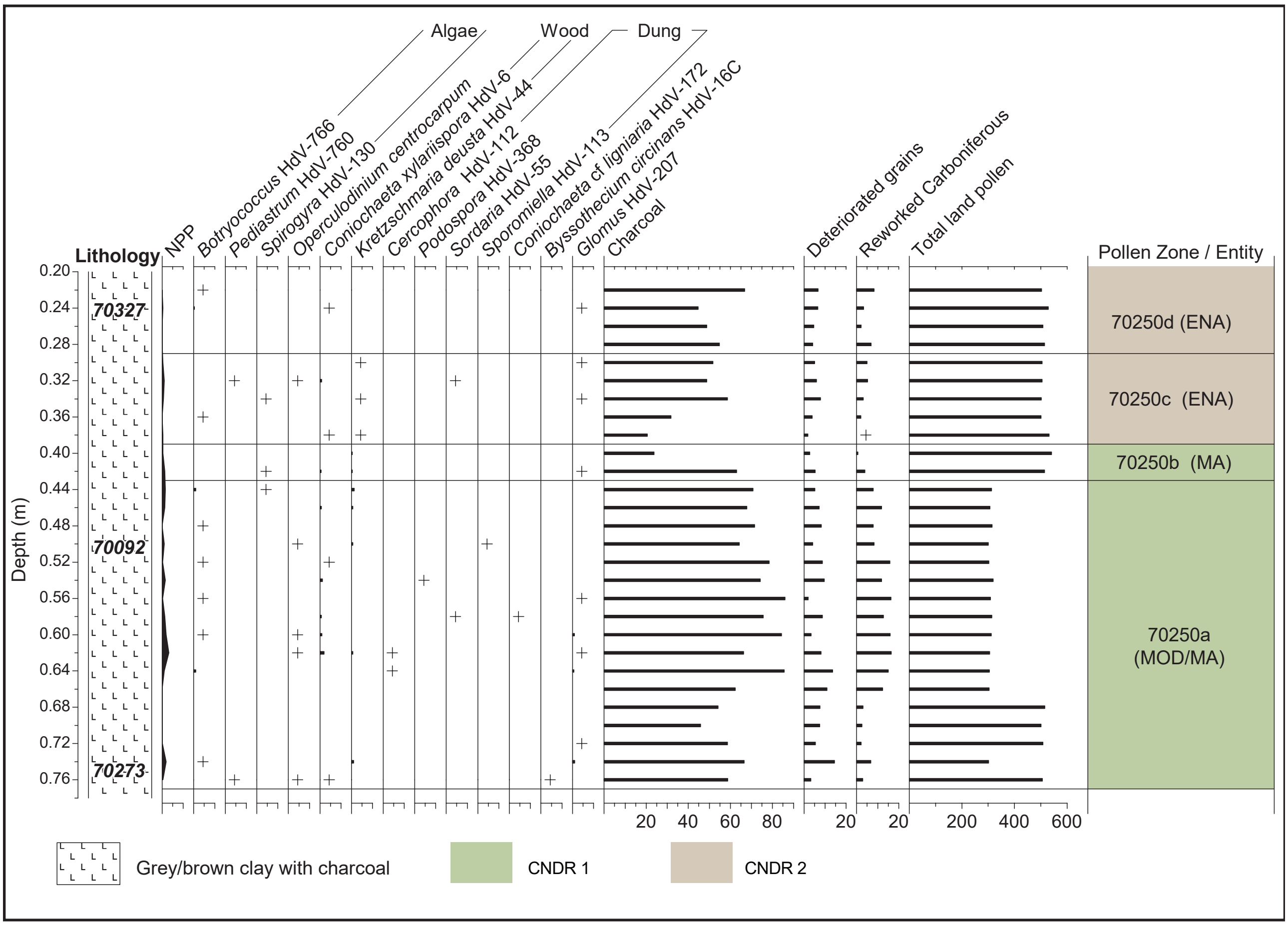
CNDR 1: Zone 70250b (0.43-0.39 m; 8.46-8.50m OD). Mesolithic alluvium: expansion of elm

Expansion of elm distinguishes this zone from those above or below (Fig 650?), while grass pollen reduced during the elm peak. The expansion of elm may suggest preferential environmental conditions for the growth of this tree, or possibly enhanced management of elm trees, allowing greater flowering, and hence more pollen production (Innes *et al* 2006). The data may suggest that conditions were put in place to encourage the spread of elm, such conditions perhaps including coppicing or pollarding as a technique for providing increased animal fodder (*ibid*), coppicing for use of stakes to make structures, or possible coppicing following beaver activity. Methods of coppicing and



Key: MOD= *Mesolithic organic deposit*; MA= *Mesolithic alluvium*; ENOD= *Earlier Neolithic organic deposit*; ENA= *Earlier Neolithic alluvium*

Figure 650: Pollen percentage diagram for monolith 70250, Bay F, Stainton West



Key: MOD= *Mesolithic organic deposit*; MA= *Mesolithic alluvium*; ENA= *Earlier Neolithic alluvium*

Figure 651: Non-pollen palymorph percentage diagram for monolith 70250, Bay F, Stainton West

pollarding result in increased production of pollen, as the trees spring new branches, which flower profusely before dying (*ibid*). Moreover, it appears that trees within the area were in some distress, as there is an increased frequency of the fungal spores *Kretzschmaria deusta* and *Coniochaeta xylariispora*, which preferentially attack deciduous trees, including elm and oak (*ibid*). Similar, but more pronounced, trends in the curves for these two fungal spores are also evident in the pollen diagrams from Bay B (Figs 643, 645), prior to the expanding values for elm.

CNDR 2: Zone 70250c (0.39-0.29 m; 8.50-8.60 m OD). Earlier Neolithic alluvium: Elm Decline

This zone is distinguished by a gradual, step-wise decline in elm-pollen values, although for those alder, hazel, and oak remained largely unchanged from the earlier zone (*above*). The curve for cereal-type pollen grains becomes consistent as the elm curve continued to decline at 0.32 m (8.57 m OD), but ribwort plantain does not appear until 0.26 m (8.63 m OD).

The step-wise decline of elm initially began at 0.38 m (8.51 m OD), with a more pronounced decline at 0.32 m (8.57 m OD), and was coincident with the occurrence of cereal-type pollen, although in this environment the possibility of some of these grains being attributable to wetland grasses such as sweetgrass cannot be ruled out entirely (Andersen 1979; Tweddle *et al* 2005; Joly *et al* 2007). Cereal-type pollen is consistently present from the Elm Decline to the Elm Decline Demise, and the curve for grass pollen rises steadily. However, ribwort plantain was not seen until 0.26 m (8.63 m OD); this could be a result of the 'drowning effect' of so much tree pollen, leading to the relative dilution of other pollen types (Bunting 2008). The pollen curves for elm can be readily correlated with those from Bay B, 70222/71155.

CNDR 2: Zone 70250d (0.29-0.22 m; 8.60-8.67 m OD). Earlier Neolithic alluvium : demise of elm and spread of alder carr

Two pollen events characterise this zone. The first is an expansion of grasses between 0.28 m (8.61 m OD) and 0.22 m (8.67 m OD), coincident with the demise of elm. The second event is the expansion of alder at the expense of hazel-type pollen, from 0.28 m (8.61 m OD).

The beginning of a switch from dominant hazel-type to alder in the *Principal palaoeochannel* is a feature common to the site as a whole. A possible raising of the watertable may have resulted in a much wetter local environment, more suitable for colonisation by alder, rather than hazel, while the expansion of grasses and species of wet meadows and/or disturbed ground, such as ribwort plantain, mints, sedges, and nettles, together with consistent cereal-type pollen, all point to possible human exploitation of the landscape and the continued opening up of the woodland canopy. This is further supported by high values for microcharcoal throughout the zone. This event has been dated in Bay D (monolith 70296) to the mid-fourth millennium BC.

Bay F: 70252

This monolith was extracted from the eastern part of Bay F, some 1 m from the centre line of the channel. This short monolith was *c* 1 m long, and sampled Mesolithic-age deposits and the *Earlier Neolithic organic deposit* (Table 306). However, it was evident that some of the later channel deposits (*ie* the *Earlier Neolithic alluvium* and *Later Neolithic organic deposit*) had been scoured out during the reactivation of the channel during the Chalcolithic period (*Ch 11*). Hence, part of this monolith sampled a deposit of alluvium relating to this scouring event, which, was, in turn, sealed by the *Bronze Age alluvium*. Analysis therefore considered the pollen contained in all five of these stratigraphic units, providing data relevant to the Mesolithic, earlier Neolithic, Chalcolithic, and Bronze Age landscapes in the vicinity of Stainton West.

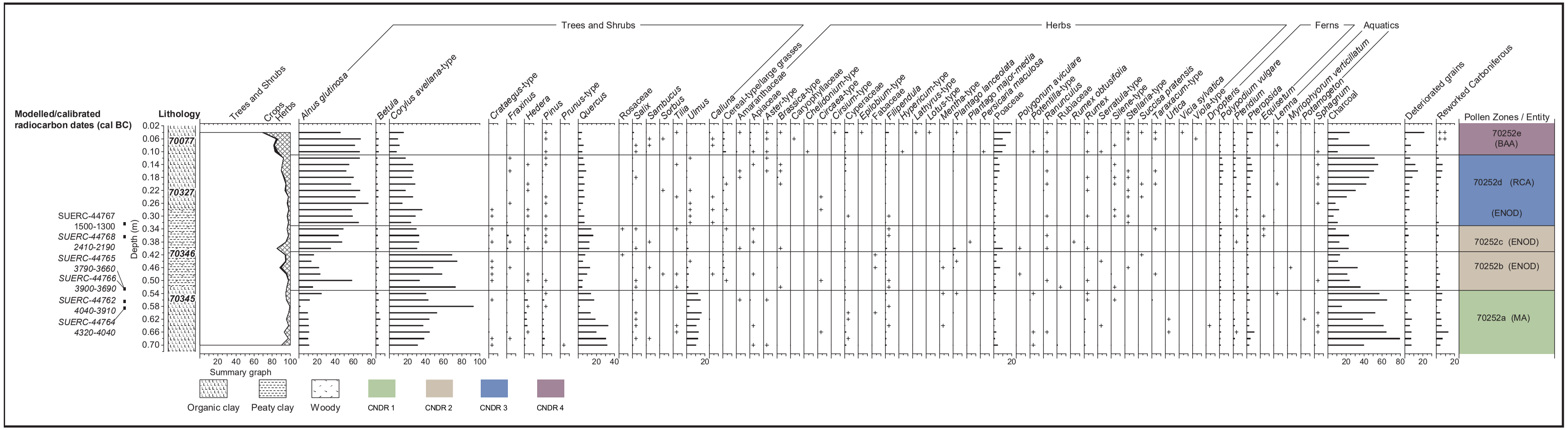
CNDR 1: Zone 70252a (0.72-0.53 m; 8.03-8.22 m OD). Mesolithic alluvium: hazel thickets

The trees and shrubs are dominated by hazel-type pollen, with common oak and elm, and lesser amounts of alder and birch (Fig 652). Other tree and shrub types include hawthorn, ash, ivy, pine, blackthorn, willow, and lime. The herb community comprises low counts of sedges and grasses, as well as fewer counts for meadowsweet, cinquefoils, docks/sorrels, bedstraw, mints, willowherbs, and the carrot family. Fern spores are well represented and include bracken, common polypody, and undifferentiated monolete ferns, while *Sphagnum*-moss spores were consistently recorded. The freshwater alga *Botryococcus* (HdV-766) is present (Fig 653), while single occurrences of the dinoflagellate cyst *Operculodinium centrocarpum* were recorded at 0.62 m (8.13 m OD) and 0.56 m (8.19 m OD). A relatively diverse range of fungal spores includes *Kretzschmaria deusta* (HdV-44), *Coniochaeta xylariispora* (HdV-6), *Coniochaeta ligniaria* (HdV-172), *Neurospora* (HdV-55C), *Glomus* (HdV-207), *Cercophora* (HdV-112), and *Chaetomium* (HdV-7A). Microcharcoal values are high throughout the zone.

The data suggest that the floodplain was dominated by hazel scrub, with mixed woodland comprising mostly oak, elm, and birch growing on other parts, or on the river terraces. Stands of alder may have developed close to the channel bank, or the pollen may reflect deposition from a wider area. Wetter areas adjacent to the channel may have been inhabited by a range of damp-tolerant herb species (*eg* meadowsweet, docks/sorrels, and grasses). A diversity of NPP suggest a range of possible palaeoenvironments, including disturbed ground (possibly grazed by herbivores), decaying woodlands, and areas subjected to burning. High counts for microcharcoal also point to the use of fire, probably both locally and regionally. There are many complex interacting factors involved in interpretation of microscopic charcoal in the pollen record. However, broad-leaved deciduous woodlands are thought not to be susceptible to fire (Rackham 1986) and it is believed that catastrophic and extensive natural fires occur infrequently (Moore 2001). Human firing is likely to have occurred at frequent intervals, possibly seasonally, and would have enhanced both herbaceous growth and attracted animals to an area (*ibid*). However, grazing, browsing, and trampling by animals could show similar appearances in pollen

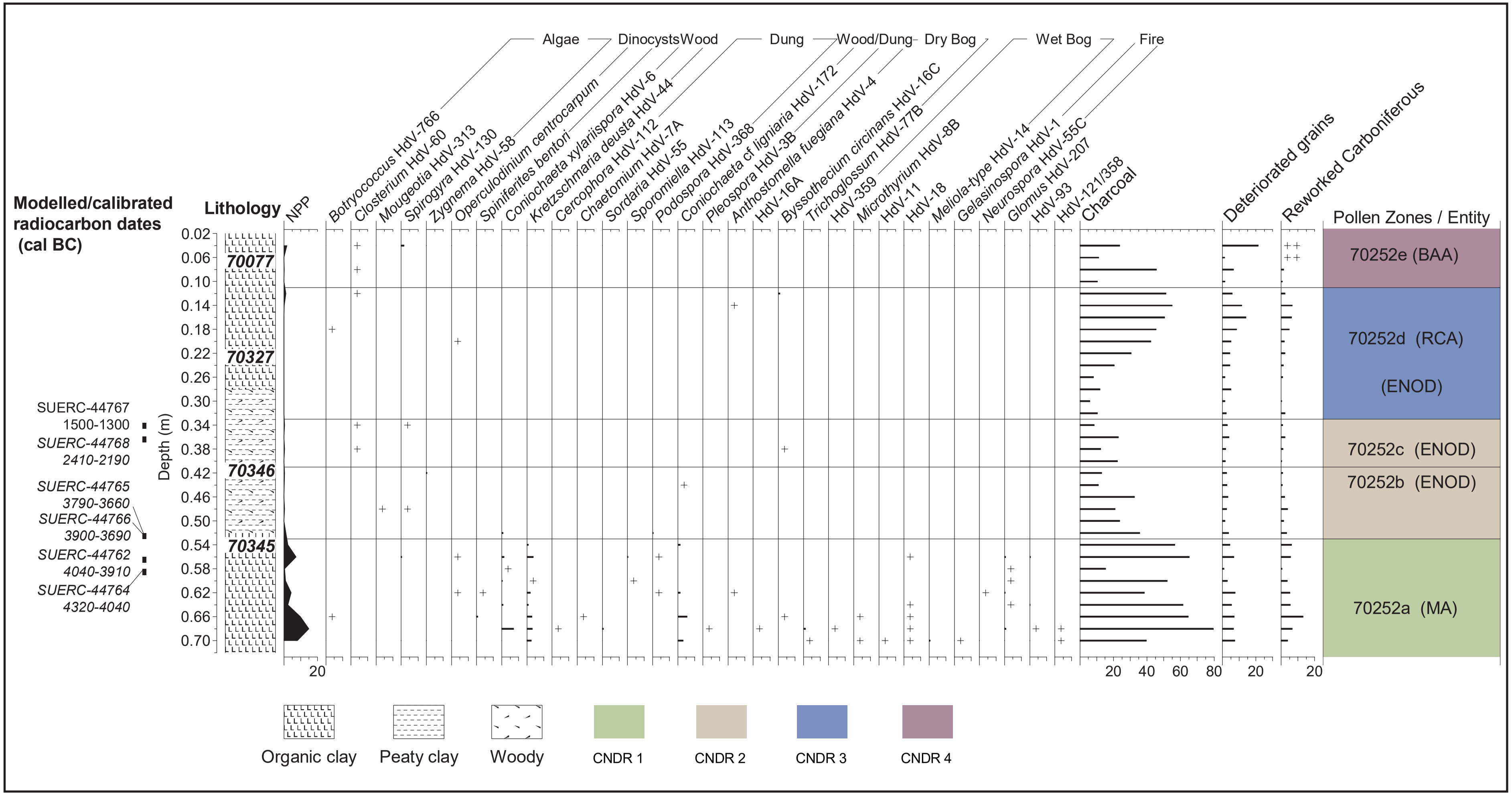
Depth (m)	Altitude (m OD)	Context	Entity	Description of sediments
0-0.05	+8.75-8.70	***70077***	*Bronze Age alluvium*	Soft light brown clay
0.05-0.28	+8.70-8.47	***70327*** (group ***70135***)	Alluvium within Chalcolithic reactivation channel	Soft grey/pale brown clay with charcoal flecks
0.28-0.52	+8.47-8.23	***70346*** (group ***70301***)	*Earlier Neolithic organic deposit*	Peaty clay with abundant plant debris and wood. Wood chunks from 0.41-0.44 m. Charcoal concentrated from 0.45-0.52 m
0.52-0.70	+8.23-8.05	***70345***	*Mesolithic alluvium*	Soft grey clay with organic inclusions and charcoal
0.70-*c* 0.84	+8.05-7.91	***70092*** (group ***70097***)		Soft grey clay with organic inclusions and charcoal with fine sand from *c* 0.80 m
0.84-1.05	+7.91-7.70	***70273*** (group ***70228***)	*Mesolithic organic deposit*	Peaty clay with sand, wood, and plant debris

Table 306: Stratigraphy for monolith 70252, Bay F¸ Stainton West



Key: MA= *Mesolithic alluvium*; ENOD= *Earlier Neolithic organic deposit*; RCA= Reactivation channel alluvium; BAA= *Bronze Age alluvium*

Figure 652: Pollen percentage diagram for monolith 70252, Bay F, Stainton West



Key: MA= *Mesolithic alluvium*; ENOD= *Earlier Neolithic organic deposit*; RCA= Reactivation channel alluvium; BAA= *Bronze Age alluvium*

Figure 653: Non-pollen palymorph percentage diagram for monolith 70252, Bay F, Stainton West

records (such as the expansion of herbaceous taxa; Buckland and Edwards 1984).

Between 0.58 m (8.17 m OD) and 0.54 m (8.21 m OD), the values for elm pollen dropped abruptly, but then rose again, a trend very different from the gradual step-wise decrease in elm seen in Bay B, 70222/71155, and Bay F, 70250. There are several factors that may have resulted in an abrupt rather than gradual signal. The apparently significant drop in elm pollen values at 0.58 m (8.17 m OD) may be a response to the high percentage values for hazel-type pollen, which could be over-represented, perhaps caused by the deposition of a hazel catkin into the palaeochannel. Indeed, plant macrofrossils from the *Mesolithic alluvium* in Bay F included hazel seeds and nut fragments, as well as anthers (*Appendix 17*), and the declining elm values are not coincident at this point with the consistent occurrence of ribwort plantain or cereal-type pollen. There is also evidence for the reworking of Carboniferous miospores in this zone, that may be indicative of erosional events, which could have caused a more mixed, less clear, Elm Decline signal, and rare dinocysts, recorded within the *Mesolithic alluvium* in this section, close to the Mesolithic/Neolithic boundary, suggest possible weak-tidal influence. Soil micromorphology from the *Mesolithic alluvium* in an adjacent monolith in Bay F (70255 deposit ***70323***; *Appendix 19*) suggests complex deposition, including both alluvial-humic silts and locally reworked sands, and possible marine influence. A hazelnut at 0.58-0.59 m (8.17-8.16 m OD) dates to *4320-4040* cal *BC* (*SUERC-44764*), whilst chronological modelling estimates that the drop in elm pollen occurred in *4330-4040* cal *BC* (*'Abrupt drop in elm pollen F'*; *Appendix 20*).

CNDR 2: Zone 70252b (0.53-0.41 m; 8.22-8.34 m OD). Earlier Neolithic organic deposit (part): Elm Decline/ Demise

This zone is characterised by declining elm pollen, reductions in oak, the appearance of sporadic, then consistent, ribwort plantain and cereal-type pollen, and the expansion of grass. Between 0.54 m (8.21 m OD) and 0.50 m (8.25 m OD), the values for elm drop to a presence only. Representatives of the blue/green algae *Mougeotia* (HdV-313) and *Zygnema* (HdV-58) are present, in addition to the fungal spores present in the preceding zone (*above*). The microcharcoal curve is relatively small.

Pollen of ribwort plantain is consistently recorded at 0.46-0.40 m (8.29-8.35 m OD), but then stops, and cereal-type pollen is present consistently from 0.50 m (8.25 m OD). A rise in both of these curves is usually coincident with falling values for elm (Tipping 1995a). Chronological modelling estimates that the appearance of ribwort plantain occurred in *3720-2870* cal *BC* (*'Ribwort plantain F'*; *Appendix 20*). More generally, the pollen signature in this section (particularly a rise in oak and alder, and a decline in hazel, when elm values are low) is consistent with a time after the Elm Decline, but before the Elm Decline Demise. Plant macrofossils have been dated to *3900-3690* cal *BC* (*SUERC-44766*) and *3790-3660* cal *BC* (*SUERC-44765*), whilst chronological modelling suggests that this event dates to *3900-3670* cal *BC* (*'Elm declining to presence F'*; *Appendix 20*).

The data suggest that subsequent to the Elm Decline, small clearances opened up, which may have been used for pasturing and perhaps small-scale arable cultivation. It is possible that the duration of such activities lasted for several centuries; however, the pollen evidence is less clear than in the adjacent monolith (70250) from Bay F, or from the equivalent deposits in both Bays B and D. The open areas would have supported a variety of meadow or wayside plants, or plants associated with disturbed ground, including stitchworts and chickweeds (*Stellaria*-type), pinks, devil's bit scabious, docks and sorrels, meadowsweet, willowherbs, and the cabbage family (Brassicaceae, a large group comprising plants such as garlic mustard, and cresses).

CNDR 2: Zone 70252c (0.41-0.33 m; 8.34-8.42 m OD). Earlier Neolithic organic deposit: alder/ hazel switch

This zone is distinguished by an expansion of alder, decreasing values for hazel, and an increase in the numbers of oak. There are occurrences of hawthorn-type, ash, ivy, pine, willow, and birch pollen, while grasses, sedges, meadowsweet, docks/sorrels, and cereal-type were recorded, as well as sporadic occurrences of knotgrass (*Polygonum aviculare*). Fern spores, including common polypody and bracken, are present and a few occurrences of horsetails were also noted. Isolated occurrences of the algal taxa *Spirogyra* (HdV-130) and *Closterium* (HdV-60) were recorded.

The pollen from this zone shows a transition of vegetation types on the floodplain, as alder became dominant, replacing the previously dominant hazel scrub. The switch from hazel-type to consistent, rising values for alder begins at 0.40 m (8.35 m OD), although irregular values for rising alder may be seen in Zone 70252b (*above*). The rise to dominance of alder has been dated from Bays B (70222/71155) and Bay D (70296) as occurring within the Neolithic period.

In addition to the developing alder carr on the floodplain, a wetter environment can be interpreted from the occurrences of damp-loving plant types such as willows, sedges, meadowsweet, and docks/ sorrels (Stace 2010). This is further supported by the occurrence of rare NPP taxa *Spirogyra* (HdV-130) and *Closterium* (HdV-60), both of which thrive in shallow, stagnant water (van Geel 1978). The main herb type is grass, suggesting continued utilisation of cleared areas, possibly for both small-scale pasture and potential cultivation. Cereal-type grains are continuously recorded, but in small numbers, and there is still a possibility that some of these grains may represent wild grasses (Andersen 1979; Tweddle *et al* 2005; Joly *et al* 2007). Microcharcoal values remain relatively low throughout the zone, indicating that fire activity may have been reduced in comparison to activity in earlier zones.

CNDR 3: Zone 70252d (0.33-0.10 m; 8.42-8.65 m OD). Alluvium 70327 within the Chalcolithic reactivation channel: alder carr

Alder dominates the tree pollen with reductions in hazel, the latter especially visible towards the top of the zone (from 0.12 m; 8.63 m OD). Values for oak drop after the increase seen in the earlier zone (*above*) and remain consistent, but low, throughout the zone. Occurrences of other tree and shrub types are indicated by small numbers of pollen grains of ash, ivy, pine, willow, elder, rowan, lime, elm, and heather. Grass pollen increases from 0.10 m (8.65 m OD) and cereal-type pollen was consistently recorded throughout the zone. The herb-pollen assemblage is similar to that in earlier zones (*above*). In addition, daisy-types, goosefoot family, redshank (*Persicaria maculosa)*, dandelion-type, and buttercups are present. Fern spores generally increase in abundance; of note is the continuous curve for bracken. Aquatic plants such as duckweed were recorded, and *Sphagnum*-moss spores are present throughout the zone, with the algal taxa *Closterium* (HdV-60) and *Spirogyra* (HdV-130) occurring towards the top. Microcharcoal values start low, but then increase towards the top of the zone.

Data suggest the channel and floodplain area were by this time largely covered in alder carr. The dying back of hazel scrub, as indicated by decreasing values for hazel-type pollen, might be because it has been out-competed by alder and perhaps also because it may have been burned as fuel, or cleared to provide open ground for pasturing and/or small-scale cereal cultivation. Values for oak are also reduced. The microcharcoal values clearly support burning activity, which may reflect local and/or fires in the wider area. The increased values for bracken might have been in response to fire-related activity, as bracken is known to invade burnt areas preferentially (Innes 1999).

The potential age of this zone is provided by two plant macrofossils recovered from the interface between deposit ***70346*** (part of the *Earlier Neolithic organic deposit*) and alluvium ***70327*** present in the reactivation channel. One of these, at 0.36-0.37 m (8.39-8.38 m OD) dates to the Chalcolithic period (*2410-2190* cal *BC*; *SUERC-44768*), whilst the other, at 0.34-0.35 m (8.41-8.40 m OD), dates to the Bronze Age (1500-1300 cal BC; 3142±35 BP; SUERC-44767). It is suspected that the latter date is derived from intrusive material (*Ch 11*).

CNDR 4: Zone 70252e (0.10-0.02 m; 8.65-8.73 m OD). Bronze Age alluvium: clearance

A distinct rise in grass and decrease in hazel-type pollen distinguishes this zone. Alder is the dominant tree/shrub present, with some birch and oak, and a little heather and willow. A variety of herbs, similar to those in the preceding zone (*above*), was recorded, but, in addition, thistles (*Cirsium*-type), wood vetch (*Vicia sylvatica*), and willowherbs (*Epilobium*-type) are also present. Pollen preservation is generally poorer than in the older sediments, reflected in a relatively large proportion of deteriorated grains. Fungal spores are absent, but a few algae are present, including *Closterium* (HdV-60) and *Spirogyra* (HdV-130).

The data provide evidence for small, possibly cleared, areas within or adjacent to the floodplain, including increasing amounts of grasses, weeds associated with disturbed ground (*eg* docks and thistles), and the occurrence of cereal-type pollen. The values for hazel-type pollen and, to a lesser extent alder, are reduced, perhaps suggesting possible selection of these trees for building or burning activity. Species of willowherb (*Epilobium*-type, present at the top of this zone) is known to grow in areas that have been subjected to fire (Innes 1989).

Bay O: 70507

Monolith 70507 was taken in the central area of Bay O. It sampled Neolithic-age deposits, and also those dating to the Chalcolithic and Bronze Age (Table 307). In addition, this monolith sampled a buried subsoil, sealing the Bronze Age alluvium (*Ch 11*). All of these stratigraphic units contained pollen suitable for analysis.

CNDR 3: Zone 70507a (1.05-0.87 m; 8.68-8.86 m OD). Earlier Neolithic alluvium (1.00-1.05 m (8.73-8.68 m OD) only) and Later Neolithic organic deposit: wooded floodplain

The zone is characterised by the dominance of arboreal pollen including hazel-type, alder, and oak (Fig 654). Other tree and shrub pollen includes consistent birch and ivy, and sporadic occurrences of heather, elm, ash, willow, pine, hawthorn, bramble (*Rubus*-type), and blackthorn-type. Rare cereal-type pollen was recorded through the zone, although the grains may be referable to wild-grass types (Andersen 1979; Tweddle *et al* 2005; Joly *et al* 2007). Grasses are consistently present, but in low numbers, and sedges occur sporadically, while herb taxa, such as meadowsweet, docks/sorrels, buttercups, daisy-types,

Depth (m)	Altitude (m OD)	Context	Entity/deposit type	Description of sediments
0-0.06	+9.73-9.67	***70474***	Topsoil	Dark humic silty-clay loam
0.06-0.43	+9.67-9.28	***70500***	Buried subsoil	Dark humic, peaty silty-clay
		70475		Dark grey silty-clay loam with traces of rootlets
0.45-0.68	+9.28-9.05	***70476***	*Bronze Age alluvium*	Grey minerogenic clayey-silty loam and charcoal flecks
		70481		Dark grey/black humic clay silt with common charcoal fragments
c 0.68-0.80	+9.05-8.86	***70477*** (group ***70299***)	*Chalcolithic alluvium*	Black silt clay with charcoal
0.87-1.02	+8.86-8.71	***70478*** (group ***70300***)	*Later Neolithic organic deposit*	Black peaty silt/clay with charcoal and wood; distinct woody peat layer at 0.95 m. Wood/peaty layer in clay at 1.01 m
1.02-1.20	+8.71-8.53	***70482*** (group ***70135***)	*Earlier Neolithic alluvium*	Grey/green /pale orange silt clay

Table 307: Stratigraphy for monolith 70507, Bay O¸ Stainton West

and ribwort plantain, are present. Fern spores are consistently present and include some appearances of bracken, common polypody, and undifferentiated monolete fern spores, and *Sphagnum*-moss spores were also recorded. Sporadic occurrences of a relatively diverse NPP assemblage are present (Fig 655), of which *Chaetomium* (HdV-7A), *Cercophora* (HdV-112), *Coniochaeta xylariispora* (HdV-6A), *Sordaria* (HdV-55C), *Glomus* (HdV-207), and *Kretzschmaria deusta* (HdV-44) are the most significant. Microcharcoal is present throughout the zone, with greater counts towards its lower half.

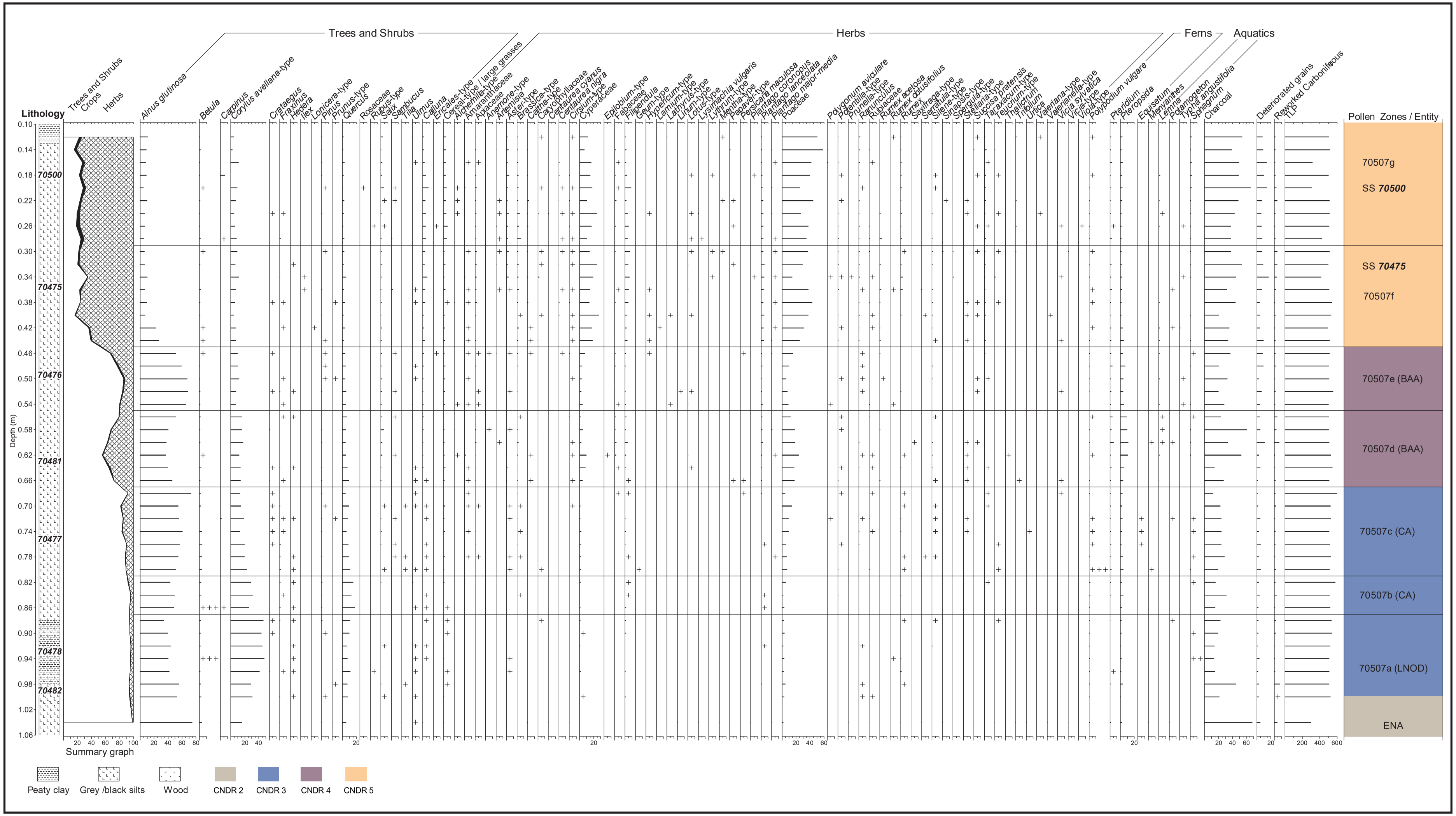
The pollen from this zone suggests a wooded floodplain, with fluctuating values for hazel-type and alder, and lesser quantities of oak. The expansion of hazel-type probably reflects drier conditions on some parts of the floodplain or terraces, while the spread of alder suggests development of wetter, carr conditions. The consistent presence of grasses as well as ferns indicates low-level, open areas on the floodplain, supporting a fairly low diversity of herb flora, including daisy-types, docks and sorrels, and herbs of damper areas, such as meadowsweet and sedges (Stace 2010). Possible cereal cultivation, associated with weeds of wet meadows/pastures (*eg* ribwort plantain, docks/sorrels, and buttercups) provides some evidence for human activity on, or possibly adjacent to, the floodplain (Gaillard 2007). Wooden stakes from the *Later Neolithic organic deposit* provide clear evidence of human activity within the palaeochannel, and debris suggests tree felling and the splitting of oak and alder (*Appendix 13*).

The fungal spore *Glomus* (HdV-207) is linked to soil disturbance (van Geel 1978), which could have been created by animals or humans using the floodplain for pasture. NPP, including sordarious fungal spores, along with *Chaetomium* (HdV-7A) and *Cercophora* (HdV-112), although present in small numbers, also provide some evidence for potential animal grazing, species of *Chaetomium* (HdV-7A) having been recorded from archaeological sites, including settlements, where they have been associated with damp straw, cloths, leather, and other substrates (van Geel and Aptroot 2006). Occurrences of the blue/green algal type *Mougeotia* HdV-313 indicate that areas of shallow open water existed at the site (van Geel 1978). A later Neolithic date of 3100-2910 cal BC (4380±35 BP; SUERC-32702), at 0.95-0.96 m (8.78-8.77 m OD), has been obtained from a sediment sample, though this date is not considered robust (*Appendix 20*).

CNDR 3: Zone 70507b (0.87-0.81 m; 8.86-8.92 m OD). Chalcolithic alluvium: fluctuations in the woodlands

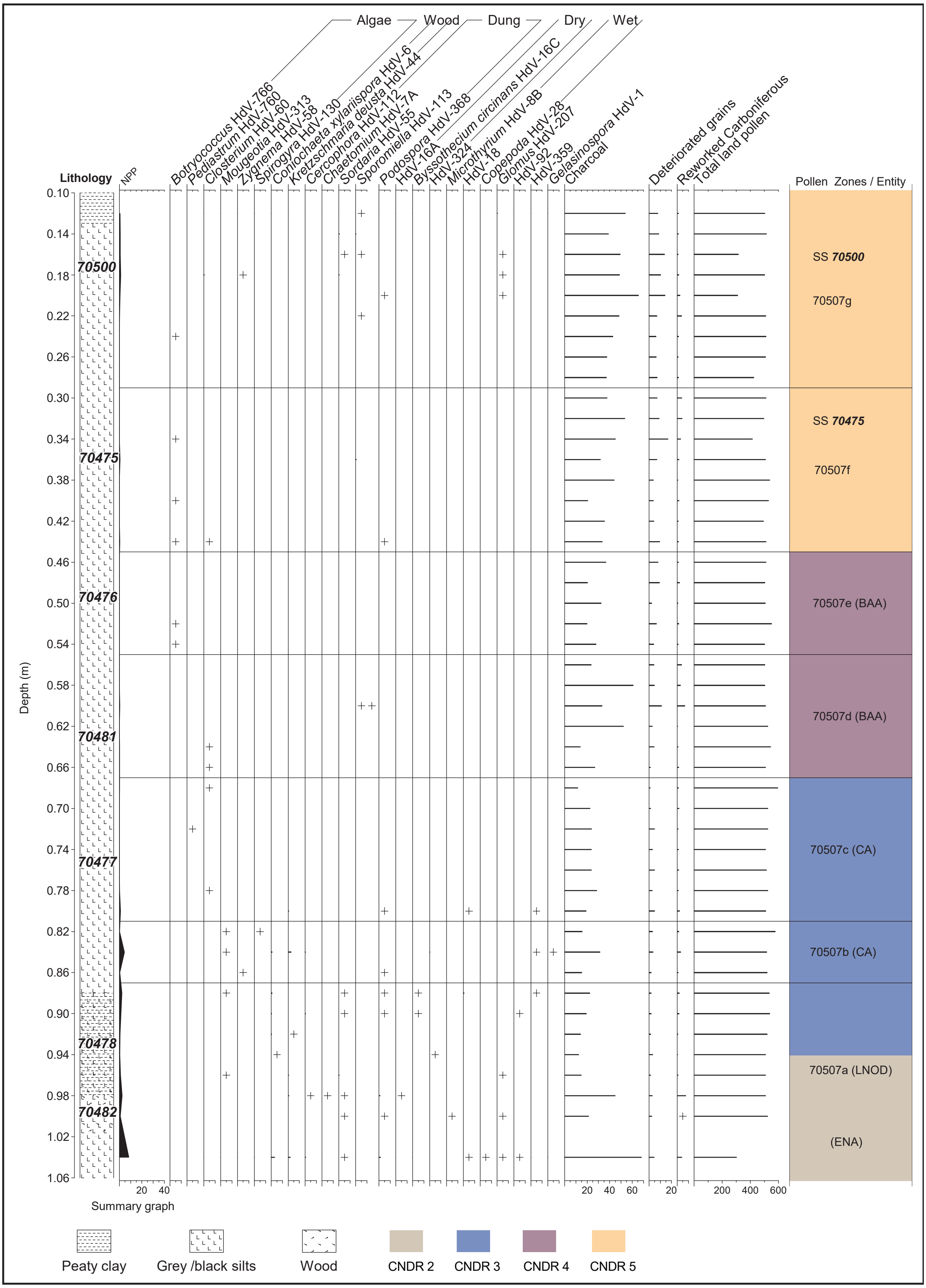
This zone is distinguished from the underlying Zone 70507a (*above*) by slightly increasing values for alder and oak, and a reduction in hazel-type pollen. Counts for microcharcoal are variable, but remain fairly low. The assemblage of fungal spores remains similar to that in the underlying zone, with the addition of *Gelasinospora* (HdV-1).

The expansion of alder would indicate wetter conditions on the floodplain, perhaps resulting from a rising watertable, due, for example, to wetter climatic conditions. Values for hazel are lower than in the earlier zone (*above*), and this trend continues throughout the rest of the pollen diagram. This may suggest preferential use of hazel as a fuel, or for building structures, or may simply reflect adverse growing conditions. The slight expansion of oak, which may have been growing on the drier river terraces, along with ash and elm, which are shade-tolerant (Gaillard 2007), suggests continuation of mixed woodland adjacent to the floodplain. The incidence



Key: ENA= *Earlier Neolithic alluvium*; CA= *Chalcolithic alluvium*; BAA= *Bronze Age alluvium*; SS= Subsoil

Figure 654: Pollen percentage diagram for monolith 70507, Bay O, Stainton West



Key: ENA= *Earlier Neolithic alluvium*; CA= *Chalcolithic alluvium*; BAA= *Bronze Age alluvium*; SS= Subsoil

Figure 655: Non-pollen palynomorph percentage diagram for monolith 70507, Bay O, Stainton West

of microcharcoal and *Gelasinospora* (HdV-1) indicates fire activity, which may have included a regional as well as local component.

CNDR 3: Zone 70507c (0.81-0.67 m; 8.89-9.06 m OD). Chalcolithic alluvium: first grass expansion
The zone is distinguished by an expansion of the grass-pollen curve. Alder dominates the arboreal assemblage, with much reduced hazel-type pollen and reducing values for oak; both hawthorn and willow were also recorded throughout the zone. Cereal-type pollen is present throughout in low numbers. The pollen of herbs found in open woodlands includes wood vetch, wood sage (*Teucrium*-type), and chickweeds/stitchwort, and herbs found on waste/arable ground, and/or grassy places or damp meadows, are also present, including the carrot family, docks/sorrels, ribwort plantain, knotgrass, bedstraw, cinquefoils, dandelions, pinks, meadowsweet, and redshank pollen. *Sphagnum*-moss spores are present sporadically throughout the zone and spores of horsetails occur, as well as the freshwater algae *Pediastrum* (HdV-760) and *Closterium* (HdV-60).

The arboreal pollen indicates a vegetated floodplain dominated by alder, while hazel scrub and a host of shade-tolerant trees and shrubs, such as ash, ivy, and hawthorn, may have been growing on the drier terraces. The pollen summary curve shows the expansion of herbs, largely attributable to grass, beginning to make an impact on the woodland vegetation. Cereal-type pollen (possibly barley) and ribwort plantain are sporadically present, but in very low numbers, and, together with knotgrass, may suggest the beginning of more concentrated disturbance associated with potential arable cultivation (Behre 1981). *Pediastrum* (HdV-766) and *Closterium* (HdV-60) both indicate shallow, freshwater environments, and willow is also present, a species known to grow preferentially in damper areas (Stace 2010).

CNDR 4: Zone 70507d (0.67-0.55 m; 9.06-9.18 m OD). Bronze Age alluvium: second grass expansion
This zone is distinguished by an expansion of sedge pollen, a rise in grasses, to a peak at 0.62 m (9.11 m OD), and expansion of fern spores. The pollen curve for alder drops back, but the curves for oak and hazel remain largely unchanged, while values for willow increase slightly, in comparison with Zone 70507c (*above*). Fungal spores of the type *Sporomiella* (HdV-113) are present in low numbers. Microcharcoal values fluctuate, but generally appear to increase in quantity within the zone.

Rising values for herb pollen are seen alongside a slight decline in alder carr, and suggest an increase in open areas on, or adjacent to, the floodplain. Plants associated with wet meadows/pastures and disturbed areas (*eg* ribwort plantain) now occur consistently (Behre 1981), and such habitats may have been used to pasture animals, supported by the recovery of rare spores of the fungal type *Sporomiella* (HdV-113), which is a reliable proxy for the presence of wild and/or domesticated herbivores (van Geel and Aptroot 2006). Evidence of possible low-level arable cultivation is based on the consistent records for cereal-type pollen (possibly barley) and associated weeds of cultivation, such as pollen from the goosefoot, carrot, and cabbage families. However, all of these groups represent many species of plants, which can inhabit a wide variety of habitats, including waste ground, footpaths, and ruderal communities (Behre 1981).

Higher microcharcoal values are coincident with decreasing values for alder and birch, suggesting potential clearance of some of these trees, possibly for the creation of meadows and small arable areas. Microcharcoal in the pollen record suggests deliberate burning, at a regional or local level, although naturally occurring fires are a possibility. Microcharcoal counts may also represent particles deposited in alluvial sediments through fluvial action.

CNDR 4: Zone 70507e (0.55-0.45 m; 9.18-9.28 m OD). Bronze Age alluvium: alder carr
This zone is distinguished by an expansion of alder and decreases in grasses and sedges. The data therefore suggest further encroachment of alder carr on the floodplain. This may have been as a result of renewed fluvial activity, causing a rising watertable, suitable for its growth. The pollen curve for grasses, in particular, and also fern spores, decreases as the alder spread again on the floodplain.

CNDR 5: Zone 70507f (0.45-0.29 m; 9.28-9.44 m OD). Bronze Age alluvium (part) and buried subsoil (part): cleared floodplain
The pollen curves show a very dramatic decline in alder in this monolith. Low values for hazel-type and dwindling oak values characterise the zone, but a steady rise in heather was also noted. Among the herb pollen, there is a striking rise in values for grasses and sedges, while increased levels of ribwort plantain and consistent, but low, values for cereal-type pollen were recorded. This latter type includes consistently larger grains; these may be attributable to wheat/oat types as well as barley. The herb assemblage shows that, in addition to most of the herb types in earlier zones, occurrences of loosestrifes (*Lythrum*-type) and marsh marigold (*Caltha palustris*) were recorded, alongside consistently high numbers of meadowsweet.

The alder-pollen curve suggests that this had been drastically reduced in the vicinity of Bay O. Perhaps large areas were cleared of alder wood to provide fuel and/or for pasture or arable cultivation, an hypothesis supported by the rising curve for grass and the continuous curve for cereal-type pollen. Evidence for wet environments is clear from the abundant sedges, as well as the occurrences of loosestrifes and marsh marigold, which have a preference for damp conditions (Stace 2010). The beginning of the spread of acid heath is indicated by the record of heather (*ibid*), which expanded through this zone. An increase in the microcharcoal particles also suggests possible increased utilisation of fires adjacent to the channel. A sediment sample at 0.36-0.37 m (9.37-9.36 m OD) produced a date of 970-800 cal BC (2725±35 BP; SUERC-32698), though this was not considered robust (*Appendix 20*).

CNDR 5: Zone 70507g (0.29-0.11 m; 9.44-9.62 m OD). Buried subsoil: cultivation of the floodplain

This zone is distinguished from underlying Zone 70507f (*above*) by a slight increase in cereal-type pollen, further reduction in already low values for oak, and, towards the top of the profile, an expansion of grasses at the expense of sedges. Values for microcharcoal remain high. The fungal spores *Glomus* HdV-207, *Podospora* HdV-368, and *Sporomiella* HdV-113 are present.

The data suggest that the floodplain continued to be exploited for consistent, but relatively small-scale, arable agriculture, including the cultivation of possibly barley and oats/wheat. Pollen associated with wet meadows and pastures, such as devil's bit scabious, docks/sorrels, ribwort plantain, and dandelion-types, suggest the land was also used for animal grazing. The NPP include the disturbance indicator, *Glomus* HdV-207, present in the profile, along with low counts for fungal spores associated with people and animals (*eg Podospora* HdV-368 and *Sporomiella* HdV-113).

Bay O: 70513

Monolith 70513 lay just outside the maximum extent of the *Principal palaeochannel* and was extracted from a section that extended along the northern side of Bay O, designed to examine a series of deposits relevant to later phases of alluviation and soil formation (*Ch 11*). This monolith therefore sampled the *Bronze Age alluvium*, which in this area lay directly above the *Basal sands and gravels*, and a later alluvial layer (*Bronze Age/Iron Age alluvium*), as well as an intervening buried land surface (Table 308). A buried subsoil, overlying the *Bronze Age/Iron Age alluvium* was also sampled, and this, together with the earlier deposits, contained pollen that was analysed.

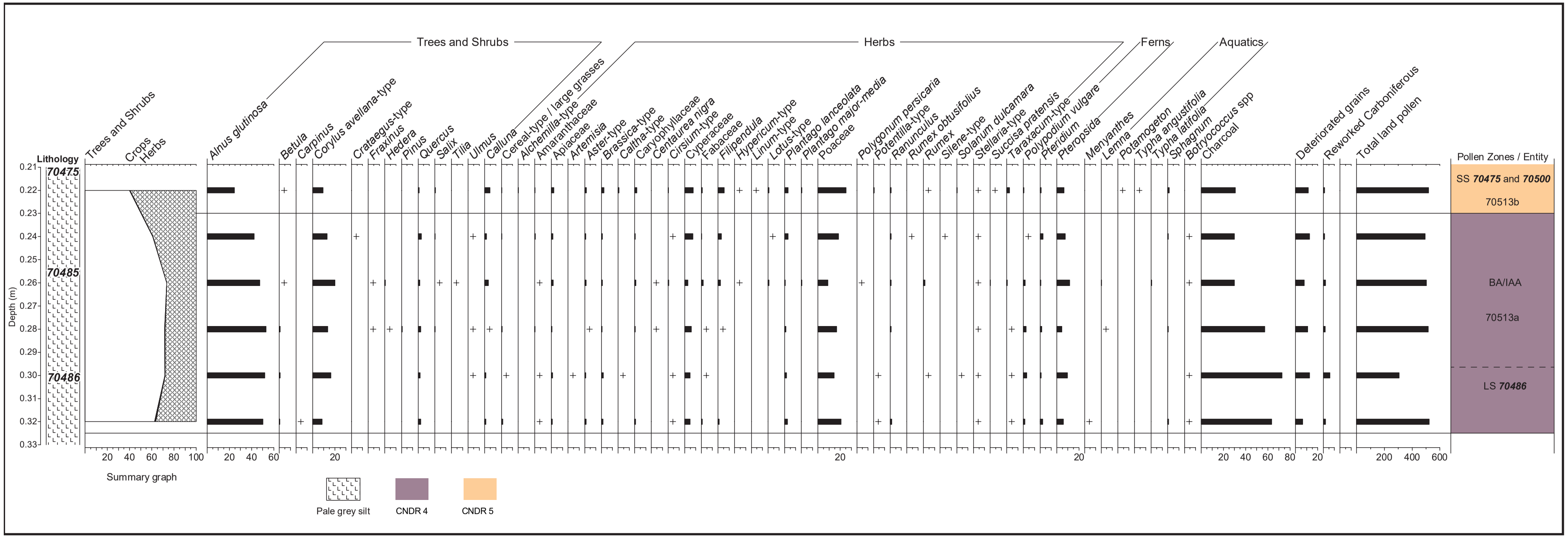
CNDR 4: Zone 70513a (0.32-0.23 m; 9.70-9.79 m OD). Buried land-surface 70486 (part) and Bronze Age/Iron Age alluvium (part): alder carr

The overall pollen assemblages from the productive sub-samples in this zone yielded similar results. Of the trees and shrubs, alder and then hazel-type occur most commonly, with the presence of birch, oak, hawthorn, ash, pine, willow, lime, elm, and heather pollen (Fig 656). Herb pollen is dominated by grasses and sedges, with occurrences of the carrot, daisy, cabbage, pinks, and goosefoot families, as well as ribwort plantain, docks/sorrels, and devil's bit scabious. The pollen of the aquatic plant bulrush is present at 0.26 m (9.76 m OD), and low values for *Sphagnum*-moss spores were found throughout. The freshwater alga *Botryococcus* (HdV-766) was recorded in small numbers. Microcharcoal particles are present throughout and show a fluctuation from abundant in the lower three sub-samples to commonly present within the upper two sub-samples of this zone. No fungal spores were recorded.

The evidence suggests the predominant habitat was one of alder carr. Grasses, sedges, and herbs with a preference for wetter habitats were present (*eg* meadowsweet, redshank, and marsh marigold), while the aquatic plant bogbean (*Menyanthes*) in the deepest sample, the sporadic occurrence of the freshwater alga *Botryococcus* (HdV-766), isolated occurrences of aquatic taxa, such as duckweed, as well

Depth (m)	Altitude (m OD)	Context	Entity/deposit type	Description of sediments
0-0.07	+10.02-9.95	***70474***	Topsoil	Dark peaty sandy silt
0.07-0.15	+9.95-9.87	***70500***	Buried subsoil	Dark peaty sandy silt with increasing silt
0.15-0.23	+9.87-9.79	***70475***		Dark grey organic silt
0.23-0.30	+9.79-9.72	***70485***	*Bronze Age/Iron Age alluvium*	Paler grey silt with iron staining
0.30-0.35	+9.72-9.67	***70486***	Buried land surface	Pale grey silt with charcoal
0.35-0.46	+9.67-9.56	***70488***	*Bronze Age alluvium*	Pale grey silt with charcoal; large stone at 0.35-0.36 m
0.46-0.52	+9.56-9.50	***70484***		Orange/grey fine sand
0.52-0.88	+9.50-9.14	***70487*** (group ***70098***)	*Basal sands and gravels*	Orange/grey sand

Table 308: Stratigraphy for monolith 70513, Bay O, Stainton West



Key: BA/IAA= *Bronze Age/Iron Age alluvium*; LS= Land surface; SS= Subsoil

Figure 656: Pollen percentage diagram for monolith 70513, Bay O, Stainton West

as pondweed and lesser bulrush in the uppermost sample, are all indicative of wetter habitats. The abundance of microcharcoal, especially in the lower part of the diagram (between 0.32 m (9.70 m OD) and 0.28 m (9.74 m OD)), indicates the presence of burning, probably relating to the activities associated with the two second-millennium BC burnt mounds at the site (Burnt Mounds 3 and 4; *Ch 11*). The apparent shift to less microcharcoal (about half as much as in the lower samples from 0.26 m (9.76 m OD)) suggests fewer common fires in the environment, and this equates to the period (*Bronze Age/Iron Age alluvium*) when burnt-mound activity had ended.

CNDR 5: Zone 70513b (0.23-0.21 m; 9.79-9.81 m OD). Buried subsoil

This zone contains only one sub-sample and is distinguished from the underlying zone by a decrease in alder pollen and relative expansion of grass. A single grain attributed to flax (*Linum*-type) is present and the aquatic plant, lesser bulrush, was also recorded. Microcharcoal values continue to be relatively low, but no fungal spores were recorded. The decline in alder is indicative of possible clearance, with a clear expansion of grassland/wet meadow environments.

Burnt Mound 2 (70235)

Burnt Mound 2 dates to the very end of the third millennium cal BC (*Ch 11*); during its excavation, a pollen monolith was extracted from its trough, sampling two sequential deposits contained within this feature (Table 309). Both deposits contained pollen suitable for analysis and these provide some evidence for the character of the earlier Bronze Age landscape.

CNDR 4: Zone BMa (0.28-0.19 m; 9.29-9.38 m OD)

The pollen assemblages in the lowest part of the section are characterised by tree and shrub pollen (Fig 657), including abundant alder, with less commonly recorded hazel-type. In addition, pollen grains of oak, willow, birch, heather, and elm were recorded. Herb pollen is diverse, principally comprising grass, with rarer occurrences of sedges, meadowsweet, mints, docks/sorrels, and nettles. Consistent occurrences of the grains of cereal types were recorded, with the greatest occurrence at 0.24 m (9.33 m OD), comprising barley-type pollen, as well as larger grains probably relating to wheat/oats. The curve for ribwort plantain is continuous. Buttercups are present, as are pollen grains of the pink family, and a single occurrence of bogbean was recorded. Spores included common polypody, bracken, and monolete fern spores. A few pollen grains from the aquatic plant duckweed were recorded, as were sporadic occurrences of *Sphagnum*-moss spores. Fewer deteriorated pollen grains are present in this zone than in the zone above. Microcharcoal counts are extremely high in the lowermost sub-samples analysed.

The data suggest that Burnt Mound 2 was created in a wet woodland setting, surrounded by alder, with open, grassy areas. Duckweed and bogbean, which have a preference for aquatic habitats (Stace 2010), support the presence of possibly shallow, freshwater pools. Evidence of burning is very strong, considering the abundance of microcharcoal found in the lower sub-samples in particular. There is some evidence for the presence of cereal-type pollen, and hence, presumably, cereals were being cultivated locally. Coprophilic fungal spores, which are often found at archaeological sites and indicate the presence of grazing animals (*cf* van Geel 1978), are absent, however.

CNDR 4: Zone BMb (0.19-0.04 m; 9.38-9.53 m OD)

The curve for alder dropped back to approximately half of its earlier level, while values for hazel expanded a little, as did values for willow. In addition to the low values for birch, pine, oak, and ivy, occurrences of honeysuckle (*Lonicera)* are present. The curve for grasses expands to a peak at 0.18 m (9.39 m OD), but then fluctuates at reasonably high levels between 0.16 m (9.41 m OD) and 0.04 m (9.53 m OD). The curve for sedge also increased slightly within the zone. Cereal-type pollen continued to be present in relatively small numbers and ribwort plantain was consistently recorded. The cabbage family is represented, along with the carrot family. Both these groups comprise diverse plant groups, from a range of habitats (for instance, wet meadows and pastures, grazed woodland, and ruderal communities). The incidence of monolete fern spores increases within this zone and the aquatic plant duckweed is present. Microcharcoal was consistently recorded, but in smaller numbers than in BMa (*above*).

Depth (m)	Altitude (m OD)	Context	Description of sediments
0-0.28	+9.57-9.29	?***70283***; upper fill of trough ***70282***	Dark brown/black silty clay with charcoal flecks and small pebbles. From 0.21-0.26 m, reddened stones in dark brown silty clay, with some orange sandy-clay inclusions, and larger charcoal pieces. Charcoal layer from 0.26-0.28 m
0.28-0.39	+9.29-9.18	?***70284***; lower fill of trough ***70282***	Pale brown sand

Table 309: Stratigraphy for monolith 70235, Burnt Mound 2, *Stainton West*

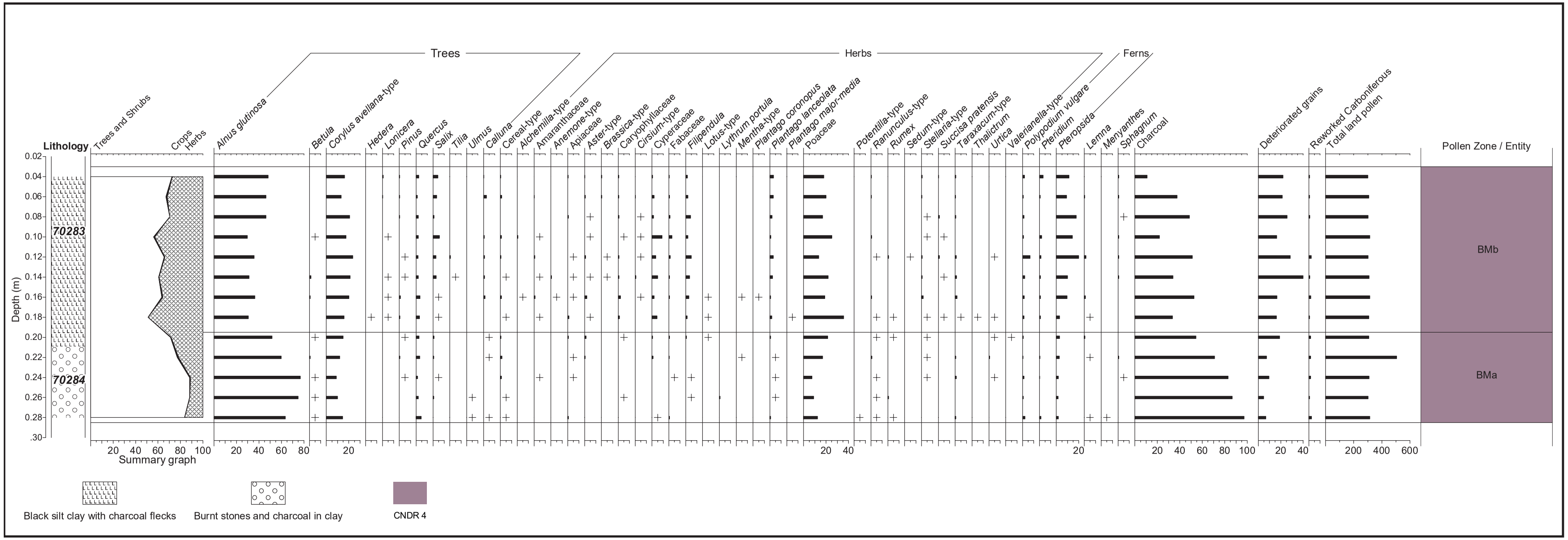


Figure 657: Pollen percentage diagram for monolith 70235, Burnt mound 2, Stainton West

A similar environmental setting to that in Zone BMa can be envisaged, but with larger open, grassy areas and fewer alder trees. Although the expansion of hazel-type pollen and consistent presence of heather, coupled with a reduction in alder, may signify a shift towards slighter drier and possibly more acidic regional environmental conditions, the continued and slightly increased levels of willow, sedge, and grass pollen suggest that damp local areas existed at the site. It may be that the pollen of heather, in particular, derived from more regionally acid moorland or raised mires, perhaps developing at this time. Alternatively, heather plants may have been deliberately brought to the site. Both honeysuckle and heather are highly aromatic, and the possibility exists that these shrubs may have been deliberately sought or harvested; both are versatile, and heather has been used since prehistory, for example, as a medicine and for bedding, and honeysuckle for rope making (Dickson and Dickson 2000; Milliken and Bridgewater 2004). An expansion of grasses and the large reduction in alder indicates possible clearance activity. The pollen of weeds associated with disturbance and cultivation, such as ribwort plantain, carrot-family, brassica-types, nettles, and chickweeds, are common, whilst small amounts of cereal-type pollen suggest the local presence of agriculture.

Fungal spores and dung beetles at Stainton West

Fungal spores are components of NPP, occurring within pollen preparations. They are significant as they often include types associated with the presence of decaying wood, dung, fire, or specific host-plant species, and, therefore, add to the overall reconstruction of the depositional context and environment (van Geel *et al* 2003; Blackford *et al* 2006).

Given the apparent percentage increase in dung beetles within the Neolithic deposits from the *Principal palaeochannel* (*Appendix 14*), an attempt has been made to group together fungal spores which may be indicative primarily of dung (*cf* van Geel 1978: van Geel *et al* 2003; Innes *et al* 2006; Blackford *et al* 2006: Blackford and Innes 2006), and to plot those occurrences against the beetle data for monolith 70222/71155, in Bay B, providing a direct comparison with the beetle data (*Appendix 14*). The possible 'dung-only' fungal spores (van Geel and Aptroot 2006) include counts for *Sporomiella* (HdV-113), *Podospora* (HdV-368), *Sordaria* (HdV-55A), and *Cercophora* (HdV-112). The total number of fungal spores was counted for each level analysed and the results combined for each context in this monolith. The percentage of suggested coprophilic-indicator species was then calculated per context, and the percentage of fungal spores that are known wood decomposers was also calculated (Table 310).

In summary, within the Mesolithic deposits at Stainton West (*Mesolithic organic deposit* and *Mesolithic/Neolithic alluvium*). fungal spores show an overwhelming dominance of wood-rot taxa, the majority of which may be assigned to *Kretzschmaria deusta* (HdV-44) and *Coniochaeta xylariispora* (HdV-6). This tallies well with the beetle data (*Appendix 14*), as the values for deadwood/terrestrial faunas average 14.5%, whereas only 2-3% of dung/foul terrestrial beetle taxa were recorded (Fig 658).

The beetle data in several of the Neolithic deposits indicate that the proportion of dung and foul terrestrial taxa rises to 12-15% (*Appendix 14*). This rise in the *Earlier Neolithic alluvium* may be a result of the relative size of the sample (the number of taxa recovered was relatively low), which may account for the lack of species indicative of woodland. However, the increase in the proportion of dung beetles in the samples from the *Later Neolithic organic deposit* does seem valid (*Appendix 14*).

In contrast, the fungal spores associated mainly with dung appear to have occurred in relatively equal proportions throughout the Mesolithic and Early Neolithic deposits from Bay B. However, the abundance of wood-rot fungi in the *Earlier Neolithic alluvium* may be skewed because of a spike in the abundance of *Coniochaeta xylariispora* (HdV-6) at one level only, and may also reflect transport of dead wood (and associated fungal spores) in this alluvial deposit.

Within the *Later Neolithic organic deposit*, although the total number of fungal spores is relatively low (as this stratigraphic unit is quite thin and contained counts

Context	Entity	Total fungal spores	% decayed wood / dung	% dung only
71091	*Mesolithic organic deposit*	314	57.00	6.37
70317	*Mesolithic/Neolithic alluvium*	372	60.48	7.53
70308	*Earlier Neolithic organic deposit*	301	37.21	8.97
70187	*Earlier Neolithic alluvium*	470	60.21	7.02
70307	*Later Neolithic organic deposit*	38	47.37	28.95

Table 310: Percentage values of selected fungal spores in monolith 70222/71155, Bay B, Stainton West

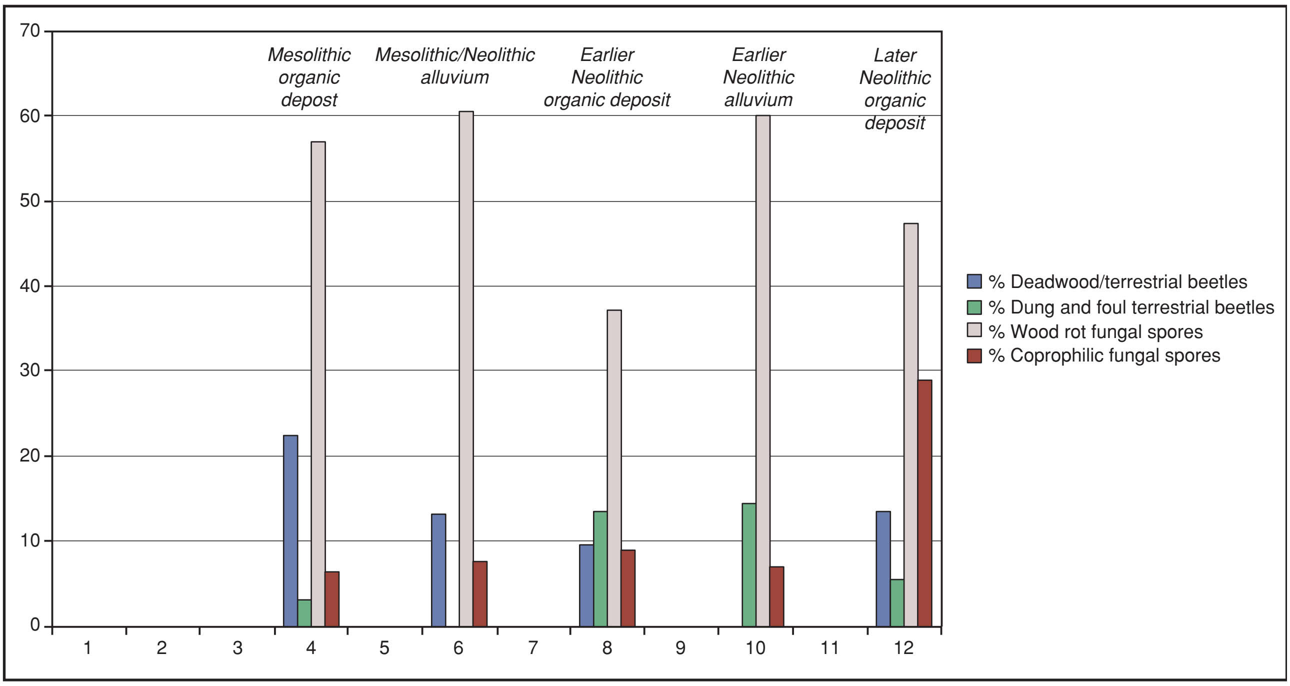


Figure 658: Deadwood and dung beetles, with fungal spores, Stainton West

from only a few levels in Bay B) the percentages of spores hosting on dung did increase, which therefore corresponds to the rise of dung-beetle taxa (*above*), whilst conversely the values for dominantly wood-rot taxa decreased. Given the various caveats regarding provenance, ecological preference, and relatively low counts, the fungal spores would therefore appear to support the interpretation of the dung beetles, in suggesting the presence of grazing animals, including possibly cattle and other domestic stock, at Stainton West at this time (*Appendix 14*).

Results: Parcel 32, Knockupworth, and the Henge Monument

Parcel 32

At Parcel 32, a pollen monolith (32046) was extracted from the fills of a putative medieval ditch (***32131***; *Ch 14*). Although the overall pollen profiles recorded from this monolith are similar, subtle differences in the pollen curves have been used to distinguish three pollen zones (Fig 659).

Zone P32a (0.80-0.68 m; 13.9-14.02 m OD)

Herb pollen, especially grass, dominates the assemblages. A range of other herb taxa includes the goosefoot, pea, cabbage, dock/sorrel, and carrot families, dandelions, daisies, buttercups, pinks, meadowsweet, and cinquefoils. Cereal-type pollen was consistently recorded. Tree and shrub assemblages are represented by alder, hazel-type, and heather, with small amounts of oak, willow, birch, and elm. Microcharcoal counts remain low, or absent, throughout the zone.

The pollen indicates a largely open landscape, dominated by grasses and other herbs of damp meadows, fields, and/or hedgerows, and rough ground (*eg* dandelions, daisies, and meadowsweet) and may suggest the land was used for pasturing animals. The herb-pollen assemblage includes cereal-type pollen, probably from barley and wheat/oats, suggesting possible small-scale arable farming or processing of cereals adjacent to the site. The alder-pollen curve may suggest possible fen-carr communities either locally or regionally. Pollen of hazel-type, which may include bog myrtle (*Myrica gale*), and heather suggests possible scrub vegetation on drier soils, or may have been derived from acid moorland/mire communities. Small quantities of birch, oak, and a little elm suggest regional stands of these deciduous trees.

Zone P32b (0.64 -0.44 m; 14.06-14.26 m OD)

The pollen sample at 0.64 m may be distinguished by initial slight increases in alder, hazel-type, and heather, and a reduction in cereal-type pollen. Although low, values for microcharcoal particles were consistently recorded.

The data show a slight increase in grains of ribwort plantain, which is used as an indicator of grazing activity (Tipping 2002). This suggests an open, grassy landscape, which may have been used for pasturing animals.

Zone: P32c (0.42-0.26 m; 14.28-14.44 m OD)

This zone is distinguished by an increase in the pollen of grasses and cereal-types, a reduction in alder, and an increase in microcharcoal. Fungal spores include occurrences of both *Sporomiella* (HdV-113) and *Chaetomium* (HdV-7A).

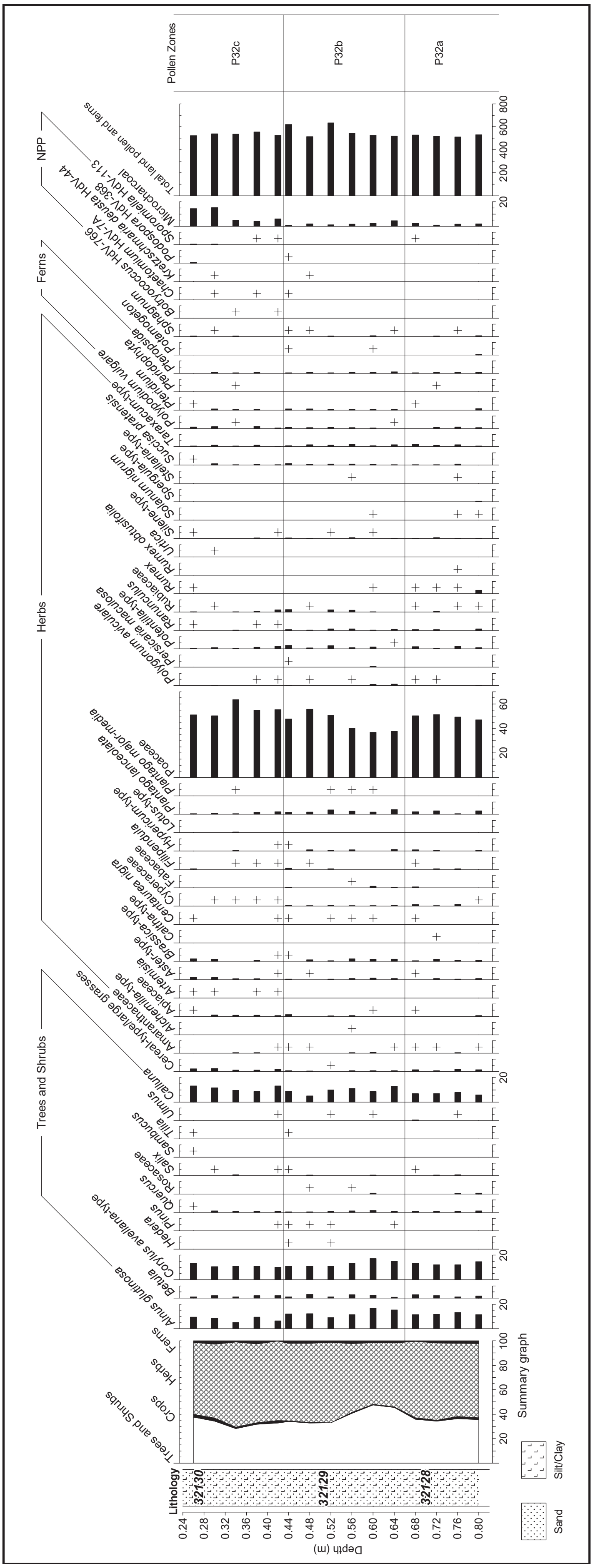


Figure 659: Pollen percentage diagram for monolith 32046, ditch **32131**, *Parcel 32*

The data may suggest an increasing management of the natural vegetation. For example, a reduction in both alder and birch may suggest preferential use of these trees, possibly for fuel and/or in construction, whilst an increase in grass pollen suggests an expansion of meadow/pastureland, possibly for grazing animals. The low, but continuous, presence of fungal spores, such as *Sporomiella* (HdV-113), is a reliable proxy for the presence of grazing herbivores (Aptroot and van Geel 2006). Some land may have been cleared for cereal cultivation, as both barley and wheat/oats have been identified. The incidence of cereal-type pollen may also suggest processing rather than on-site arable cultivation in the immediate vicinity.

Knockupworth

Ditch *50081*

Sample 50013 was taken through ditch ***50081***, thought to have been Bronze Age in origin, but still an open feature into the Roman period (*Ch 11; Ch 13*). The fills of this ditch were sealed by clay, earth, and turf (***50083***), seemingly deriving from denudation of the north mound of the Vallum.

The pollen is very similar throughout, tree and shrub pollen being represented primarily by alder, with commonly recorded grains of hazel-type (Fig 660). There are occurrences of other tree and shrub pollen, including birch, pine, oak, willow, elm, and heather. The herb pollen is dominated by grasses, with a wide range, but low occurrence, of taxa such as ribwort plantain, dandelions, and daisies. The pollen curve for cereal-types shows a greater presence towards the top. Fungal spores are also more common towards the top of the diagram. Microcharcoal is present in relatively small numbers throughout.

The data show a dense alder-carr environment. Common hazel-type pollen suggests scrub was prevalent, probably on drier soils. The low pollen counts of oak and birch may suggest stands of these trees in the wider environment. Areas of disturbance, or clearance, are indicated by the presence of common weeds associated with damp meadows/pastureland (Behre 1981), such as ribwort plantain, and from the increase of grass, which became more extensive towards the upper part of the monolith. Pollen grains of herbs indicative of disturbed and/or open areas (*eg* daisies, dandelions, and buttercups) were also recorded. Small-scale cultivation may have occurred; a few cereal-type grains are present within the upper part of the fill (***50084***), above 0.2 m. Of possible significance in the uppermost sample, at 0.12 m (fill ***50083***), is an increase in grass pollen, greater numbers of cereal-type pollen, with both barley and wheat/oats represented, and the decline in both alder and hazel-type pollen. This evidence suggests some possible land clearance, potentially associated with pastoralism and arable cultivation, although on-site processing of cereals may account for these grains in the record. Rare fungal spores in the uppermost sub-sample are types associated with animal dung (*eg Sporomiella* HdV-113) and suggest that the area may have been grazed by herbivores.

Pre-Roman buried soil *50072*

Monolith 50000 was extracted from old ground surface ***50072***, beneath the north mound of the Vallum. The assemblages are dominated by alder pollen, with lesser amounts of hazel-type (Fig 661?), oak, birch, elm, ash, and heather pollen also being recorded. The herb community is dominated by grass, with sporadic occurrences of dandelions, daisies, and, in the upper sub-sample, ribwort plantain and buttercups. The pollen preservation is poor, and, in places, the percentage of deteriorated grains is very high.

The data are consistent with that recorded for monolith 50013 (*above*). Pollen suggests that alder woodland was dominant, with hazel stands on drier ground. Grass pollen indicates open, possibly cleared areas. Very low counts for oak, birch, and ash may indicate that stands of deciduous trees existed in the wider landscape. Apart from a weak signal for possible cultivation in the uppermost level, there are no significant differences in the pollen profile.

Laminated turf deposit *50126*

A single sub-sample (51023) from laminated turf deposit ***51026*** was analysed. Sediment from this returned a radiocarbon date of 360-170 cal BC (2183±26 BP; SUERC-42030), although it seems to have been derived from the Roman frontier system, probably from the slighting of the Turf Wall, or associated denudation of the Vallum mounds (*Ch 13*). Given the radiocarbon date, this turf had probably been accumulating for some considerable time before it was stripped from the adjacent ground for use in the construction of the Hadrianic frontier.

The pollen is dominated by grass and sedge assemblages and a wide variety of herbs, including sheep's bit scabious, meadowsweet, ribwort plantain, daisies, dandelions, cinquefoils, and pinks (Table 311). Tree and shrub pollen comprises mostly heather, with hazel-type, alder, and also some oak, birch, and pine. The fungal spore *Glomus* (HdV-207) was frequently recorded, and there are rare occurrences of other fungal spores, including *Podospora* HdV-368, *Sporomiella* HdV-113, and *Neurospora* HdV-55C.

The data show a largely open landscape dominated by herb pollen, mostly grasses and sedges, and

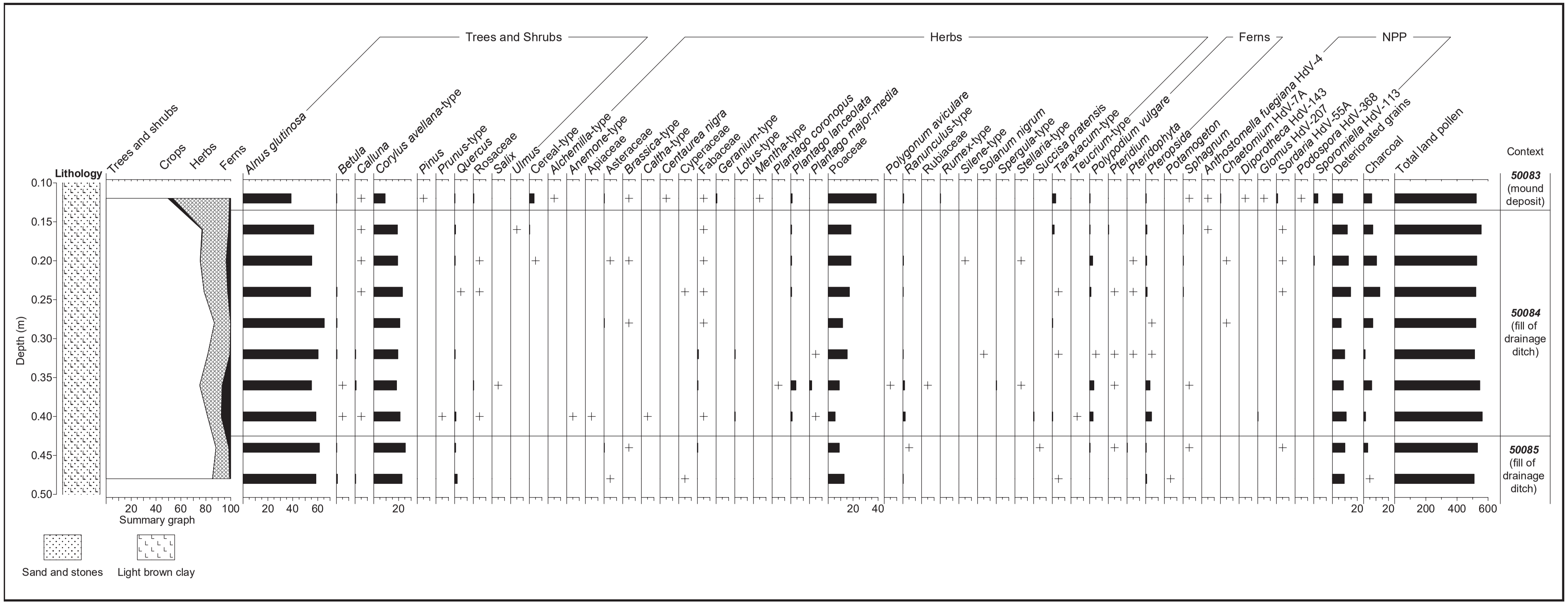


Figure 660: Pollen percentage diagram for monolith 50013, ditch **50081**, *Knockupworth*

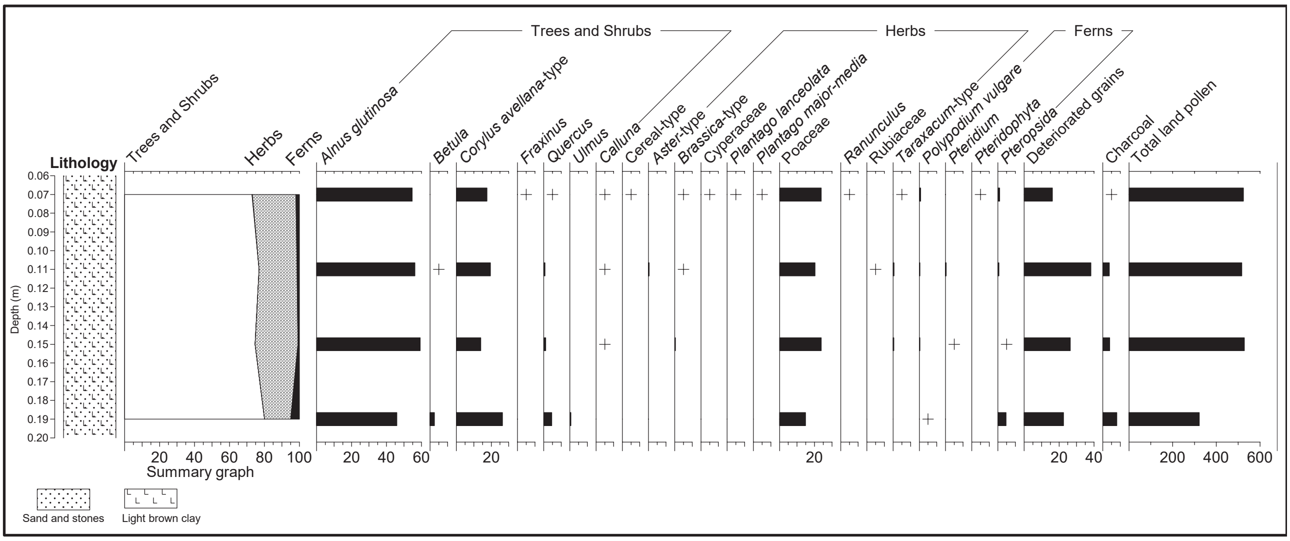


Figure 661: Pollen percentage diagram for monolith 50000, buried soil **50072**, *Knockupworth*

Pollen group and name	Number of grains counted
Trees and Shrubs	
Alnus glutinosa	18
Betula sp	4
Corylus avellana-type	22
Pinus sp	1
Quercus sp	5
Calluna	56
Herbs	
Asteraceae (Lactucoideae)	16
Asteraceae	1
Caryophyllaceae	1
Amaranthaceae	2
Cyperaceae	69
Filipendula	2
Plantago lanceolata	7
Plantago media/major	2
Potentilla-type	4
Poaceae	97
Succisa pratensis	7
Ferns	
Polypodium	3
Pteridium	5
Filicales	4
Total land pollen	***314***
Deteriorated grains	58
Microcharcoal particles	58
Number Lycopodium spores (exotic)	51
Fungal spores	
Neurospora HdV-55C	1
Glomus HdV-207	9
Podospora HdV-368	1
*Sporomiella*HdV-113	1

Note: Sub-sampled at 0.1 m only

Table 311: Pollen counts from sample 51023, deposit **51026**, *Knockupworth*

herbs associated with grassy, wet places, such as meadowsweet, ribwort plantain, and devil's bit scabious (Stace 2010). Rare fungal spores suggest the possible presence of grazing animals. The spread of acid heathland may be inferred from the abundance of heather pollen and hazel-type scrub.

Medieval soil at the henge monument

A monolith sample (250007) was extracted from fill ***200106*** within the ditch of the Neolithic henge (*Ch 10*). This deposit appears to have been a medieval soil that had gradually accumulated, as a result of nearby cultivation, filling the ditch defining the earlier monument (*Ch 14*). This fill contained plant macrofossils which produced radiocarbon assays of cal AD 1300-1440 (560±35 BP: SUERC-37827) and cal AD 1030-1210 (905±35 BP; SUERC-37828), suggesting that the ditch became filled between the mid-eleventh and early fifteenth centuries.

At 1.36 m, tree pollen (almost entirely alder and hazel-type) comprised relatively low percentages of the total land-pollen count, relative to cereal-type and other herbaceous pollen, such as grasses, daisies, and dandelions, from open/disturbed-ground habitats (Fig 662). A less reliable assemblage at 1.28 m (there were large numbers of deteriorated grains) shows greater tree cover (again restricted to alder and hazel), but with grasses and plants of waste ground dominating most of the assemblage. Where more productive levels (with pollen counts of 500 TLP grains) have been achieved, grass pollen dominates the assemblage and tree cover was clearly much reduced. At 0.72 m, a count in excess of 500 pollen grains produced predominantly grass pollen, with very little tree pollen. The evidence therefore points to the entire assemblage representing a highly cleared landscape, with abundant evidence for cereal cultivation and weeds of open and waste places.

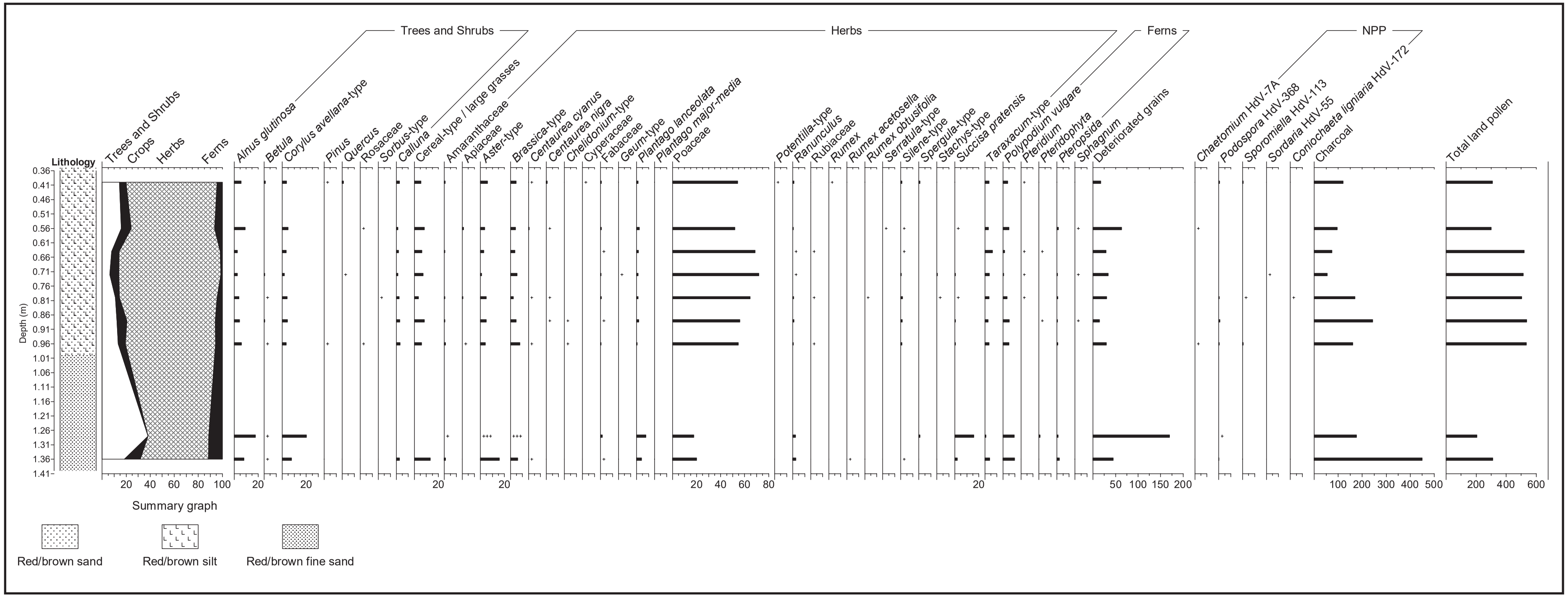


Figure 662: Pollen percentage diagram for monolith 250007, soil ***200106****, henge monument*

Discussion

The bulk of the pollen evidence came from Stainton West, where five pollen superzones have been identified, providing clear evidence for changing vegetation, from both local and regional sources, between the Late Mesolithic period and the Bronze Age (Table 312). Other sites along the CNDR provided additional data, extending this temporal sequence, allowing insights into the later Iron Age/Roman and medieval landscapes. Thus, taken as a complementary dataset, the pollen sequences reveal a broad sequence of woodlands, woodland decay, clearance, and deforestation, use, in the form of burning, early 'forest farming', and a more extensive and chronologically broader phase of clearance associated with pastoralism and arable cultivation at the head of the Solway Firth.

Age BC	Age	Pollen superzone	Characteristics
1000	Middle Bronze Age or younger	CNDR 5	Grasses/sedges
1500	Early Bronze Age	CNDR 4	Alder/grasses
2000			
2500	Chalcolithic	CNDR 3	Alder/hazel/oak dominance
3000	Neolithic		
3500		CNDR 2	Alder expansion Elm Decline Demise (EDD) Elm Decline (ED)
4000			
4500	Late Mesolithic	CNDR 1	Hazel/elm/oak dominance
5000			
5500			

Table 312: The age and characteristics of the pollen superzones, Stainton West

CNDR 1: the Late Mesolithic landscape at Stainton West

The character of the vegetation

The pollen assemblages within the *Mesolithic organic deposit*, *Mesolithic alluvium*, and *Mesolithic/Neolithic alluvium* are very similar to each other and suggest that, throughout this period, hazel scrub was the dominant vegetation type on the floodplain adjacent to the *Principal palaeochannel*. Hazel thicket, surrounded by mixed oak woodland, has been described previously from floodplain settings (*cf* Brown 1988), and the arboreal pollen at Stainton West suggest, in some measure, the presence of 'typical' Mesolithic woodlands, with common oak and elm pollen, as well as lesser amounts of birch, ash, and pine. These tree types imply a generally dry, warm environment, which equates with the mid-Holocene climatic optimum (Innes 1999).

One noticeable feature of the Stainton West Mesolithic pollen sequence is the paucity of alder, particularly when compared with the alder-pollen curve evidenced at other upland and lowland sites across the British Isles. For instance, throughout the early Holocene, alder is known to occur sporadically at many sites, and, at most, the rise of its pollen is a feature of the mid-Holocene (Hibbert and Switsur 1976). Close to Stainton West, the alder rise has been dated at Scaleby Moss, on the north Cumbrian plain, to 6490-5920 cal BC (7361±146 BP; Q-167; Godwin and Willis 1959), with an interpolated age of *c* 6150 cal BC and a peak value at *c* 5700 cal BC (Tipping 1997a, 18). At Burnfoothill Moss, Dumfriesshire, it is dated over a prolonged period, extending between *c* 5750 cal BC and 5200 cal BC, and, in this instance, it appears to have coincided with anthropogenic woodland disturbance (Tipping 1995a; 1997a).

At Stainton West, although there is a paucity of its pollen, bark beetles that feed on alder were present in all of the Mesolithic stratigraphic units (*Appendix 14*). This, in turn, implies that alder trees were indeed growing locally, but were. perhaps, less abundant at this particular locale, being specifically confined to nearby damp or wet areas. The factors that may have contributed to this apparent lack of abundance of alder on the floodplain could have included edaphic (soil) conditions and, possibly, competition, particularly, in this instance, from hazel.

Woodland openings, fire activity, and Mesolithic exploitation

A diversity of herbs and fern spores was also present in the Stainton West Mesolithic deposits, but in very low numbers, suggesting small openings in, or at the edges of, the hazel thicket. The presence of low, but persistent values for grasses, along with intermittent records for docks/sorrels, species of the carrot family, meadowsweet, devil's bit scabious, and cinquefoils, may suggest development of areas of open, grassy, possibly damp ground (Stace 2010). Species of NPP (*eg Spirogyra* (HdV-130) known to live in stagnant, shallow-water pools provide additional evidence for some wetter areas on, or adjacent to, the palaeochannel/floodplain (van Geel 1978), as do sporadic occurrences of the freshwater algae *Pediastrum* (HdV-760) and *Botryococcus* (HdV-766).

Of interest are the fungal spores *Glomus* (HdV-207), *Coniochaeta xylariispora* (HdV-6), and *Kretzschmaria deusta* (HdV-44). The former is associated with disturbed ground and the latter two are indicators for decaying deciduous wood (especially elm and oak; *ibid*; Blackford *et al* 2006). Moreover, the presence of decaying wood appears to be confirmed by the large number of beetles associated with dead and rotting wood that were present in all of the Mesolithic deposits (*Appendix 14*). A possible interpretation is that the fungal spores reflect the presence of grazing herbivores (deer or other animals) using the woodland areas for browsing, and possibly causing damage to trees by scraping bark. In addition, the presence of animals is supported by the beetles, as dung beetles were found in the Stainton West Mesolithic deposits (*Appendix 14*).

Other possible interpretations for the presence of small openings and disturbed ground are that the deciduous woodlands may have been infected with disease, or were damaged through Mesolithic woodland management, which itself enhanced the growth of fungal spores (Innes *et al* 2006). With regard to this latter interpretation, it is perhaps significant that it has been suggested that Mesolithic hunter-gatherers in Scotland may have regularly and systematically visited productive areas of hazel and oak woodland for intensive nut-gathering, and also possibly for the collection of wood for timber and fuel (Bishop *et al* 2015). At Stainton West, further evidence for Mesolithic exploitation of the woodland included modified alder/hazel (possibly coppiced) and elm roundwood, oak timber, oak-felling debris, bark from the debarking or felling of an elm tree, and potential oak burr-wood blanks for the production of wooden bowls or dishes (*Appendix 13*). Given this evidence, it is quite likely that Mesolithic groups were exploiting, even managing, the area close to Stainton West, and this might have resulted in, or contributed to (*below*), the creation of small openings within the nearby woodland. More generally, this environment would have provided a wide range of foods, including fruits, nuts, and roots, as well as wild animals and birds, perhaps in similar palaeoenvironments to those at the Mesolithic site at Star Carr (Innes *et al* 2011).

At Stainton West, there is also evidence from the *Mesolithic organic deposit* for a probable beaver lodge and dam (*Ch 3*), along with several pieces of beaver-modified wood (*Appendix 13*). Given this, one possibility is that localised woodland disturbance and coppicing caused by beaver clearings produced a locale that was particularly attractive to the Late Mesolithic communities of the area. For example, such locations may have provided ready-made coppice stems that would have been ideal for constructing light structures or for hafting flint tools. In addition, new tree growth, within such clearings, would have encouraged foraging, through the presence of easily accessible food supplies, and perhaps also hunting, as such clearances might have been grazed by herbivores. Indeed, this human/beaver association appears to have been replicated elsewhere; for instance, wooden platforms at Williamson's Moss, in the Esk Valley of the Lake District (Bonsall *et al* 1994), associated with Mesolithic flint scatters, may originally have been beaver platforms or collapsed lodges, whilst at Star Carr, North Yorkshire, a collapsed beaver lodge had been used for a variety of Mesolithic activities (Coles 2006).

Microcharcoal was also present in varying amounts throughout the Mesolithic deposits at Stainton West. This may be indicative of both regional and local fire activity. Furthermore, the pollen of bracken, a positive pyrophyte that regularly grows in burnt areas (Innes 1999), occurs consistently through the Mesolithic deposits at the site. Although there are many complex interacting factors involved in the interpretation of microscopic charcoal in the pollen record, broad-leaved deciduous woodlands are not thought to be particularly susceptible to natural fires, and as such these types of catastrophic events probably only occurred relatively infrequently (Rackham 1986; Moore 2001). In contrast, intentional firing of the woodland by humans is likely to have occurred at frequent intervals, possibly seasonally, and would enhance both herbaceous growth and attract animals to an area (Moore 2001). Fires may also have been used to aid hunting, by driving animals into specific areas, or it could have spread accidentally from campfires (Innes *et al* 2011). Human-induced fire activity might, therefore, be responsible for some of the microcharcoal at Stainton West, a proportion of which may have been fluvially deposited, and also the charcoal that has been commonly reported in Mesolithic stratigraphy at other lowland raised mires within Cumbria (Hodgkinson *et al* 2000). Significantly, a few cereal-type pollen grains were also recorded from the Late Mesolithic elements of monoliths at Stainton West; however, the dimensions of these overlap with those of wild grasses, such as species of sweet-grasses, which can live in or by rivers, on mud, or in shallow water (Stace 2010). Tellingly, beetles associated with reed sweet-grass have also been recorded in the Late Mesolithic deposits at Stainton West (*Appendix 14*).

In summary, the pollen and NPP data suggest the presence of extensive hazel thickets adjacent to the palaeochannel during the Late Mesolithic period, with probable small-scale woodland disturbance and fire activity, resulting in the creation of small, open areas. Across the wider area, small-scale Late Mesolithic clearance/disturbance events have also been reported. On the northern Solway coastal plain, an anthropogenic disturbance of woodland was recognised in the pollen sequence from Burnfoothill Moss, close to Gretna (Tipping 1995a), where two possible clearance phases were noted, dating between *c* 5750 cal BC and 5250 cal BC. Initially, clearance was through the use of fire, with cleared areas perhaps being maintained through grazing (Tipping 1997a, 19). Similarly, at Beck Burn, on Solway Moss, evidence for the selective burning of birch carr is evident, across the sixth millennium cal BC, reaching a peak at *c* 5000 cal BC (Rutherford and Gregory forthcoming).

Although further distant from Stainton West, two other pollen sites on the northern side of the Solway provide additional evidence for Late Mesolithic anthropogenic woodland disturbance. These are The Dod, in upper Teviotdale, where a disturbance event has been dated to *c* 5600 cal BC, and Catherine Hill, Annandale, where small-scale human woodland disturbance is dated to *c* 5500 cal BC (*ibid*). On the southern side of the Solway, on the northern Cumbrian plain, although the available pollen data relating to the mid-Holocene are more chronologically problematic, it has been suggested that possible Late Mesolithic anthropogenic disturbance might be visible in the pollen diagrams from Oulton Moss, dating to *c* 5000 cal BC, and Bowness Common (Hodgkinson *et al* 2000, 107).

Further south, in southern Cumbria, small-scale anthropogenic woodland disturbance has been reported in Lonsdale, on the southern limestone fringe of the Lake District, during the latter part of the Mesolithic period (Taylor *et al* 1987; Middleton *et al* 1995). Similarly, in north Lancashire, clearance/disturbance events have been detected in mires of Mesolithic age, though these pre-date the sediment sequence at Stainton West. For instance, falls in tree pollen and peaks in bracken and open-ground indicators at Thwaite House Moss (Middleton *et al* 1995) and Little Hawes Water (Taylor *et al* 1994) suggest anthropogenic forest clearance dating to *c* 6000-5500 cal BC and *c* 7530-6650 cal BC, respectively. Clearance episodes also occur in the Wirral, Merseyside, in the Late Mesolithic period, and associated records for cereal pollen may indicate possible sedentary lifestyles (Cowell and Innes 1994), whilst possible Late Mesolithic cereals have been identified in the pollen assemblages from the West Lancashire plain (Tooley 1978). Such cultivation may have occurred in seasonally tended plots, compatible with a mobile hunting/gathering lifestyle (Cowell 2000).

Maritime influence?

The Stainton West analysis also revealed that during the Late Mesolithic period the *Principal palaeochannel* might have been subjected to weak marine influences, possibly relating to tidal surges. This suggestion is based on occurrences of the dinocysts *Operculodinium centrocarpum* and *Lingulodinium machaerophorum*, both of which are tolerant of estuarine conditions (Edwards and Andrle 1992), within Bay B (70222/71155 and 70225/71158). Interestingly, there are also occurrences of goosefoot-family pollen throughout the same sub-samples. Although these pollen grains have a wide geographical distribution, some species may indicate proximity to marine influences (Long *et al* 1998; Taylor 1995). A slight brackish influence is also indicated by the beetles from the *Mesolithic/Neolithic alluvium* (*Appendix 14*), whilst the apparent absence of dated sediments within the *Principal palaeochannel* during the period 4500-4300 cal BC may suggest that erosive storm events occurred locally, including possible tidal-storm surges (*Ch 6*).

When the broader evidence for sea-level change within the Solway Firth is considered, it is possible that some of the detected fluctuations in relative sea level might equate with the possible evidence for Late Mesolithic marine influences at Stainton West. Although it appears that the maximum marine transgression for this estuary occurred prior to the deposition of the sediments within the *Principal palaeochannel*, minor transgressions do appear to have occurred before the final regression at 770-400 cal BC (2430±60 BP; B-103261; Lloyd *et al* 1999), which could have influenced the channel. For instance, on the southern side of the Solway Firth, at Bowness Common, Donald Walker (1966) identified two marine transgressions, whilst David Huddart *et al* (1977) identified one. This was dated at Bowness Common to between 5880-5630 cal BC (6850±60 BP: HV6208) and 5310-4330 cal BC (5875±220 BP; HV6207), when the relative sea level was 4.7-5.9 m above present, and at Wedholme Flow from between 5990-5620 cal BC (6870±95 BP: HV5228) and 4890-3630 cal BC (5385±280 BP; HV4713) when the relative sea level was 4.8-6.2 m above present (Lloyd *et al* 1999). A rise of +6 m is quite high, and may have led to seawater penetrating as far inland as Stainton West.

CNDR 2: the earlier Neolithic landscape at Stainton West

The Elm Decline

Palynologically, the earlier Neolithic deposits (*Earlier Neolithic organic deposit* and *Earlier Neolithic alluvium*) in the *Principal palaeochannel* at Stainton West are characterised by the Elm Decline. Significantly, across Britain and Ireland, this forms a major pollen event that at many sites is coincident with the onset of agriculture (*cf* Whitehouse *et al* 2014; Woodbridge *et al* 2014). At Stainton West, this is visible as a gradual decline in elm pollen in the monoliths from Bay B (monolith 70222/71155; Fig 642), Bay F (monolith 70250; Fig 650), and Bay D (monolith 70296; Fig 647). Percentage changes in the declining elm curve (expressed as elm pollen as a percentage of TLP) show a drop of 11.5% over 0.1 m from Bay B, while in Bay D, a 9.6% decline in elm pollen was noted over 0.1 m. A very gradual decline was seen from the deposits in Bay F, where elm pollen values dropped by 22% over a 0.16 m interval. The results from monolith 70252, Bay F (Fig 652?), are more difficult to interpret, as they show a *c* 13% decline over 0.04 m. It is worth noting, however, that this core was taken from a section of the palaeochannel which appears to have undergone numerous channel reactivations, and hence the pollen signal may be confused.

Detailed pollen analysis has permitted two points on the Elm Decline curve to be recognised locally. The first, or 'main', Elm Decline (ED) is when values in elm pollen initially declined from relative peak values, whilst the second phase is termed the Elm Decline Demise (EDD), when elm values fell, never to recover to previous (pre-Elm Decline) levels. Radiocarbon dates have been modelled to provide robust dating for the initiation and termination of the Elm Decline at Stainton West (*Appendix 20*). Chronological modelling of Bay B (monolith 70222/71155) places the start of the trend at *3940-3730* cal *BC* (*'Elm peak immediately prior to Elm Decline B'*), whilst the Elm Decline Demise occurred at *3780-3520* cal *BC* (*'Elm Decline Demise B'*). Significantly, a tighter date range for this was provided by the Bay D pollen core, modelling estimating that this occurred at *3640-3510* cal *BC* (*'Elm Decline Demise D'*).

The Elm Decline at Stainton West also occurred in association with indications of forest opening, through reductions in tree pollen and increases in open-ground or agricultural-indicator taxa, such as grasses, ribwort plantain, and cereal-type pollen. This is especially clear in the pollen diagram from Bay D (Fig 647), as the summary curve shows an expansion of crops and herbs in a dominantly wooded environment. Bayesian modelling also provides some chronological estimates for the occurrence of cereal pollen and ribwort plantain as recorded in specific pollen monoliths (*Appendix 20*). For instance, in Bay B, the occurrence of cereal-type pollen is estimated to date to *3870-3670* cal *BC* (*'Cereal-type pollen B'*), whilst in Bay D, cereal-type pollen occurred at *3690-3530* cal *BC* (*'Cereal-type pollen D'*). In terms of ribwort plantain, in Bay D, this was first present at *3860-3540* cal *BC* (*'Ribwort plantain D'*), whilst in Bay B its appearance dates to *3930-3710* cal *BC* (*'Ribwort plantain B'*). The estimated dates for its occurrence in Bay F are less informative, as they span the period *3720-2870* cal *BC* (*'Ribwort plantain F'*).

Overall, therefore, this ecological evidence suggests that human activity may have had an impact on the forest, as was suggested for similar pollen successions from the Swale/Ure floodplain in North Yorkshire (Bridgland *et al* 2011). The elm woodlands may have been modified (through coppicing, pollarding, or girdling) to increase fodder production for domesticated animals (Rasmussen and Christensen 1999). Trees weakened by disease (interpreted from high counts of wood-rot fungal spores during the Late Mesolithic and continuing on into the Early Neolithic period), whether initially caused by animals, people, or through natural events such as waterlogging, could also have been exploited by humans.

Significantly, at Stainton West, there is evidence for coppice-derived wood, split timbers, and felling debris associated within the earlier Neolithic stratigraphic units (*Appendix 13*), clearing attesting to the exploitation of the nearby woodland, as well as the occurrence of consistent grains of cereal-type pollen. If it is assumed that these derived from cultivated cereals rather than wild grasses (*cf* Andersen 1979; Tweddle *et al* 2005; Joly *et al* 2007), this appears to suggest that agriculture was coincident with disturbance of the elm woodlands. During this period, the forests may have been used to provide improved browsing conditions for animals, as well as to clear areas for potential cereal cultivation (Innes *et al* 2006; 2013). Such 'forest farming' might operate where cereal cultivation could occur for a year in an axe-cleared coppice, providing ample leaf fodder for animals, after which the woodland would be allowed to regenerate (Göransson 1982; 1986; Edwards 1993); however, it is perhaps worth noting that models of pioneer 'forest farming' remain contentious (Ghilardi and O'Connell 2013). At Stainton West, fungal spores, including coprophilic types such as *Podospora* (HdV-368), *Cercophora* (HdV-112), and *Sordaria* (HdV-55A/B), provide additional evidence to suggest that animals were present in the local environment at this time. Furthermore, the beetle data suggest that forest grazing of cattle and other domestic stock may have been practised (*Appendix 14*). From the modelled radiocarbon dates, it would appear that the site may have been exploited agriculturally over several generations in the earlier Neolithic period, resulting in some opening of the landscape and changes in the vegetation.

Across the wider region, on the north Cumbrian plain, there is evidence of clearance activity from Scaleby and Solway Mosses, which also appears to have been associated with the Elm Decline. At Scaleby Moss, the Elm Decline is dated to *c* 4520-3990 cal BC (5421±130 BP; Q-120; Walker 1966, 43), and it has been noted (Tipping 1997a, 19), when assessing the available radiocarbon dates from this sequence, that it appears that the end of this elm decline was at *c* 3775 cal BC, apparently corresponding to the termination of the decline noted at Stainton West (*above*). At Scaleby Moss, this event was also coincident with a reduction in oak pollen, a rise in ribwort plantain and grasses, and the occurrence of disturbed-ground indicators such as docks/sorrels (Hodgkinson *et al* 2000, 109). Furthermore, hazel, ash, and birch pollen increased, perhaps in response to the opening up of the woodland canopy (*ibid*). At Solway Moss, a seemingly younger date for the elm decline was obtained, a radiocarbon assay from a cereal-type grain placing this immediately before 4050-3760 cal BC (5110±60 BP; GU-5275; Huckerby and Wells 1993). Similarly, at Midgeholme Moss, another area of mossland immediately south of Scaleby Moss, the elm decline appears to date to *c* 4050 cal BC (Tipping 1997a, 19).

On the northern Solway coastal plain, in eastern Dumfriesshire, evidence for the Elm Decline has also been recognised at Burnfoothill Moss, relatively close to Stainton West. Analysis of the pollen sequence there detected two elm declines (Tipping 1995a; 1997a), the first dated to *c* 3650 cal BC. This was an extremely abrupt event, spanning 40-60 calendar years, with no clear evidence for associated anthroprogenic disturbance. Chronologically, it appears therefore to equate with the estimated date range for the Elm Decline Demise event at Stainton West (*above*). The second decline in elm at Burnfoothill Moss appears to have been associated with agricultural activity, dating to *c* 3350 cal BC, and hence post-dates the Elm Decline at Stainton West. Several other pollen sites within eastern Dumfriesshire have produced evidence for the Elm Decline, including Burnswark Hill, where this has been dated to *c* 4150 cal BC, and Over Rig where, in a similar fashion to Burnfoothill Moss, two elm declines were identified. The earlier of these is dated to between *c* 3950 cal BC and 3550 cal BC, which again approximately equates to the Stainton West Elm Decline, whilst the latter dates to *c* 3300 cal BC (Tipping 1997a, 19).

This double Elm Decline is not, however, confined to eastern Dumfriesshire, but has also been identified at several sites in south Cumbria. At Williamson's Moss, on the west Cumbrian plain, a very early primary decline was dated to *c* 4450-4050 cal BC (5440±70 BP; SRR-3065; Tipping 1994a). Interestingly, this is comparable in date to the abrupt drop in elm pollen identified in Bay F, at Stainton West, which is estimated to have occurred in *4330-4040* cal *BC* (*'Abrupt drop in elm pollen F'*; *Appendix 20*). However, in contrast to Stainton West, the primary decline at Williamson's Moss also included reductions in hazel and oak pollen, and was associated with ribwort plantain, suggesting anthropogenic influence (*ibid*). A similar primary Elm Decline was recorded at Barfield Tarn, where traces of small forest clearings were dated to *c* 4450-3940 cal BC (5340±120 BP; K-1057; Pennington 1970; 1975), whilst at Ehenside Tarn, the presence of similar reductions in arboreal pollen were also identified (Walker 1966; 2001). It appears, however, that these southern Cumbrian clearings were not maintained. For example, at Williamson's Moss, by 3960-3660 cal BC (5010±70 BP; SRR-3067), partial woodland regeneration was reclaiming the area (Hodgkinson *et al* 2000, 68), although this regeneration was short-lived, being followed by the second, or main, Elm Decline. At Williamson's Moss, this is dated to 3900-3370 cal BC (4850±80 BP; SRR-3068; *ibid*) and it saw the gradual depletion of elm, followed by its eventual demise, after which elm failed to recover. Therefore, the sequence and chronology of the main Elm Decline at Williamson's Moss appears to be comparable to that recorded at Stainton West.

Reassessment of dated pollen sequences from over 100 sites in the British Isles suggests that the Elm Decline was a 'catastrophic, uniform phased event' (Parker *et al* 2002, 28). It is further postulated that the cause of the Elm Decline could have been a unique and complex set of interrelated factors, probably including disease, human impact, and climate change (*ibid*). Significantly, comparative information on the destructive nature of disease is available through consideration of the modern spread of Dutch Elm Disease that affected the British elm stock in the late twentieth century. For example, elm woodlands in Kent and Oxfordshire suffered an outbreak in the late 1970s and early 1980s, which resulted in a decline of similar proportions to that found during the mid-Holocene (Perry and Moore 1987; Carp and Mannion 1994). Moreover, the twentieth-century outbreaks practically eliminated elm from these areas in as little as 20 years, resulting in an increase in open-ground pollen types in areas where elm was once abundant (Perry and Moore 1987).

It is therefore possible that a pathogenic attack on elm trees during the mid-Holocene might have been responsible for an increase in open-ground indicators (including ribwort plantain) in certain areas, rather than this being solely a result of human activity. Disease, associated with the elm bark beetles *Scolytus scolytus* and *S multistriatus*, is widely regarded as a potential contributor to the cause of the mid-Holocene elm decline (Peglar 1993; Peglar and Birks 1993), and small numbers of the elm bark beetle *S scolytus* were recorded in Late Mesolithic deposits at Stainton West (*Appendix 14*). In addition, the wood-rot fungal spores *Kretzschmaria deusta* (HdV-44) and *Coniochaeta xylariispora* (HdV-6), which occur throughout the Late Mesolithic to Early Neolithic deposits, are considered of potential ecological significance in the interpretation of the causes and nature of the elm decline (Innes *et al* 2006), as they proliferate on trees that have already been damaged. However, although disease and other natural factors, such as beaver activity and flooding, cannot be ruled out as instigators that resulted in damaged trees, human interference of woodland seems an obvious agent for change. This is particularly compelling in an area such as Stainton West, where abundant archaeological evidence exists for human activity next to the River Eden, and appears to have entailed both the exploitation and management of the nearby woodland.

The rise of alder

At Stainton West, palynological evidence for major changes in the composition of the earlier Neolithic floodplain vegetation are apparent from Bay B (monolith 70222/71155; Figs 642-3), where deposits (***70187***) of the *Earlier Neolithic alluvium* were characterised by an influx of abundant alder pollen. This is also seen in Bay F (monolith 70250; *Earlier Neolithic alluvium* ***70327***; Fig 650?) and Bay D (monolith 70296; *Earlier Neolithic alluvium* ***70315***; Figs 647-8?), which has been dated to *3640-3490* cal *BC* (*SUERC-44783*) and *3640-3520* cal *BC* (*SUERC-44784*). Although a distinct change in the dominance of alder pollen is seen in Bay F (monolith 70252; Fig 652?), the initial pollen signal is less clear than in the pollen curves from the other bays.

The appearance of alder is comparatively late at Stainton West and the switch to its dominance on the floodplain must reflect changes bringing about wetter, damper conditions, more suitable to alder fen-carr development than hazel scrub. In this context, waterlogging, potentially caused by a rise in the watertable as a result of flooding, may have led to the development of alder carr on the floodplain. Flood events within the lowlands may also be related to upland clearance activity that, in turn, resulted in increased sediment load in the rivers, which led to flooding (Bridgland *et al* 2011). Marine-flooding events could also have resulted in the ponding up of fresh water in areas beyond the reach of the tidal flood, such as Stainton West, which could have created a wetter environment conducive to the growth of alder. It may, therefore, be significant that parts of the north Cumbrian coast were probably inundated during the earlier Neolithic period, the final stages of which are dated to 3940-3370 cal BC (4845 ±100 BP; Hv-4418; Huddart *et al* 1977).

Another possible explanation for the late arrival of alder on the floodplain may have been the earlier presence, in the Late Mesolithic period, of a very thick hazel-type scrub, along with extensive deciduous-woodland cover (including only about 10% alder) on the floodplain. Given this, perhaps the area was impenetrable until the clearance had been initiated of oak, elm, and then hazel-type trees/shrubs in the earlier Neolithic period, which subsequently allowed for the spread of alder. A pollen sequence from Carn Dubh, Eastern Grampians, shows that alder only expanded in this area after a clear Elm Decline, and it was suggested that Neolithic human activity was the major factor associated with this expansion (Tipping 1999b). A similar pattern was also noted in a sequence from Prestatyn, North Wales, where the rise of alder was coincident with the Elm Decline (Armour-Chelu *et al* 2007). Therefore, in these circumstances ,gaps in the existing woodland, perhaps created by Neolithic people, could have been large enough, or open for long enough, to allow alder to colonise (*ibid*; Huntley 1996a).

Clearance and agriculture

During the earlier Neolithic period at Stainton West, the palynological material provides some evidence for clearance (of elm, oak, and hazel-type trees), perhaps associated with arable and pastoral farming, followed by some renewed tree growth (predominantly alder). This is particularly apparent in the pollen sequences from Bay D (Fig 647), which reveal possible small-scale agricultural clearances, followed by less intensive use of the landscape. This pattern appears to imply that 'garden-type' agriculture was in operation, where cereals were grown in small plots, whilst domesticated animals probably grazed open woodland during the summer and may have been sustained with fodder such as hay, leaves, and ivy during the winter months (*cf* Long *et al* 2004: Jones and Rowley-Conwy 2007).

The pollen data then suggest continued use of plots of land for significant periods of time, which may imply longer-term, possibly fixed-plot, agriculture, rather than that associated with shifting cultivation (Whitehouse *et al* 2014). Chronologically, this phase of agriculture correlates with a period of intense Early Neolithic agricultural activity across a wide area, which has been dated to *c* 3700-3500 cal BC (Bayliss *et al* 2007; McSparron 2008).

CNDR 3: the later Neolithic and Chalcolithic landscape at Stainton West

The pollen assemblages in the *Later Neolithic organic deposit*, *Chalcolithic alluvium*, and alluvium within a reactivation channel indicate that this timeframe witnessed the stabilisation of alder covering the floodplain and probably the infilling channel, which suggests that alder became naturally dominant, preventing the invasion of other trees. This was probably a result of waterlogging, since alder can survive flooding and rises in the watertable, through the production of adventitious roots (Brown 1988), and also of changes in the floodplain conditions, including increasing soil stability. Significantly, cereal-type pollen, possibly barley, was consistently recorded, whilst ribwort plantain is sporadically present and, together with occurrences of knotgrass, may suggest the beginning of more concentrated disturbance associated with clearance and grassland expansion. Furthermore, in Late Neolithic sediments, fungal spores and the beetle data (*Appendix 14*) indicate the presence of grazing animals (probably cattle) which may suggest the possible continuation of 'forest-farming' practices. These may also have caused soils to be washed into river systems and then deposited as alluvium at Stainton West during extreme flooding events. This is analogous to those sites in the Swale/Ure Washlands where similar trends towards alder-carr vegetation coincided with periods of alluviation (Bridgland *et al* 2011).

At a regional level, it has been noted that much of the third millennium BC (*c* 3100-2200 cal BC) was characterised by phases of woodland regeneration, and it has been suggested that this may relate to a reduction in the intensity of land-use across the area (Tipping 1997a, 19). However, a renewed phase of clearance may have occurred from *c* 2300 cal BC across the lowland landscape of the inner Solway Firth, detectable in the pollen sequences from Burnfoothill Moss, Scaleby Moss, and Bolton Fell Moss (*op cit*, 20). It is therefore possible that, at Stainton West, some of the clearance indicators in the *Chalcolithic alluvium* relate to this postulated event.

CNDR 4: the earlier Bronze Age landscape

The pollen from the penultimate superzone probably relates to the landscape existing at the very end of the third millennium and in the earlier part of the second millennium BC, as it includes sequences from Burnt Mound 2 (*Ch 11*), the *Bronze Age Alluvium*, buried land surface ***70486***, and the earlier part of *Bronze Age/Iron Age Alluvium* (*Ch 11*). It appears therefore to follow directly on from the pollen sequences present in the underlying *Chalcolithic alluvium* (*above*) and relate to the landscape that existed when the other Bronze Age burnt mounds at the site (Burnt Mounds 3 and 4) were in use.

At a regional level, this period appears to equate with more sustained clearance and agricultural activity, potentially initiated at *c* 2300 cal BC (*above*). Moreover, it has been argued that this was the start of a prolonged period of agricultural activity across the Solway area, which continued into the Bronze Age (*below*). It has also been suggested that this phase of renewed clearance across the lowlands of the Solway Firth corresponded to the movement of arable farmers into adjacent upland areas (Tipping 1997a, 20). Cereal-type pollen has been consistently recorded at pollen sites across the inner Solway Firth and adjacent areas after *c* 1800 cal BC, implying the presence of arable agriculture with, for example, substantial cereal-pollen records dating from the Middle Bronze Age from lowland areas (Walker 1966; Tipping 1997a, 20). It also has been argued that after 1800 cal BC, there were no dramatic increases in clearance and that the levels of land-use remained fairly static throughout the remainder of the Bronze Age (Tipping 1997a, 20).

The pollen evidence at Stainton West largely conforms to this regional picture, but, significantly, allows the nuances of clearance to be explored. The earliest evidence relating to this pollen superzone came from Burnt Mound 2. This indicates that at the very end of the third millennium BC the site was in an area of alder woods, which contained shallow, freshwater pools. Cereal-type pollen was also identified, suggesting the presence of arable agriculture within cleared areas; however, after Burnt Mound 2 was abandoned, the record shows a decline in alder, which may be attributed to clearance, or may reflect changing hydrological conditions. This pattern, specifically a reduction in alder, along with hazel, is also evident in the pollen data for the *Bronze Age alluvium*, in Bays F (Zone 70252e) and O (Zone 70507d), which together with increases in herb pollen (in Zone 70507d) suggest an increase in open areas adjacent to the floodplain, which may have been used for both arable cultivation and for the pasturing of animals. It appears, however, that clearance may have been fairly transient as, during the *Bronze Age alluvium* pollen zone (Bay O, Zone 70507e), there was renewed encroachment of alder carr on the Stainton West floodplain. Similarly, the pollen assemblage from the buried land surface (***70486***) and the earlier part of *Bronze Age/Iron Age alluvium*, which probably relates to the use and abandonment of Burnt Mounds 3 and 4, indicates that the predominant habitat was one of alder carr.

CNDR 5: the late second millennium BC(?) and later landscape at Stainton West

The uppermost superzone is confined to Bay O (monolith 70507), the pollen record there suggesting clearance and cultivation on the floodplain. Although there is no radiocarbon-dated material from the sediments associated with this, it must have post dated the mid-second millennium BC, either dating to the late second millennium BC, or possibly even younger.

The data for this superzone indicate that it was characterised by a continuous cereal-type pollen curve, implying that arable farming was present close to the site. The pollen sequence also suggests that the floodplain at Stainton West had been cleared during this period, with wet areas containing sedges, loosestrifes, and marsh marigold. Heather was also present close to the site, indicating the nearby development of acid heath.

The later Iron Age/Roman landscape at Knockupworth

Pollen evidence relevant to the Iron Age and Roman period is contained in the material from Knockupworth. The data from both samples 50013 (from Bronze Age ditch ***50081***, though open in the Roman period) and, to a lesser extent, 50000 (buried soil ***50072***, beneath the north mound of the Vallum) show a strong correlation with Tarraby Lane, on Hadrian's Wall, close to Carlisle (Balaam 1978). The major feature of the pollen profiles from Tarraby Lane is the dominance of alder and hazel over all other species. At the top of the profiles, the subsequent switch to the dominance of grassland was interpreted as a result of clearance for farmland, and it was concluded that at the time of the construction of the Turf Wall, the area around Tarraby Lane was a patchwork of open fields bordered by hedges and ditches (*ibid*). Poorly drained ground could have been covered with alder and fringed with hazel/alder scrub, containing some oak and a limited number of other trees. Pollen from beneath the Vallum mound at Knockupworth and from ditch ***50081*** similarly indicates areas of alder carr dominating the environment, with significant grassy openings, which were possibly used for pastoralism. Dense alder woodland has also been indicated by material from beneath the Turf Wall at Birdoswald (Wiltshire 1997), whilst pollen from Midgeholme Moss, near Birdoswald (Innes 1988), shows the pre-Roman section to be dominated by tree pollen, especially alder and hazel, but with significant quantities of grass and ribwort plantain, suggesting a predominantly pastoral economy.

The single pollen sample (51023) from laminated turf ***51026***, dumped in the Vallum ditch, is directly dated to the later Iron Age (360-170 cal BC; 2183±26 BP; SUERC-42030) and provides a snapshot of the environment immediately before the construction of Hadrian's Wall. This indicates that a cleared landscape, with less than 20% tree cover, existed, also characterised by wet meadows, and there is evidence for the spread of acid-heath vegetation, with some remaining stands of alder on damper ground. This environment is largely consistent with pollen assemblages from other pre-Roman buried-soil deposits in Carlisle (Huckerby 2009) and sealed beneath sections of the Hadrianic frontier at Crag Lough (Dark 2005), Butterburn Flow (Yeloff *et al* 2007), and Appletree (Wiltshire 1992). This latter site has particular similarities with sample 51023, as there was an abundance of grasses and sedges, as well as evidence for open moorland (*ibid*). In all of the samples from Knockupworth, there are only a few occurrences of cereal-type pollen, which may reflect the local processing of cereal grains, or may indicate piecemeal, low-level arable cultivation across this area.

Significantly, the pollen evidence from Knockupworth fits comfortably with the wider regional evidence from the inner Solway Firth. The evidence from numerous pollen sites indicates that extensive and concerted woodland clearance occurred throughout the Iron Age (from *c* 500 cal BC onwards) and, in some places, into the early Roman period (Tipping 1997a, 20-1; Hodgkinson *et al* 2000, 114-17; Stallibrass and Huntley 2011). The purpose of this clearance appears to have been to convert larger areas of the landscape into agricultural land and, across the region, pollen evidence exists for both arable and pastoral farming (Tipping 1997a, 20-1; Hodgkinson *et al* 2000, 114-17).

The medieval landscape: Parcel 32 and the medieval soil from the henge monument

The pollen data (monolith 32046) from the putative medieval ditch (***32131***) at Parcel 32 implied that an economically useful landscape existed in this area, which was largely given over to grassland, creating potential for grazing and arable farming. In addition, the data suggested the presence of hazel, which could have been coppiced, alder/hazel/birch, which could have been used for building, and heather, which could have been employed in a variety of uses (*cf* Dickson and Dickson 2000). The cereal-type pollen from the lower and the upper fills (***32128*** and ***32120*** respectively) of the ditch appear to show two possible phases of distinct arable land-use. For instance, there was a paucity of charcoal in the earlier fill, perhaps suggesting an absence of local land-management practices involving fire, with an obvious increase in charcoal particles within the upper fill. This also contained the consistent presence of cereal-type pollen, including several grains that might imply the cultivation of oats/wheat and barley.

The material in the ditch was not dated, although an adjacent, and probably associated, ditch (***32041***; *Ch 14*) has been dated to the beginning of the later medieval period. This is based on a radiocarbon assay of cal AD 980-1160 (995±35 BP; SUERC-32725) obtained from a plant macrofossil from its basal fill, and sherds of pottery, dating to the twelfth to fourteenth century, from its secondary fill. It is therefore possible that the pollen assemblage from ditch ***32131*** is of a similar date.

The medieval soil (***200106***) filling the ditch of the Neolithic henge monument contained plant macrofossils dated to cal AD 1300-1440 (560±35 BP: SUERC-37827) and cal AD 1030-1210 (905±35 BP; SUERC-37828), suggesting that it had filled between the mid-eleventh and early fifteenth centuries. The pollen evidence points to the presence of a highly cleared landscape, with areas given over to the cultivation of cereal, alongside open and waste places.

Several other pollen sites are known from across the region, which allow the partial reconstruction of the medieval landscape of the inner Solway Firth (*Ch 14*); this evidence largely accords with that from the CNDR evidence It appears, for example, that, at the beginning of the later medieval period, some parts of the landscape were cleared for farming, whilst others were abandoned, resulting in woodland regeneration (*cf* Tipping 1997a, 22; Hodgkinson *et al* 2000, 121; Mauquoy *et al* 2002). However, from the fourteenth century onwards, the area was largely cleared, and the landscape was subjected to widespread and stable agricultural exploitation, which appears to have been little affected by climatic deterioration, causing the 'Little Ice Age, or indeed the turbulent political events of the period (Tipping 1997a).

Conclusion

The pollen sequences from the *Principal palaeochannel* at Stainton West, and from the other sites along the CNDR have proved extremely useful for reconstructing the form of the landscape over the millennia, and determining early periods of clearance and farming. Significantly, taken as a whole, this analysis will contribute to wider palaeoenvironmental reconstructions of other river systems in north-west England, such as those focused on the catchments of the rivers Eden and Mersey, which, have also produced a broad spectrum of palaeoenvironmental data relevant to the evolving landscape during the Holocene (*inter alia*; Shimwell 1985; Hall *et al* 1995; Chinn and Innes 1995; Wilkinson *et al* 1999; Innes 2001; Yeloff *et al* 2007).