PALAEOENVIRONMENTAL ANALYSIS

Introduction

A sequence of eariy Holocene deposits, representing a localised area of ancient wetland within the south-western part of the developed area of Bedale, was examined in detail to characterise the ancient environment and gain absolute dates for organic accumulations. To this end, a series of radiocarbon dates were obtained fbr the deposits, while pollen and plant and invertebrate macrofossils were analysed. The results of the eariier assessment and subsequent works, including full details of the processing and the recording of the remains are presented in Carrott et *al*. (2004) and Gearey et *al*. (2006), respectively.

Results and discussion

The sequence of deposits in Section 18 comprised c. 1.50m of muds/organic silts (the lower half of the sequence) and detritus peat layers (the upper half) sampled via two parallel series of four overiapping 0.50m column tins (Column Samples 3 and 4, Tins A to D; see Fig. 10). Outiine descriptions of the sediment sequence (as seen in Column Sample 3) are given in Table 1.

The lower deposits were initially assessed for the presence of diatoms (sub-samples at 1.02m, 1.22m, 1.29m and 1.49m, all within Context 176; preparations following Batterbee et *al*. 2001) but none were detected and no further analysis was possible. The presence of copulae (girdle bands connecting the diatom frustules) in some samples indicated that diatoms had once been present, but it is difficutt to draw further conclusions based on this evidence alone. The absence of identifiable remains may be a result of the acid environment causing dissolution of the silica based frustules. Further information regarding preservation and taphonomic processes may be found in Lowe and Walker (1998, 177) and Batterbee (1986).

Dates quoted in the following text refer to the conventional radiocarbon age obtained, unless stated otherv/ise.

Radiocarbon dates

The radiocarbon dates gave a timeframe for the deposits ranging from 8770 +/- 40 BP to 7290 +/- 40 BP (the earliest peat layers being dated to 7940 +/- 40 BP). The individual results from radiocarbon dating of the selected deposits are detailed in Table 2. Interestingly, three of the dates retumed, those from Contexts 171, 172 and 173, were effectively the same but represent around 0.25m of deposit, suggesting a rapid development of the peat at this time.

Pollen

The pollen diagram for deposits in Section 18 (Fig. 11) reflects a sequence of early Holocene vegetation changes on and around a shallow body of water which infilled through natural processes of hydroseral succession. The diagram has been divided into five Local Pollen Assemblage Zones (LPAZ) prefixed 'BED' and based on changes in the biostratigraphy; the main features of these zones are given in Table 3.

The radiocarbon dates indicated that sediment accumulation began at 8770 +/- 40 BP (Beta-187370). The basal zone, BED-1 corresponds to the laminated organic silts/muds and reflects sediment accumulation within a body of water such as a pool or lake. High percentages of *Corylus avellana*-type pollen reflect a hazel (*Corylus*) dominated wood/scrub land around the sampling site. Other trees and shrubs were recorded at lower percentages but it seems likely that birch (*Betula*) formed a secondary component of the local vegetation, with elm (*Ulmus*) also growing as a subordinate tree on better-drained soils in the wider landscape. Scots pine (*Pinus sylvestris* L.) was not present to any great extent and, perhaps more surprisingly, neither apparently was oak (Quercus, see below).

Littie herbaceous pollen was recorded, suggesting a dense canopy with a depauperate understorey, an impression that was maintained for the entire diagram. The occasional grains that were observed included *Filipendula* (meadowsweet), Caryophyllaceae (pink family), Apiaceae (carrot family) and *Succisa* (devil's bit scabious); these taxa probably represent wetland/tall herb vegetation communities on the damper soils at the edge of the basin, and the ferns *Thelypteris palustris* Schott (marsh fern) and *Equisetum* (horsetail ferns) would probably also have grown in this habitat Only a single grain of *Typha latifolia* L. (reed-mace) indicated aquatic taxa in this zone.

BED-2 opens at a date of 8190 +/- 50 BP (Beta-216398) with a marked expansion of sedges (*Carex*) and ferns (Pteropsida), whilst hazel displays a concomitant decline. However, it is unlikely that this represents the actual replacement of hazel by these taxa. The stratigraphic transition from laminated organic silts to peat at a depth of around 0.90m indicates that the water body in which these sediments were accumulating was infilling as a result of hydroseral succession. Sedges and ferns were probably spreading onto the surface of the peat, and hence the pollen record becomes strongly biased in favour of these local plants and away from the vegetation growing in the wider landscape. This process also explains the reductions in oak, elm and birch across this zone since these trees would have also been present largely on the dryland areas. The rise in pine reflects the ability of this tree to expand onto the damper/poorer soils that became available at this time near to the sampling site.

The opening of BED-3 was dated to just after 7960 +/- 50 BP (Beta-187368). The pollen record continues to be dominated by local vegetation with sedges and fems remaining established on the sampling site. There was evidence for some fluctuations in the arboreal populations, with oak showing a small increase at the base of the zone, apparentiy at the expense of pine. Establishing the precise nature and sequence of changes in the upper section of this zone and the basal part of BED-4 is complicated by the absence of countable concentrations of pollen from 0.57m after a date of 7490 +/ - 60BP (Beta-187366). This may be the result of a dry mire surface; the marked peaks in pine and then birch following the hiatus in the biostratigraphy in BED-4 indicating that water tables had fallen sufficiently to allow the surface of the peat to be colonised by these trees. Reductions in sedges at this time also support the inference of a drier local environment.

Owing to the low concentrations of pollen, there was also a hiatus in the pollen record in the final zone BED-5. By the close of the diagram, shortly after 7290 +/- 40 BP (Beta-187365), pine (*Pinus*), hazel and alder (*Alnus*) all appear to be expanding. The fall in sedges following a recovery at the opening of the zone again suggests a drier local environment; pine was probably benefiting directly from this on the peat soils near to the sampling site.

The overall picture was of a closed, hazel-dominated, woodland environment with some birch and elm present. This is typical of the general regional picture of vegetation development in this area during the eariier Holocene (Day 1995). However, oak does not seem to have been a significant component of the woodland at Bedale. This is perhaps hard to explain on ecological grounds since this tree was well established in northern England by this time (Birks 1989), but interpretation was hindered by the fact that for much of the sequence, and particularly from BED-2, the pollen record was strongly biased towards vegetation growing locally. Following the growth of peat on the sampling site from around 8190 BP, a sedge fen developed and this vegetation dominates the pollen record fbr much of the diagram.

This was evidently a relatively 'dry' peat-accumulating environment, with abundant fems but few other wetland plants indicated. As mentioned above, phases of dry mire surface could be responsible for the poor pollen preservation in two parts of the sequence.

The fluctuations in the arboreal taxa appear largely to reflect localised processes of competition between birch and pine connected to the growth of peat rather than competitive interactions in the wider landscape (see, fbr example, Bennett 1986). Following the spread of the main arboreal taxa at the opening of the Holocene, competitively inferior taxa such as birch and pine were excluded to poorer or wetter soils such as those that were present at and around the sampling site. The pollen diagram derived from Section 18 at Bedale therefore provides a 'snapshot' of local processes of vegetation change in this area over a period of about 1500 years, which tend to be invisible in pollen sequences from larger sampling sites (see Day 1995).

Plant and invertebrate macrofossils

Plant macrofossil remains (Table 4) preserved by anoxic waterlogging were generally well-preserved and usually reasonably abundant, though identifiable macrofossils were often of quite restricted diversity and the bulk of the remains formed by herbaceous and woody detritus, as might be expected in deposits which were largely detritus peats. Preservation of invertebrate remains (Table 5) was very varied within and between deposits. Some assemblages gave the subjective impression that there may have been general decay, so perhaps the sequence as a whole may be at risk from dewatering. The concentration of invertebrates also varied, from very low to moderately high (extremely high if crustaceans are included), probably reflecting ecological conditions, rate of sediment accumulation and (in the case of the lake deposits – samples from Contexts 175 and 176) distance from the shoreline.

Many of the plant and insect remains from the two lowest deposits (Context 176, Samples 301-304 and Context 175, Sample 305, corresponding to LPAZ BED-1) were of aquatic taxa. Most of the plant remains identified were those that float on or grow submerged in fresh water (e.g. muskgrass/stonewort – *Chara*/Characeae, white water-lily – *Nymphaea alba* L.) or grow in very wet terrestrial places (sedges – Carex). A record of the weevil Tanysphyrus *lemnae* (Paykull) provided indirect evidence of the presence of duckweed (*Lemna*). The rest of the invertebrate fauna was also predominantiy aquatic and indicated a rich environment, with abundant vegetation (e.g. by the snail *Valvata cristate* Müller). A wide range of beeties and bugs living in a pond/lake environment were recorded and beetles found exclusively in mnning water were also well represented. The elmids, four species of which were recorded here (*Esolus parallelepipedus* (Müller), *Oulimnius*, *Limnius volkmari* (Panzer), *Elmis* aenea (Müller) and *Riolus*/*Normandia*), have a system of respiration that requires the very well-oxygenated water found in streams and rivers and also, though more rarely, on the stony shores of lakes. In addition to the elmids, there were several other taxa that live in running water and the water conditions generally would have been clear and unpolluted. A range of swamp dwelling taxa were represented but open areas of water must also have been present to attract insects such as pond skaters (*Gerris*) - all of the records for pond skaters were from the lower parts of the sequence (Contexts 175 and 176). *Aphodius* dung beetles were also represented in four samples from the two lowest deposits. Members of this genus are typically found in herbivore dung in the open, but some species are also attracted to foul decomposing plant material. Unfortunately, none of the remains could be identified to species and their presence does not necessarily imply the presence of grazing animals nearby. However, their consistent occunence in these lowest samples, albeit in small numbers, is of note.

From Context 174 upwards (corresponding with the beginning of BED-2), beetles and bugs that would have exploited moss and litter in a swamp became predominant in the assemblages and, indeed, the thin deposit, Context 174, was largely composed of matted Drepanocladus moss. Another moss, Hypnum cf. cupressiforme Hedw., was represented amongst the identifiable plant remains from Context 173. There were shallow, unpolluted well-vegetated pools supporting a substantial aquatic fauna, again including Tanysphyrus lemnae (Contexts 174, 172 and 171, but not recorded from Context 173) which implies the presence of duckweed. Apart from moss and duckweed, there were few indications of other vegetation, although some taxa feeding on sedges (Carex) were present and remains of these plants were common in Context 174 and the two immediately overlying deposits (Contexts 173 and 172). There were records of the fioghopper Aphrophora major from three of the samples (from Contexts 174 and 173, and the next to uppennost Context 71) in the upper part of the sequence, implying the presence of its host plant bog-myrtle (Myrica gale L.), although remains of the plant itself were not identified.

For all of the deposits, the plant remains of terrestrial vegetation were dominated by birch (detennined as silver/downy birch – Betula pendula Roth/S. pubescens Ehrh. where better preserved). Silver birch forms woods on light, mostiy acid soils, especially heathland, and usually in drier places than downy birch. In particular, Context 176 (Samples 301-304) gave large quantities of birch female catkin-scales and nuts. The pollen record indicates that hazel dominated the local woodland at this period, with birch as very much a secondary component, but the macrofossil evidence shows the reverse with only a few nut shells confirming the presence of hazel. However, this may simply be a reflection of the greater mobility of the delicate birch structures. Oak (Quercus), which was surprisingly poorly represented in the pollen record, was similarly sparsely represented in the botanical macrofossil assemblages by small numbers of buds/bud scales in just two deposits (Contexts 175 and 173). Small numbers of wood-associated invertebrate taxa were also recorded consistentiy throughout the sequence, but, other than this, there were few indications of terrestrial habitats other than swamp. Several ground beetle taxa (e.g. Pterostichus diligens (Sturm) and P. nigrita (Paykull)) were typical inhabitants of moist ground and Trechus rivularis (Gyllenhal) was recorded from Context 71 close to the top of the sequence. The latter is found on moist shady peat sites often with a growth of birch, alder and willow (Salix), and an underlying vegetation of moss and sedges (Lindroth 1985, 121).

The pollen spectra for the upper third or so of the sequence (LPAZs BED-5, BED-4 and the upper part of BED-3) suggested a relatively 'dry' peat accumulating environment (though the area is still clearly 'swampy' with very wet areas and probably shallow bodies of standing, though perhaps not all permanent, water) and this was also reflected in the macrofossil assemblages (Contexts 67, 71, 171 and 172). Concentrations of identifiable plant and invertebrate remains were reduced in these upper layers and aquatic and wetland species decline or were absent (e.g. Characeae spp., sedges, white water-lily). At the same time, there was an increase in wood fragments (including twigs) culminating in these being abundant (with some bark also present) in the uppermost deposit (Context 67) which corresponds with the expansion of pine, hazel and alder evinced by the pollen in BED-5. A single fragment of a wood boring beetle *Grynobius planus* (Fabricius) from Context 67 may also be an indication of trees growing locally.

The distribution of many insects in England is heavily influenced by temperature and consequently the distributions of various species in the past can be used as indicators of climatic change. The bug *Hebrus pusillus* Fallén is of interest in this regard as it is confined to southern England at the present day (Macan 1956; Southwood and Leston 1959, 341-2). It was recorded from the samples from Contexts 173 and 174, and was especially common in the latter. The presence of this species may indicate that the climate of the area at the time the deposits formed was somewhat warmer than at present, perhaps with similar mean temperatures to those of the far south of Britain. In palaeoclimatological terms, the Atlantic period of Holocene northern Europe, with mean temperatures perhaps 2.5°C higher than today, begins between BP 9000 and 8000 calibrated (ending around BP 4300 calibrated and punctuated by a cooling event at around BP 8200), with some regional variation (this period is still in the process of definition). Therefore, it seems likely that the sudden change in the biostratigraphy seen in Section 18 from Bedale at around 0.93m depth (from BED-1 to BED-2 and dated sometime after 9290 BP calibrated and before 8620 BP calibrated) marks the beginning of the Atlantic period at this site. Contexts 173 and 174 would then have been deposited during this time of warmer climate which would have allowed *Hebrus pusillus* to extend its range to more northerly locales. It may also be that the less dramatic changes in the biostratigraphy seen for the starts of BED-4 and BED-5 are related to the cooling event of around 8200 BP calibrated.

Overall, the plant and insect assemblages supported the pollen evidence indicating aquatic deposition throughout, though in the upper (peat) layers of the sequence this was in a swamp environment rather than the open water implied by the assemblages from the lower (mud/organic silt) layers. The insect assemblages in particular mirrored the pollen evidence for a natural hydroseral succession leading to swampy sedge fen with *Myrica* (though there was no specific evidence for this plant in the botanical material). There was no evidence of human activity from the biological remains at any point through this sequence of deposits.

Position in column	Context	Sample no.	Troels-Smith	Transition	Description	Notes
Tin A: 18.0 to 50.0 cm (depth ~0.07 to 0.39 m)	67	311	Dl2Dh/Dg2	grades to...	Dark brown, crambly, woody detritus peat	
Tin A: 0.0 to 18.0 cm Tin B: 82.0 to 50.0 em (depth ~0.39 to 0.57 m)	71	310	Dh/Dh3Ld1	gmdes to...	Dark brown, somewhat crumbly, detritus peat	
Tin B: 20.0 to 62.0 cm (depth ~0.57 to 0.69 m)	171	309	Ld3Dg/Dh1	grades to...	Dark brown, rathar crumbly, mix of mud and fine detritus peat	
Tin B: 8.0 to 20.0 cm (depth ~0.69 to 0.81 m)	172	308	Ld3Dg/Dh1	gredes to...	Dark brown mud with fine detritus peat	softer and less crumbly than Sample 309
Tin B: 0.C to 8.0 cm Tin 0: 88.0 to 48.0 cm (depth ~0.81 to 0.89 m)	173	307	Ld4?Dg+	grabes to...	Mid to dark brown (somewhat 'banded'), mix of mud and fine detritus peat	
Tin 0: 36.0 to 88.0 cm toeräh ~0.89 to 0.91 m)	174	306	Dh4	grades to...	Mid to dark brown, 'moss-rich' detritus	mostly matted moss
Tin C: (34.0-36.0) to 36.0 cm (deräh ~0.91 to 0.93 m)	175	305	Ld3Dg1	aharp boundary to...	Dark brown, soft mud, with a little herbaceous detritus	
Tin C: 12.0 to (34.0-36.0) om (depth ~0.89 to 1.15 m)	176	304	Ld4test mol.+	grades to...	as 303 but locally paler brown	
Tin C: 0.0 to 12.0 om Tin D: 27.0 to 50.0 om (depth ~1.15 to 1.38 m)	176	303	Ld4test mol.+		Dark grey-brown, soft (working more or less plastic), mud, with some fine laminations/partings. Snails were present	some fine laminations /partings
Tin 0: 9.0 to 27.0 cm (depth ~1.38 to 1.56 m)	176	302	Ld4test mol.+	grades to...	Mid grey-brown, soft (working more or less plastic), mud. Snails present	lighter shsdo of grey-brown
Tin D: 0.0 to 9.0 cm (depth ~1.56 to 1.65 m)	176	361	Ld4test mol.+		Mid yellowish-brown (dxidising mid to dark grey-brown), ao8 (vrarking more or loos plastic), mud, with moderath nuloosts of snails present	yellow-brown in colour

Table 1. Summary of the column sample descriptloos for Section 18. The deposits are listed in stratigraphio sequence from top to bottom with their positions within the individual monoliths renorded from the base of each lin. Where the overlapping of the monoliths has resulted in the same deposit being present in two tinc the positiono within each ere given. The 'Troels-Smith' solumn gives desoriptions following Troels-Smith (1955).

Context	Sample	Location in column sample monolith	Beta Number	Submitted material	Measured radiocarbon age	13C/12C ratio	Conventional radiocarbon age	Calibration of radiocarbon age to calendar years @ 2-sigma
67	311/T	Tin A: 18.0 to 50.0 cm (depth ~0.23 m)	Beta-187365	Bark fragments, probably birch (*Betula*): 335 mg	7340 +/- 40 BP	-28.1 o/oo	7290 +/- 40 BP	Cal BC 6230 to 6620 (Cal BP 8180 to 8620)
71	310	Tin A: 1.0 to 0.0 cm (Tin B: 33.0 to 88.0 cm) (depth ~0.50 m)	Beta-187366	Organic sediment: 220 g	7550 +/- 60 BP	-28.8 o/oo	7490 +/- 60 BP	Cal BC 6445 to 6225 (Cal BP 8395 to 8175)
171	309/T	Tin B: 80.0 to 32.0 cm (depth ~0.61 m)	Beta-187367	Small wood and bark fragments: 90 mg	8020 +/- 40 BP	-29.7 o/oo	7940 +/- 40 BP	Cal BC 7040 to 6620 (Cal BP 9000 to 8620)
172	308	Tin B: 9.0 to 14.0 cm (depth ~0.79 m)	Beta-187368	Organic sediment: 115 g	8010 +/- 50 BP	-28.0 o/oo	7960 +/- 50 BP	Cal BC 7055 to 6620 (Cal BP 9005 to 8620)
173	307/T	Tin B: 0.0 to 8.0 cm Tin 0: 38.0 to 48.0 cm (depth ~0.86 m)	Beta-187369	Three small fragments of well preserved hazel (*Corylus avellana* L.) nutshell: 70 mg	7980 +/- 40 BP	-27.7 o/oo	7940 +/- 40 BP	Cal BC 7040 to 6670 (Cal BP 9000 to 8620)
175	305	Tin 0: (34.0-36.0) to 86.0 cm (depth ~0.93 m)	Beta-216398	Organic sediment: ~90 g	8250 +/- 50 BP	-28.6 o/oo	8190 +/- 50 BP	Cal BC 7340 to 7070 (Cal BP 9290 to 8620)
176	301/T	Tin 0: 0.0 to 9.0 cm (depth ~1.80 m)	Beta-187370	Tree bud-scales, birch female catkin scales, dicotyledonous leaf fragments: 27 mg	8810 +/- 40 BP	-27.2 o/oo	8770 +/- 40 BP	Cal BC 7970 to 7650 (Cal BP 9920 to 8600)

Table 2. The radiocarbon dates from Section 18.

Zone	Depth-m	Main characteristics
BED-5	0.14-0.27	*Pinus* increases to ~35%, *Corylus* to 25% and *Alnus* to 9%. *Betula* reduced to 5%, *Quercus* to trace (<1%) values and Cyperaceae to 20%.
BED-4	0.27-0.45	An equally sharp peak of 50% in *Betula* follows a pronounced peak of 50% in *Pinus*. *Corylus* increases to ~20% but falls to ~2% by close of zone. Cyperaceae drops steadily to 35%. Pteropsida increases to 90%TLP+spores.
BED-3	0.45-0.75	*Pinus* drops at the opening of the zone before rising to 25% before dropping to 12%, *Quercus* also shows an increase to 10% at the opening of the zone. *Corylus* at ~10%. High Cyperaceae percentages (60%) throughout, whilst Pteropsida rises to 70%.
BED-2	0.75-0.95	*Pinus* increases to around 15%, but other trees including *Quercus*, *Ulmus* and *Betula* all decline and *Corylus* shows a significant fall to ~35%. Cyperaceae rises to 30%.
BED-1	0.95-1.65	Dominated by *Corylus* (70-80%), with other trees including *Betula* (10%), *Ulmus* (5%). *Quercus* (2-3%) and *Pinus* (3-4%) recorded at lower values.

Table 8. Summary of LPAZs for Section 18. All values are TLP unless otherwise stated.

Qontext			67	71	171	172	173	174	175	176	176	176	176
Sample			311/T	310/T2	309/T	308/T2	307/T	306/T	305/T	304/T2	303/T	302/T2	301/T
Volume of residue (litres)			0.12	2.29	0.375	0.90	1.30	1.20	0.08	1.05	1.75	0.85	0.20
Identified plant remains	**Vernacular name**	**Parts recorded**											
Betula pendula Roth/*B. pubescens* Ehrh.	silver/downy birch	female catkin-scale				1				2	2	2	
Betula pendula/pubescens	silver/downy birch	wingless nut		2		1				3	2	2	
Betula pendula Roth	silver birch	winged nut								3	2	2	
Betula sp.	birch sp. indet.	buds/bud scales					1		1				2
Betula sp.	birch sp. indet.	female catkin-scals					1		1				2
Betula	birch sp. indet.	fruits	1		1		1	1	3				2
Carex	sedge	nut, utricle		1		2	2	2		1	1		
Ceratophyllum	hornwort	fruits							1				
Chara/Characeae	muskgrass/stonewort	oogonium		1		1			1	2	3	3	3
Cladium mariscus (L.) Pohl	saw-sedge	nutlets							1				1
Corylus avellana L.	hazel	nut shell					1			1		1	
Drepanocladus	moss							3	1				
Hypnum cf. *cupressiforme* Hedw.	moss						1						
Menyanthes trifoliata L.	bog bean	seed							1				
Nymphaea alba L.	white water-lily	seed								1	1	1	
Populus	poplar/aspen	buds/bud scales											1
Quercus	oak sp. indet.	buds/bud scales					1		1				
Sorbus aucuparia L.	rowan	fruit							1	1			
?*Thelypteris palustris* Schott	marsh fern	shoots					1						

Context			67	71	171	172	173	174	175	176	176	176	176
Other plant remains													
bark			1							1	1	1	
buds/bud scales										2	1	1	
moss									2				
plant fibres (epidermis)				3		2					2		
rootlets					3	3	3	1					
stem fragments					2							1	
tree leaf fragments									2				2
wood fragments (incl. twiglets)			3	1	1	1	1					1	

Table 4. Complete list of plant macrofossils from the column samples of Section 18. Nomenclature follows Stace (1997). Abundances have been recorded semi-quantitatively on a three-point scale as follows: '1' = present, i.e. one or relatively few remains or less than 10% by volume; '2' = common, or about 10-50% by volume; '3' = abundant, or more than 50% by volume. Samples suffixed '/T' were also included in the assessment, those suffixed '/T2' were only processed and recorded for the analysis.

Context	**67**	**71**	**171**	**172**	**173**	**174**	**175**	**176**	**176**	**176**	**176**
Sample	311/T	310/T2	309/T	308/T2	307/T	306/T	305/T	304/T2	303/T	302/T2	301/T
Taxon											
Cladocera spp. (ephippia)	+	+	++	++	+	-	+	++	+++	+++	++
Ostracoda sp.	-	-	+	-	-	-	+	-	+	++	+
Lyppoidae spp.	1	2	-	1	-	-	-	-	-	-	-
Cymus glandicolor Hahn	-	-	-	-	-	3	-	-	-	-	-
Cymus ?glandicolor	1	3	-	2	6	-	1	-	-	-	1
Saldidae sp.	-	-	-	-	3	1	-	-	-	-	-
Hebrus pusillus Fallén	-	-	-	-	1	18	-	-	-	-	-
Hebrus ruficeps Thorason	-	1	-	-	3	2	1	-	-	-	-
Gerris sp.	-	-	-	-	-	-	1	4	-	4	2
Corixidae sp.	-	-	-	-	-	-	1	3	1	1	1
Heteroptera spp.	-	-	-	-	1	1	-	-	3	1	-
Aphrophora major Uhler	-	1	-	-	1	1	-	-	-	-	-
Delphacidae spp.	2	22	-	21	12	-	1	4	1	2	3
Auchenorhyncha spp.	-	2	1	4	2	-	-	1	-	1	1
Psyllidae sp. indet.	-	-	-	-	-	-	-	1	-	-	-
Aphidoidea sp.	-	-	-	-	-	-	+	-	-	-	-
Bibionidae sp.	+	-	-	-	+	-	-	+	-	-	+
Diptera spp. (adults)	-	-	-	-	-	+	-	-	-	-	+
Diptera spp. (puparia)	-	-	+	+	+	-	-	+	-	-	+
Formicidae sp.	-	-	-	-	-	-	-	-	-	-	+
Hymenoptera Parasitica spp.	-	-	-	-	-	++	-	-	-	-	-
Leistus sp.	-	-	-	-	-	-	1	-	-	-	-
Clivina sp.	-	1	-	-	-	-	-	-	-	-	-
Trechus rivularis (Gyllenhal)	-	3	-	-	-	-	-	-	-	-	-
Bembidion (Philochthus) sp.	-	-	-	-	2	-	-	-	-	-	-
Pterostichus diligens (Sturm)	-	3	-	-	1	-	-	-	1	-	-
Pterostichus minor (Gyllenhal)	-	-	-	2	-	-	-	-	-	-	-
Pterostichus nigrita (Paykull)	-	1	-	-	-	-	-	-	-	-	-
Pterostichus spp.	-	1	-	-	-	-	-	1	-	-	-
Agonum sp.	-	3	-	-	-	-	-	1	-	-	-
Carabidae spp.	1	1	1	-	3	2	-	1	2	-	2
Haliplus spp.	-	-	-	-	-	-	1	1	-	3	3
Noterus sp.	-	-	-	-	-	-	-	1	-	-	-

Context	67	71	171	172	173	174	175	176	176	176	176
Sample	311/T	310/T2	309/T	308/T2	307/T	306/T	305/T	804/T2	303/T	302/T2	301/T
Bidessus unistriatus (Schrank)	-	-	-	-	-	4	-	-	-	-	-
Hygrotus inaequalis (Fabricius)	-	-	-	-	-	4	-	2	1	-	-
Suphrodytes dorsalis (Fabricius)	-	-	-	-	-	2	1	-	-	-	-
Hydroporus spp.	-	-	-	4	14	6	-	9	3	2	-
Stictotarsus duodecimpustulatus (Degeer)	-	-	-	-	-	-	-	-	-	1	-
Hydroporinae spp.	1	12	-	-	-	-	7	5	-	3	3
Agabus bipustulatus (Linnaeus)	-	1	-	1	-	-	-	3	1	1	-
Agabus sp.	-	3	-	1	-	-	-	3	-	-	1
Agabus or *Ilybius* spp.	2	3	1	-	1	2	1	8	3	4	1
Colymbetes fuscus (Linnaeus)	-	1	-	-	-	-	1	10	7	3	2
Colymbetinae sp.	-	-	-	-	-	-	-	-	-	2	-
?*Hydaticus transversalis* (Pontoppidan)	-	-	-	-	-	-	-	-	-	1	-
Acilius sp.	-	1	1	-	-	-	2	8	7	3	2
Dytiscus sp.	-	-	-	-	-	-	-	2	1	1	-
Dytiscidae spp.	1	-	-	-	-	-	-	1	-	-	1
Gyrinus sp.	-	1	-	-	-	-	-	-	2	2	1
Hydrochus brevis (Herbst)	-	1	-	1	1	2	-	-	1	-	-
Helophorus spp.	-	-	-	-	-	-	-	1	1	2	-
Coelostoma orbiculare (Fabricius)	1	1	1	1	6	5	1	3	-	-	-
Cercyon spp.	-	3	-	1	4	-	-	1	-	-	-
Hydrobius fuscipes (Linnaeus)	-	1	-	1	1	-	1	6	3	1	-
Anacaena spp.	-	4	-	-	1	-	-	-	-	2	-
?*Hydrophilus piceus* (Linnaeus)	-	-	-	-	-	-	-	2	-	-	-
Hydrophilinae spp.	2	3	1	2	3	6	4	9	2	2	-
Ochthebius minimus (Fabricius)	2	15	-	8	-	7	16	74	49	57	23

Context	67	71	171	172	173	174	175	176	176	176	176
Sample	311/T	310/T2	309/T	308/T2	307/T	306/T	305/T	304/T2	303/T	302/T2	301/T
Hydraena gracilis Germar	-	-	-	-	-	-	-	3	-	-	-
Hydraena ?palustris Erichson	-	5	-	1	4	1	4	2	3	2	2
Hydraena sp.	3	7	2	1	3	3	7	12	14	9	12
Limnebius aluta (Bedel)	-	7	-	3	9	9	3	2	1	-	2
Limnebius spp.	-	-	-	-	-	-	1	6	2	3	4
Ptenidium sp.	-	1	-	-	-	-	-	-	-	-	-
Acrotrichis sp.	-	2	-	-	-	-	-	-	-	-	-
Catopinae sp.	-	-	-	-	-	-	-	1	-	-	1
Silpha atrata Linnaeus	-	-	-	-	-	-	-	1	1	-	-
Micropeplus tesserula Curtis	-	-	-	-	1	-	-	-	-	-	-
Micropeplus sp. indet.	-	-	-	-	-	1	-	-	-	-	-
Metopsia retusa (Stephens)	-	1	-	-	-	-	-	-	-	-	-
Olophrum piceum (Gyllenhal)	-	-	-	-	1	-	-	1	-	-	-
Olophrum sp.	-	1	-	-	-	-	-	-	-	1	2
Eusphalerum sp.	-	1	-	-	2	-	-	-	-	-	-
Omaliinae spp.	-	3	1	-	2	2	-	1	-	-	-
Carpelimus sp.	-	1	-	-	1	-	2	-	1	-	1
Apioderus caelatus (Gravenhorst)	-	-	-	-	-	-	-	1	-	-	-
Platystethus capito or *nodifrons*	-	-	-	-	1	-	-	-	-	-	-
Anotylus sp.	-	-	-	-	-	-	-	1	-	-	-
Stenus spp.	-	8	1	4	3	1	1	1	1	1	1
Paederus sp.	-	-	-	-	2	1	-	-	-	-	-
Lathrobium sp.	-	2	2	1	1	-	-	-	-	-	-
Ochthephilum fracticorne (Paykull)	-	-	-	-	-	-	1	-	-	-	-
Paederinae spp.	-	2	-	-	-	-	-	1	-	-	-
Erichsonius cinerascens (Gravenhorst)	1	1	-	1	2	1	-	-	-	-	-
Philonthus sp.	-	-	-	-	-	-	1	-	-	-	-
Staphylinus ?caesareus Cederhjelm	-	-	-	-	-	-	-	1	-	-	-
Quedius sp.	-	-	-	-	-	-	-	1	-	-	-

Context	67	71	171	172	173	174	175	176	176	176	176
Sample	311/T	310/T2	309/T	308/T2	307/T	306/T	305/T	304/T2	303/T	302/T2	301/T
Acylophorus glaberrimus von Nordmann	-	-	-	-	-	2	-	-	-	-	-
Staphylininae spp.	-	2	-	-	2	1	1	1	2	-	-
Aleocharinae spp.	2	9	4	10	18	7	2	4	3	3	2
Amauronyx maerkeli (Aubé)	-	4	1	1	5	1	1	-	-	-	1
Pselaphus heisei (Herbst)	-	1	-	-	-	-	-	-	-	-	-
Pselaphidae spp.	2	3	-	1	2	-	-	-	-	1	-
Aphodius spp.	-	-	-	-	-	-	1	3	1	-	1
Cyphon padi (Linnaeus)	-	-	22	23	28	13	-	13	5	1	2
Cyphon spp.	4	30	5	14	19	8	2	12	-	3	1
Dryops sp.	-	1	1	1	1	-	-	-	-	1	-
Elmis aenea (Müller)	-	-	-	-	1	-	-	7	5	5	2
Esolus parallelepipedus (Müller)	-	-	-	-	-	-	1	6	3	4	1
Limnius volkmari (Panzer)	-	-	-	-	-	-	-	3	9	11	3
Normandia or *Riolus* sp.	-	-	-	-	-	-	-	-	-	-	1
Oulimnius sp.	-	-	-	-	-	-	-	3	4	4	1
Melanotus sp.	-	-	-	-	-	-	-	-	1	-	-
Elateridae spp.	-	3	-	-	-	-	-	1	-	-	1
Elateridae sp. (larval apices)	-	2	-	-	-	-	-	-	-	-	-
Cantharidae spp.	-	-	-	-	-	-	1	4	2	4	1
Grynobius planus (Fabricius)	1	-	-	-	-	1	1	-	-	-	-
Cerylon fagi Brisout	-	-	-	-	-	-	-	-	1	1	1
Corticariinae spp.	-	1	-	-	1	-	-	2	1	-	-
?Corylophidae sp.	1	10	-	3	-	-	-	-	-	-	-
Rhinosimus sp.	-	-	-	-	-	-	1	-	-	-	-
Plateumaris sp.	-	-	-	-	-	-	-	2	-	1	-
Donacia sp.	-	-	-	-	-	-	-	1	-	1	-
Donaciinae sp.	-	-	-	1	-	-	1	-	1	-	1
Lochmaea sp.	-	-	-	-	-	-	-	-	1	-	1
Altica spp.	-	-	-	-	2	-	-	-	-	-	-
Halticinae spp.	-	-	-	1	-	1	-	-	-	-	-
Chrysomelidae sp.	-	-	-	1	-	-	-	-	-	-	-
Apion spp.	-	-	-	-	-	-	1	2	1	-	1

Context	67	71	171	172	173	174	175	176	176	176	176
Sample	311/T	310/T2	309/T	308/T2	307/T	306/T	305/T	304/T2	303/T	302/T2	301/T
Phyllobius or *Polydrusus* sp.	-	-	-	-	-	-	-	3	1	1	1
Tanysphyrus lemnae (Paykull)	-	-	1	1	-	1	1	1	-	-	-
Ceutorhynchinae sp.	-	-	-	-	-	-	-	1	-	-	-
Limnobaris sp.	-	1	-	-	-	-	-	-	-	-	-
Curculionidae spp.	4	17	3	3	2	-	1	1	-	2	2
Scolytidae sp.	-	-	-	-	-	-	-	1	-	-	-
Coleoptera spp.	2	2	-	3	2	2	1	-	5	6	-
Insecta spp. (larva)	-	++	-	++	+	++	++	-	+	-	-
Acarina spp.	+	++	++	++	++	++	-	+	-	-	++
Araneae spp.	-	-	-	-	+	+	-	-	-	-	-
Valvata cristata Müller								++	++	++	++
?planorbid sp. indet.											+
Pisidium sp.										+	
Mollusca spp.								++	++	++	++

Table 5. Complete list of invertebrate remains from the column samples of Section 18. Nomenclature and taxonomic order for beetles and bugs follows Kloet and Hincks (1964-77). Snails follow Kerney (1999). Figures are minimum numbers of individuals represented. The abundance of other orders has been recorded semi-quantitatively on a three-point scale as follows: '+ ' = present, i.e. one or relatively few remains or less than 10% by volume; '++' = common, or about 10-50% by volume; '+++' = abundant, or more than 50% by volume.

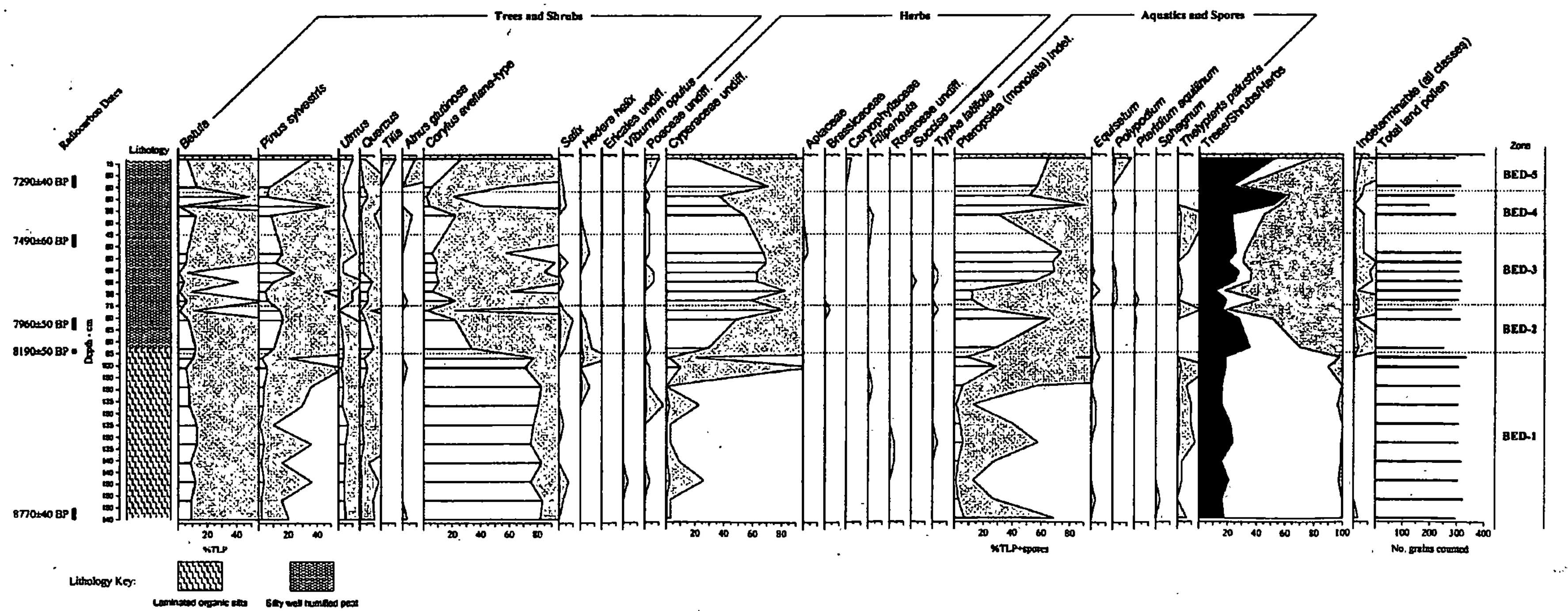
Trees and Shrubs
Herbs
Aquatics and Spores
Radiocarbon Dates
Lithology
Betula
Pinus sylvestris
Ulmus
Quercus
Tilia
Alnus glutinosa
Corylus avellana-type
Salix
Hedera helix
Ericales undiff.
Viburnum opulus
Poaceae undiff.
Cyperaceae undiff.
Apiaceae
Brassicaceae
Caryophyllaceae
Filipendula
Rosaceae undiff.
Succisa
Typha latifolia
Pteropsida (monolete) indet.
Equisetum
Polypodium
Pteridium aquilinum
Sphagnum
Thelypteris palustris
Trees/Shrubs/Herbs
Indeterminable (all classes)
Total land pollen
Zone
BED-5
BED-4
BED-3
BED-2
BED-1
7290±40 BP
7490±60 BP
7960±50 BP
8190±50 BP
8770±40 BP
Depth - cm
%TLP
%TLP+spores
No. grains counted
Lithology Key:
Laminated organic silts
Silty well humified peat

Figure 11.