SCA15 was highly variable The large numbers of corroded grains in the samples suggest that conditions were not always ideal for preservation, and this is particularly true in the upper 50mm of fill *14885* (0 16-0 245m), in much of fill *14884* (0 10-0 16m), and in the lower sample taken at a depth of 0 30m Very abundant microscopic charcoal particles concealed many of the pollen grains in the samples taken at depths of 0 27m and 0 06m It was felt that the five countable samples from the ditch did, however, provide enough data with which to construct an interpretable pollen diagram (Fig 69) Due to the limited number of samples, no pollen assemblage zones were defined

6 3 18 Values of arboreal pollen at the very base of the diagram represent *c* 50% TLP, and, following a peak at 0 27m, these decline very gradually thereafter This pattern is more or less determined by the curve of the most dominant tree, alder, although hazel is also fairly well represented and shows a steady decline Other arboreal taxa, as more than rare types, include heather, which also peaks very slightly at 0 27m, and oak Occasional grains of willow (*Salix*) were recorded, and one or two grains of field maple (*Acer campestre*) and Scots pine (*Pinus sylvestris*) were evident in the lowermost sample

6 3 19 The herbaceous assemblage from the ditch remains more or less constant at *c* 40% TLP, apart from a decline in values at 0 27m, attributed mainly to a significant decline in grass, and a corresponding rise in arboreal pollen The range of taxa is very similar to the herbaceous assemblage recorded in the Scots Dyke ditch, and, alongside the dominant grass pollen, there is a range of taxa typical of meadows/pastures and/or disturbed ground The much lower values of ribwort plantain are noticeable in this ditch when compared with the very high values in the Scots Dyke ditch Very occasional grains of oat/wheat pollen are restricted to the lowermost three samples, which may suggest cereal cultivation/usage at the settlement during the earliest stages of the filling of the ditch

6 3 20 Herbaceous taxa recorded in this ditch, which were not present in the Scots Dyke, include *cf* marsh gentian (*Gentiana pneumonanthe*), crane's-bill (*Geranium*), *cf* lousewort (*Pedicularis*) and woundwort-type (*Stachys sylvatica*-type), which includes woundwort, betony, black horehound, dead-nettle, and hemp nettle Geranium and woundwort-type pollen grains are difficult to identify to species level and the habitat range is quite varied across several species It may be significant, however, that marsh gentian and lousewort, which were both recorded in the sample taken at 0 27m, grow on wet heaths or bogs (Stace 1997, 524, 626)

6 3 21 The summary diagram (Fig 69) shows a slight increase in fern spores in the upper part of the profile, which is inverse to the arboreal component of the diagram The ferns, which include undifferentiated monolete and trilete spores, royal fern, and polypody, may have been growing in the ditch itself, which may suggest that the ditch was allowed to become vegetated at times, especially towards its final stages of filling This fact alone may explain the perceived decline in arboreal pollen, the increase in fern cover perhaps causing less arboreal pollen to be received at the sampling site

6 3 22 *Interpretation* the pollen evidence from the ditch is consistent with that from the Scots Dyke and indicates a relatively open pastoral landscape, with areas of alder and hazel scrub/woodland Slightly higher arboreal pollen at this site may indicate that this slightly lower-lying area was more wooded

6 3 23 The only noticeable change in the pollen data is the slight peak in arboreal pollen and corresponding decline in grass pollen, at 0 27m, from fill *14886* This fill has been interpreted as a possible dumped deposit (*Section 3 3 46*), whilst micromorphological analysis (*Section 6 2*) also indicates that *14886* was an anthropogenic humic fill consisting of fuel ash from both wood and peaty turf Although the latter component may explain (and corroborate?) the presence of marsh gentian and lousewort, and the slight increase in heather, in this sample, which may have arrived at the site on peat turves, the increase in alder and hazel, and the corresponding fall in grass pollen, is harder to explain The charcoal from this feature (*Section 6 5 12*) was dominated by ash and oak, which are both poorly represented in the pollen diagram (which is interesting in itself, although ash is known for its poor pollen production) The only possible explanation could be that the material dumped into the ditch was itself covered with pollen from the surrounding alder and hazel woodland

6 3 24 Analysis of the charred plant remains (*Section 6 4 8*) suggests that at least some of the material making up fill *14886* consisted of cereal-processing waste Whilst this does suggest that cereals were being used at the site, it does not necessarily imply local cultivation Similarly, the presence of cereal pollen in the lower fills is not direct evidence for its cultivation at the site, as a source from harvested cereals cannot be ruled out (Robinson and Hubbard 1977)

6 3 25 ***Discussion*** the pollen evidence from both the Scots Dyke ditch (SCA10 *12035*) and ditch *14683* at SCA15 indicates an Iron Age landscape of open grassland/pasture with alder and hazel scrub/woodland The heathland component is generally less marked in the settlement ditch, although the most significant difference between the two assemblages is the much lower values of ribwort plantain pollen in the settlement ditch (*14683*) Ribwort plantain is one of the key indicators of grazing livestock, so perhaps the difference may be explained by the proximity and intensity of the grazing, the SCA15 settlement perhaps being more far removed from areas of intense grazing than the Scots Dyke ditch

6 3 26 The scarcity of typical hedgerow taxa at both sites is interesting, especially given the evidence for possible livestock rearing Occasional rosaceous pollen grains, which include hawthorn, blackthorn, wild cherry and crab apple, were recorded in the sediments at the Scots Dyke (Fig 68), and a single grain of field maple, which is also common at woodland margins or in hedgerows (Stace 1997, 470), was recorded in the settlement ditch The quantities, however, do not provide evidence for a managed landscape It is possible that other forms of livestock control existed that are no longer visible, or that livestock, away from the settlement at least, was allowed to roam relatively freely in the way that they do in upland areas today Indeed, it is also possible that livestock control and/or land division was maintained by the construction of major field boundaries, such as large ditches (Coggins 1985, 1986), much like the Scots Dyke itself

6 3 27 ***Conclusion*** the pollen evidence is consistent with other sites in the north-east of England, which demonstrate the most extensive clearance phases in the immediate pre-Roman period (Coggins 1985, 1986) Evidence from sites in Upper Teesdale (*ibid*) and on Bowes Moor (Vyner 2001a), which are on land above 300m, show that, by the end of the first millennium BC, both were deforested At Simy Folds, in Upper Teesdale, large-scale clearance was accompanied by a dramatic rise in grass, sedge, heather and associated herbs Though cereal pollen was recorded at sites there as late as the medieval period, both Coggins (1985, 1986) and Vyner (2001a) maintain that the areas would have been used primarily for animal husbandry during the Iron Age Like in the assemblage from the Scots Dyke ditch, plantain had become a very dominant component of the local flora at many of the sites This evidence is set against a backdrop of climatic deterioration and soil degradation, following what appears to have been a 'high' of the Bronze Age mixed farming economy (Coggins 1985, 1986, Vyner 2001a)

6 3 28 The abundant alder pollen in both the Scots Dyke and SCA15 ditches suggests that local conditions were relatively damp, or that much of the surrounding landscape contained watercourses or ponds It is possible that a mixed farming economy was operating, and evidence for cereal processing was certainly evident at SCA15 (***Section 6 4 8***), although this may have taken the form of subsistence farming, rather than large-scale production The effect the Roman occupation had on the existing economy is difficult to ascertain, especially given the extra demand the '***oppidum***' at Stanwick is likely to have placed on local production (Coggins 1986) The evidence from the Scots Dyke ditch, however, suggests that very little change occurred in the area at least until the early medieval period, and that the main land use was pastoral It is possible that the more intensive cereal cultivation was taking place elsewhere, away from the damp/flood-prone conditions the pollen evidence seems to indicate

6.4 THE CHARRED PLANT REMAINS

6 4 1 Of the 115 bulk soil samples that were assessed for charred plant remains (OA North 2008), 22 were selected for full analysis These came from three sites, SCA8 (Rock Castle), SCA13, and SCA15, the majority (19) being from the latter The bulk of the SCA15 samples came from ditch fills, as did all three samples from SCA8 (two samples) and SCA13 (one sample), but the fills of a roundhouse ring-gully, two postholes, three pits, and an oven/hearth from SCA15 were also analysed

6 4 2 ***Methodology*** between 10 litres and 40 litres of each sample was processed by either hand flotation or using a modified Siraf-type flotation machine The resulting flots were collected onto a 250µm mesh, air-dried, and examined with a Leica MZ6 binocular microscope The charred material was extracted and identified where possible, and waterlogged seeds and other material were recorded Charred plant remains were counted, since there is a statistical relationship between the various types of remains, such as cereals, chaff, and weed seeds, which can assist in the interpretation of which crop husbandry stages may be represented Identification was aided by comparison with the modern reference collection held at OA North, and with reference to the

Digital Seed Atlas of the Netherlands (Cappers *et al* 2006) Nomenclature follows Stace (1997) In the following, the charred plant remains are given as actual counts, other remains, such as other vegetative material, charcoal, and bone, are quantified on a scale of 1 to 5, where 1 = less than five items and 5 = more than 100 items A number of the samples contained seeds that were uncharred, although most of these were considered to be modern contaminants

6 4 3 The cereal remains and cereal chaff are listed separately, and the weed seed taxa are grouped according to habitat types that broadly correspond to defined ecological groups (after Druce *et al* in prep, following Huntley and Hillam 2000, Huckerby and Graham 2009), though it is acknowledged that many taxa may grow in more than one habitat

1 Ruderals and weeds of arable and cultivated land These include ruderal plant communities found growing on waste or fallow ground and annuals found in arable fields and cultivated ground Ruderal plants are usually perennials or biennials and inhibit the growth of annuals,

2 Grassland plants, to be found growing in open grassland or meadows,

3 Wet ground and aquatic plants, found on wet marshy ground, water meadows, on the banks of rivers, ditches and ponds, and in water meadows,

4 Heath/bog plants, which grow on areas of heath or bog, often in acidic conditions,

5 Woodland/scrub plants, comprising trees and shrubs, and ground flora common in woodland clearances and hedgerows,

6 Plants belonging to broad ecological groupings, which are not characteristic of any one community, but are found in several

6 4 4 ***Results SCA8*** both of the deposits analysed from SCA8 (Table 18) were ditch fills (*11190*, a fill of ditch *11117* (*Section 2 3 12*), and *11235*, a fill of ditch *11124* (*Section 2 3 8*)), and both contained some charred cereal grains and charred weed seeds The most abundant cereal grains came from *11190*, which contained 13 barley (*Hordeum vulgare*) grains and 18 wheat (*Triticum* spp) grains, one of the latter provided a radiocarbon date of 160 cal BC-cal AD 60 (2025±30 BP, SUERC-27048, *Section 7 1*) One of the wheat grains was short and plump, characteristic of bread wheat (*Triticum aestivum*), and one had a very pronounced dorsal ridge, a feature associated with emmer wheat (*Triticum dicoccum*) Twenty-four cereal grains were too distorted through the effects of burning to be identified positively Very little chaff was present in the sample, being represented by just two indeterminate glume-base fragments

	Site	SCA8	SCA8	SCA13	SCA15	SCA15	SCA15	SCA15
	Context No	*11190*	*11235*	*13052*	*14043*	*14175*	*14205*	*14886*
	Feature/ Group No	*11117*	*11124*	*13077*	*14016*	*14006*	*14012*	*14683*
	Feature type	Ditch	Ditch	Ditch	Ditch	Ditch	Ditch	Ditch
	Sample No	37	41	62	74	158	171	297
	Sample Size (l)	30	10	20	30	40	40	20
	Items per litre	2	2	4	7	16	2	19
Cereal Grains								
Avena sp	cultivated/ wild oat			3	2	8	1	
cf *Avena* sp						16		
Hordeum vulgare	barley	13				2		
cf *Hordeum vulgare*					3	1		
Triticum spp	wheat	16	2	3	12	19	10	12
Triticum cf *aestivum*	*cf* bread wheat	1		1	48	2		4
Triticum cf *dicoccum*	*cf* emmer wheat	1		1				
Indeterminate charred cereals		24		4	24	156	11	91
Indeterminate charred cereal fragments			2	1	15			
Total cereal grains		*55*	*4*	*13*	*104*	*204*	*22*	*107*
Cereal Chaff								
Triticum spelta glume bases	spelt wheat					148		11
cf *Triticum spelta* glume bases			1			39		
Triticum spelta spikelet forks			1					6
Triticum spp glume bases	glume wheat			1		34		1
Triticum spp basal rachis nodes	wheat							2
Triticum spp basal rachis internodes								1
Hordeum vulgare rachis nodes	barley			1		1		
Culm nodes						1		
Total cereal chaff		*0*	*2*	*2*	*0*	*223*	*0*	*21*
Unquantifiable glume base fragments		2	21	3		215	14	4
Coleoptiles			4					
Weed Seeds								
Ruderals and arable/cultivated land								
Brassica sp	mustards/ cabbages	2						
Chenopodium album	fat-hen			1	3			

Persicaria lapathifolia	pale persicaria			1		2	3	
Polygonum aviculare	knotgrass	1		5	4			7
Stellaria media	common chickweed			5	16		2	
Tripleurospermum inodorum	scentless mayweed				1		2	12
Grassland								
Plantago media	hoary plantain		1			1		
Plantago sp	plantain				6	1	4	19
Poaceae seeds >4mm	grass family		1	1		58		
Poaceae seeds 2-4mm	grass family	1	1	6	8	26	5	65
Poaceae seeds <2mm	grass family			16	7	6		
Rumex acetosa	common sorrel							2
Rumex acetosella	sheep's sorrel	2	1	1	4	5	1	39
Stellaria graminea	lesser stitchwort		1		3			
Damp/wet places								
Carex lenticular	sedges, two-sided			2		1		
Carex trigonous	sedges, three-sided	3	4	2	34	4	3	36
Eleocharis sp	spike-rushes			2		1		1
Juncus spp	common rush						1	5
Montia sp	blinks					1	2	4
Heaths/bogs								
Danthonia decumbens	heath-grass				5	1		18
cf. *Pedicularis sylvatica*	*cf* lousewort				3			
Potentilla erecta-type	tormentil			3	3			
Hedgerows/wood clearings								
Lapsana ssp *communis*	nipplewort				1			
Luzula sp	wood-rushes		1					
Broad Ecological Grouping								
Bromus sp	bromes	4	1	3		104	14	12
Fabaceae seeds <4mm	pea family		1	4		1	1	3
Galium sp	bedstraws		2				2	1
Silene sp	campions							7
Viola	violets				1			
Indeterminate charred weed seeds				6	14		1	29
Total weed seeds		***13***	***14***	***58***	***113***	***212***	***41***	***260***
Other Charred Plant Remains								
Buds					9			21
Corylus avellana fragment	hazelnut shell	1	1					1
cf. *Geranium* sp fruit capsule	crane's-bills				1			
Pre-quaternary spore					1			

Poaceae stem fragments	grass family		2					6
Arrhenatherum elatius var *bulbosum* tuber	onion couch grass				2			
Indeterminate rhizome/tuber fragments					15	4		13
Unknown plant remains					4			5
Indeterminate charred remains						1		

Table 18 Charred plant remains from SCA8 SCA13 and ditches at SCA15 (see also Table 19), given as actual counts. Counts are of seeds unless stated otherwise

6.4.5 Deposit *11235* contained two wheat (*Triticum* spp) caryopses, and although much of the cereal chaff consisted of indeterminate glume-base fragments, one glume base, radiocarbon-dated to 370-170 cal BC (2185±30 BP, SUERC-27049, *Section 7.1*), and one spikelet fork were positively identified as spelt wheat (*Triticum spelta*). The presence of four coleoptiles suggests that some of the cereal grains had sprouted. Both samples contained a number of charred weed seeds, including grassland taxa, hoary plantain (*Plantago media*), sheep's sorrel (*Rumex acetosella*), also found on open heathy ground and cultivated ground (Stace 1997), and lesser stitchwort (*Stellaria graminea*). Nutlets of the damp/wet ground indicator, sedge (*Carex* sp), were also present in both samples, and *11235* contained wood-rushes (*Luzula* sp), which indicates the presence of hedgerows/open woodland or heathland. Both samples contained abundant charcoal fragments, and *11190* also contained abundant heat-affected vesicular material (havm).

6.4.6 *SCA13*: the single sample analysed from SCA13 (Table 18) came from fill *13052* of ditch *13077*, which contained a variety of charred cereals, including three cultivated/wild oat (*Avena* sp) and five wheat (*Triticum* spp) grains. One of the charred cereal grains from this feature provided a radiocarbon date of 730-390 cal BC (2395±30 BP, SUERC 26251, *Section 7.1*). One of the wheat grains was short and plump, characteristic of bread wheat (*Triticum aestivum*), and one had the very high dorsal ridge characteristic of emmer wheat (*Triticum dicoccum*). Some chaff remains were present, including one *Triticum* spp glume base, three indeterminate glume-base fragments, and one barley (*Hordeum*) rachis node. Charred weed seeds were abundant and included bromes (*Bromus* sp), three-sided sedges (*Carex* trigonous), Fabaceae with seeds less than 4mm (pea family), grasses (Poaceae), knotgrass (*Polygonum aviculare*) and common chickweed (*Stellaria media*). The matrix consisted of abundant charcoal, with moderate amounts of heat-affected vesicular material (havm) and a few fragments of calcined bone.

6.4.7 *SCA15*: at SCA15, radiocarbon dates were obtained from charred plant remains recovered from two ditches (*Section 7.1*). In ditch *14683*, plant fragments from the base and top of fill *14886* yielded dates of 200 cal BC-cal AD 1 (2080±35 BP, SUERC-26438) and 50 cal BC-cal AD 120 (1975±35 BP, SUERC-26439) respectively, whilst a wheat grain from fill *14663* of ditch

14680 (Table 19) yielded a date of 110 cal BC-cal AD 60 (2020±30 BP, SUERC-27898)

6 4 8 All 11 ditch fills (Tables 18 and 19) were found to contain cereal grains In addition, eight contained frequent to abundant cereal chaff A range of cereal types is present, including oats (*Avena* sp), barley (*Hordeum vulgare*), wheat (*Triticum* spp), including spelt wheat with the spikelet fork attached (*T. spelta*) and bread wheat (*T. aestivum*) The chaff consisted primarily of *Triticum* spp/*T. spelta* spikelet forks/glume bases A few wheat (*Triticum* spp) basal rachis/internodes were also observed in *14886* (ditch *14683*), *14665* (ditch *14679*), and *14944* (ditch *14946*, Table 19) One or two barley (*Hordeum vulgare*) rachis nodes/internodes were recovered from five of the samples, and fill *14944* contained very abundant barley rachis, producing 51 nodes and 38 internodes This fill contained the most abundant cereal chaff, with over 500 items

	Site	SCA15	SCA15	SCA15	SCA15	SCA15	SCA15	SCA15
	Context No	*14781*	*14783*	*14806*	*14912*	*14663*	*14665*	*14944*
	Feature/Group No	*14017*	*14017*	*14683*	*14943*	*14680*	*14679*	*14946*
	Feature Type	Ditch	Ditch	Ditch	Ditch	Ditch	Ditch	Ditch
	Sample No	311	312	316	322	324	325	326
	Sample Size (l)	30	30	20	20	30	20	30
	Items per litre	7	7	5	4	3	4	46
Cereal Grains								
Triticum sp	wheat	37 (two sprouted)		7	5 (one sprouted)	2	5 (two sprouted)	43 (seven sprouted)
Triticum cf *aestivum*	*cf* bread wheat	2		4				
Triticum spelta	spelt wheat	1						
Hordeum vulgare	barley undifferentiated	9			2	3	3 (two twisted)	20 (three sprouted)
	hulled barley	1					1	5 (one sprouted)
Indeterminate charred cereals		58	12	8	4	5	2	15
Total cereal grains		*107*	*12*	*19*	*11*	*10*	*11*	*83*
Cereal Chaff								
Triticum spelta spikelet fork	spelt wheat	3	2	1				13
Triticum spelta glume bases		25	128	18	13	4	10	290
Triticum spp spikelet fork bases	glume wheat	1	7	2	3	1		14
Triticum spp glume bases		12	12	5	1	1	1	122
Triticum spp basal rachis nodes	wheat						1	27
Triticum spp basal rachis internode							1	18
Hordeum vulgare rachis nodes	barley	1	1		1			51
Hordeum vulgare rachis internodes		1	1		1		1	38

Indeterminate rachis nodes				2				6
Indeterminate rachis intemodes								17
Culm nodes		4						
Total cereal chaff		***47***	***151***	***28***	***19***	***6***	***14***	***596***
Unquantifiable glume base fragments			13	3	5			10
Weed Seeds								
Ruderals and arable/cultivated land								
Chenopodium album	fat-hen	1						
Galeopsis tetrahit	common hemp-nettle	1						
Hyoscyamus niger	henbane						1	
Polygonum aviculare	knotgrass	2						
Persicaria lapathlfolia	pale persicaria	2	3					
Persicaria maculosa	redshank	12						1
Tripleurospermum inodorum	scentless mayweed							2
Grassland								
Plantago sp	plantam	3				10	3	
Poaceae seeds >4mm	grass fanuly		16	26	12		20	593
Poaceae seeds 2-4mm	grass family	1			6	8	6	9
Poaceae seeds <2mm	grass family	4		4	4	1	6	1
Rumex acetosa	common sorrel					3		
Rumex acetosella	sheep's sorrel	2	I	7			1	13
Damp/wet'places								
Carex lenticular	sedges, two-sided					3		
Carex trigonous	sedges, three-sided	4			2	27	2	31
Juncus spp	common msh					2	1	13
Montia sp	blinks							1
Heaths/bogs								
Danthonia decumbens	heath-grass	2			1	13	5	17
Broad ecological grouping								
Bromus sp	Bromes	25	15	16	7	4	8	22
Fabaceae seeds <4mm	pea family	1			1		2	1
Galium sp	Bedstraws	1						
Polygonum undifferentiated	Knotgrasses	3						
Silene sp	Campions						1	
Indetermmate charred weed seeds		6	5	1		3	1	
Unknown charred weed seeds			1			2		
Total weed seeds		***70***	***43***	57	***41***	***76***	57	***714***
Other Charred Plant Remains								
Buds				1		5		
Arrhenatherum elatius var *bulbosum* tuber	onion couch grass	1						

Rhızome/tuber fragments		4				7		
Poaceae spıkelet	Grass							1
Unknown plant remaıns		1				9		

Table 19 Charred plant remaıns from SCA15 dıtches (see also Table 18) gıven as actual counts Counts are of seeds unless stated otherwıse

6 4 9 The dıtch samples contamed varymg amounts of weed seeds, rangmg from 41 m dıtch fills *14205* (dıtch *14012*, Table 18) and *14912* (dıtch *14943*, Table 19), to 714 m fill *14944* Although the seeds of many typıcal crop weeds, such as common chıckweed (*Stellarıa medıa*), scentless mayweed (*Trıpleurospermum ınodorum*), and redshank (*Persıcarıa maculosa*), were present, the samples also contamed a hıgh proportıon of grassland taxa such as grass famıly (Poaceae) and plantams (*Plantago* sp), and taxa of damp/wet ground It ıs therefore possıble that tall grasses grew amongst the crops alongsıde the other crop weeds Sımılarly, grasses, sedges and rushes may have been growmg at the margms of the fields and were subsequently harvested wıth the crop, or these may have arrıved ın the features along wıth functıonal materıal, such as roofing or beddmg

6 4 10 A number of the dıtch samples contamed heath-grass (*Danthonıa decumbens*) seeds, whıch, along wıth sedges (*Carex* sp), blınks (*Montıa* sp), and sheep's sorrel (*Rumex acetosella*), ıs classıfied as a key mdıcator specıes for heathland, and also for the presence of turf (Hall 2003, Hall and Huntley 2007) In addıtıon, fill *14043* (dıtch *14016*, Table 18) contamed other heathland mdıcators, such as lousewort (*Pedıcularıs sylvatıca*) and tormentıl (*Potentılla erecta*-type) seeds, and charred heather (*Calluna vulgarıs*) roundwood The presence of charred rhızome/tuber fragments, mcludmg onıon couch grass (*Arrhenatherum elatıus* var *bulbosum*), m many of the dıtch samples may also mdıcate turf Interestmgly, the pollen analysed from dıtch *14683* (*Sectıon 6 3 20*), whıch contamed fill *14886*, also mcluded pollen from the heath/bog mdıcators lousewort (*Pedıcularıs sylvatıca*) and marsh gentıan (*Gentıanana pneumonanthe*) In addıtıon, soıl mıcromorphology (*Sectıon 6 2 28*) suggests that thıs deposıt was an anthropogenıc fill, consıstmg of fuel ash from both wood and peaty turf, provıdıng further evıdence that at least some of the dıtch assemblages mcluded possıble turf materıal cut from heath/moorland or blanket peat Overall, the charred plant remams from the SCA15 dıtches are lıkely to represent settlement debrıs generated by a range of actıvıtıes, mcludmg crop processmg, the provısıon of roofing and/or beddmg materıals, and the firıng of domestıc hearths

6 4 11 A smgle fill of a rmg gully (*14258*, m gully *14398* of roundhouse *14000*) was analysed (Table 20) and found to contam a few cereal remams, comprısmg sıx mdetermmate grams, one glume-base fragment and one culm node Charred weed seeds, mcludıng heath-grass (*Danthonıa decumbens*) and sheep's sorrel (*Rumex acetosella*), both common heathland taxa, dommated the weed seed assemblage As wıth the materıal m the dıtch assemblages, these may have derıved from turves, whıch may have been used as roofing materıal or fuel (Hall 2003, Hall and Huntley 2007)

	Site code	SCA15	SCA15	SCA15	SCA15	SCA15	SCA15	SCA15	SCA15
	Context No	*14258*	*14266*	*14851*	*14420*	*14447*	*14457*	*14964*	*14959*
	Feature/Group No	*14398*	*14267*	*14852*	*14024*	*14024*	*14024*	*14983*	*14983*
	Feature Type	Ring gully (roundhouse *14000*)	Posthole (roundhouse *14000*)	Posthole	Pit-group	Pit-group	Pit-group	Hearth/ kiln	Hearth/ kiln
	Sample No	176	268	320	269	273	275	328	329
	Sample Size (l)	30	20	10	10	20	30	20	20
	Items per litre	1	92	8	25	59	3	4	6
Cereal Grains									
cf *Avena* sp	cultivated/wild oat		*c* 700						
Triticum sp	wheat		94	5 (two sprouted)	40		5	1	3
Triticum cf *aestivum*	*cf* bread wheat		75			8			3
Hordeum vulgare	barley							3	3
Indeterminate charred cereals		6	19	2	148	127	46	18	18
Total cereal grains		*6*	*c 888*	*7*	*188*	*155*	*51*	*22*	*25*
Cereal Chaff									
Triticum spelta spikelet fork	spelt wheat			3	1	17			1
Triticum spelta glume bases				34	2	254	6	1	10
Triticum dicoccum glume bases	emmer wheat					1			
Triticum spp spikelet forks	glume wheat			1		4		1	7
Triticum spp glume bases					3	3		1	10
Triticum spp basal rachis nodes	wheat		2	2	10	14		2	6
Triticum spp basal rachis internode				2		10		3	3
Hordeum vulgare rachis nodes	barley		2		4	13			1
Hordeum vulgare rachis internodes					5	1			2
Indeterminate rachis nodes					3				
Indeterminate rachis internodes					4	8			1
Culm nodes		1	22			4			
Total cereal chaff		*1*	*26*	*42*	*32*	*329*	*6*	*8*	*41*
Unquantifiable glume base fragments		1	107		5	57			

Weed Seeds									
Ruderals and arable/cultivated land									
Anthemis cotula	stinking chamomile					1			
Chenopodium album	fat-hen	1							3
Fallopia convolvulus	black-bindweed					1			
Galeopsis tetrahit	common hemp-nettle	1							
Hyoscyamus niger	henbane					4			
Polygonum aviculare	knotgrass					3			
Persicaria lapathifolia	pale persicaria			1	3				
Persicaria maculosa	redshank		2			2			
Ranunculus sardous	hairy buttercup		2				1		
Spergula arvensis	com spurrey						1		
Stellaria media	common stitchwort								
Tripleurospermum inodorum	scentless mayweed		6		3	4		2	
Grassland									
Plantago sp	plantain		2		1	3	3	1	1
Poaceae seeds >4mm	grass family		*c* 770	18		597			21
Poaceae seeds 2-4mm	grass family	3	8		6	7	3	14	2
Poaceae seeds <2mm	grass family								8
Rumex acetosa	common sorrel	1	1						
Rumex acetosella	sheep's sorrel	8	15	2	6	17	3		1
Stellaria graminea	lesser stitchwort					4			
Damp/wet places									
Carex lenticular	sedges, two-sided				1			1	1
Carex trigonous	sedges, three-sided				6	17	3	16	1
Juncus spp	common rush					1			
Montia sp	blinks				2	5			
Heaths/bogs									
Calluna vulgaris	heather					10			
Danthonia decumbens	heath-grass	16			2	15		10	
Broad Ecological Grouping									
Bromus sp	bromes		139	12	6	9	7	4	11
Fabaceae <4mm	pea family	2	15		1	1			2
Galium sp	bedstraws	2	3			1			
Hypericum sp	St John's worts					4			
Lithospermum sp	gromwells					1			

Silene sp	campions			1		1		4	
Indeterminate charred weed seeds						16	5	7	5
Total weed seeds		*33*	c *963*	*34*	*37*	*724*	*25*	*57*	*56*
Other Charred Plant Remains									
Arrhenatherum elatius var *bulbosum*	onion couch grass		2						
Buds					5			1	
Corylus avellana fragment	hazelnut					1			
Rhizome/tuber fragments					4	16	4	7	3
Unknown plant remains					1	1	1	10	5
Indeterminate charred material						2			

Table 20 Charred plant remains from contexts other than ditches at SCA15, given as actual counts Counts are of seeds unless stated otherwise

6 4 12 The two posthole fills analysed (Table 20) contained very different assemblages Fill *14266* of posthole *14267*, which was within roundhouse *14000* (*Section 3 3 18*), contained abundant cereal grains dominated by oats (cf *Avena* sp) and wheat (*Triticum* sp), including 75 bread wheat (*Triticum* cf *aestivum*) grains There was very little identifiable chaff, though 107 indeterminate glume-base fragments were recorded Large grass seeds (Poaceae >4mm in size) were also very abundant, which were probably poorly preserved oats (*Avena* sp), but which were too distorted to identify with confidence Although it is possible that a cultivated variety of oat was being utilised (*Avena sativa*), the lack of any diagnostic floret bases means that this cannot be proven

6 4 13 Other weed seeds include abundant bromes (*Bromus* sp), pea family (Fabaceae seeds less than 4mm in size), sheep's sorrel (*Rumex acetosella*) and scentless mayweed (*Tripleurospermum inodorum*) Given the very abundant oat (*Avena* sp) grains and large grasses, it is possible that the assemblage represents the remains of a crop prepared for human consumption, or a possible fodder crop The processing of oats would have varied slightly from that of wheat, and the abundant wheat grains and glume fragments suggests that the assemblage may represent the waste from more than one activity or burning event Fill *14851*, of a posthole (*14852*) situated in the southern part of Enclosure 7, south of roundhouse *14021* (*Sections 3 3 29-31*), contained much fewer cereal grains and weed seeds, but more diagnostic cereal chaff fragments, of mainly spelt wheat (*Triticum spelta*) glume bases

6 4 14 Three fills (*14420*, *14447*, *14457*) within pit-group *14024*, which was located east of roundhouse *14021* in Enclosure 7 (*Section 3 3 36*), were analysed for charred plant remains (Table 20) All three contained wheat (*Triticum* sp) cereal grains, though most were too distorted to identify with certainty Cereal chaff was recorded in all three deposits, but was particularly abundant in *14447*, where the assemblage was dominated by spelt wheat (*Triticum spelta*)

glume bases, *14447* and *14420* also contaıned barley (*Hordeum vulgare*) rachıs nodes/ıntemodes In addıtıon, *14447* contaıned a sıngle eınmer wheat (*Trıtıcum dıcoccum*) glume base, whıch suggests eıther that emmer wheat was stıll ın cultıvatıon or that ıt was growıng as a casual specıes amongst the ınaın crop of spelt wheat (*Trıtıcum spelta*)

6 4 15 The relatıve abundance of chaff to weed seeds was broadly sımılar ın the three samples, wıth *14447* contaınıng the most abundant and dıverse weed seed assemblage Thıs contaıned a range of weeds assocıated wıth arable/cultıvated ground, ıncludıng stınkıng chamomıle (*Anthemıs cotula*), scentless ınayweed (*Trıpleurospermum ınodorum*), knotgrass (*Polygonum avıculare*) and henbane (*Hyoscyamus nıger*) The sample also contaıned very abundant large wıld grass seeds, whıch may also have been harvested along wıth the crop, or ınay have derıved from some other form of domestıc materıal, such as floorıng/beddıng or anıınal fodder As wıth the materıal ın many of the dıtch samples, the assemblage also contaıned common sedge seeds and blınks (*Montıa* sp) Other ındıcator taxa, such as sheep's sorrel (*Rumex acetosella*), heath-grass (***Danthonıa** decumbens*), and heather (*Calluna vulgarıs*), suggest that at least some of the materıal derıved from heathland, and perhaps orıgınated from functıonal ıtems or turves

6 4 16 The cereal and chaff remaıns assocıated wıth hearth/kıln *14983* (Table 20) are consıstent wıth the other materıal from the sıte, and ındıcate the use of wheat (*Trıtıcum*), ıncludıng spelt (*T. spelta*) and bread wheat (*T. aestıvum*), and barley (*Hordeum vulgare*) Wet ground and heathland taxa are also present, as elsewhere The precıse functıon of feature *14983* ıs not known, however, the scarcıty of charred plant remaıns ın ıts fills suggests that ıt ıs unlıkely to have been used for dryıng com, unless ıt was carefully cleaned before ıt went out of use Charred seeds from fill *14959* provıded a radıocarbon date of 100 cal BC-cal AD 70 (2010±30 BP, SUERC-26259, *Sectıon 7 1*)

6 4 17 ***Dıscussıon*** the number of archaeologıcal sıtes ın north-east England that have yıelded assemblages of charred plant remaıns ıs now quıte large, and thıs ıs especıally tme of sınaller rural settlements dated to the later Iron Age and Roınan perıods ın North Yorkshıre, Co Durham and Cleveland (Hall and Huntley 2007) Compared to many of these sıtes ın the regıon, the charred plant assemblages from the A66 Project are relatıvely rıch Hall and Huntley (*ıbıd*) often refer to sıtes producıng no more than one charred ıtem per lıtre of saınpled materıal The A66 samples produced, at worst, one ıtem per lıtre (fill *14258* of rıng gully *14398* ın roundhouse *14000*), and, at best, 92 ıteıns per lıtre (fill *14266* of posthole *14267*, also assocıated wıth roundhouse *14000*) The SCA15 dıtch fills generally contaıned less materıal than the other features froın thıs sıte, whıch mıght be expected gıven that the dıtches were lıkely to have been utılısed for the casual dumpıng of settlement debrıs One deposıt that stood out as contaınıng more ıtems per lıtre was fill *14944* (of dıtch *14946*), whıch contaıned a number of sprouted cereal graıns Thıs assemblage may represent part of a spoılt harvest that was subsequently bumt It may also be sıgnıficant that thıs dıtch was sıtuated faırly close to hearth/kıbı *14983*, though sımılar materıal was not found ın dırect assocıatıon wıth that feature

6.4.18 The charred plant remains are consistent with the wider evidence from the region, which indicates an Iron Age and Romano-British agricultural regime based, primarily, on the cultivation of spelt wheat with evidence for occasional bread/club wheat, hulled barley (probably six-row) and oats. One or two *cf* emmer wheat grains were recovered from the A66, which again is in keeping with earlier data (van der Veen 1992, Hall and Huntley 2007). Spelt wheat had replaced emmer as the main crop by *c* 300 BC, certainly in the Tees lowlands (*ibid*) and it is possible that emmer may have remained as a casual invader among the main crop. Earlier excavations at Rock Castle, adjacent to SCA8, yielded very little evidence of emmer (one grain and one glume base, which was interpreted as a probable weed growing within the main spelt crop, van der Veen 1994).

6.4.19 Present evidence suggests that free-threshing bread/club wheat was probably introduced into the North East towards the end of the Iron Age (*ibid*). Two samples of bread wheat chaff from a pit at the Rock Castle site provided dates of 170 cal BC-cal AD 220 and 100 cal BC-cal AD 260 (1970±70 BP, OxA-1737 and 1920±70 BP, OxA-2132, van der Veen 1994). A possible bread wheat grain in fill *11190* of ditch *11117* at SCA8 is consistent with this dating, since charred material from this ditch yielded a late Iron Age-early Roman radiocarbon determination (*Section 7.1*). Similarly, the presence of bread wheat in a few samples from SCA15 is consistent with the overall dating for that site, which suggests a *floruit* in the late Iron Age-early Roman period, *c* 100 BC-AD 100. A potentially early example could be provided by the possible bread wheat grain recovered from fill *13052* of ditch *13077* at SCA13, since other charred plant material from this deposit yielded an early-middle Iron Age date (*Section 7.1*). However, another ditch that was seemingly spatially contemporary with *13077* contained Romano-British pottery (Evans 2007), which casts some doubt on the integrity of the dated sample; in any case, there is some morphological overlap between wheat grains, so the identification of the grain in question as bread wheat cannot be regarded as certain. A dated bread wheat grain from a third-century BC context at Thorpe Thewles, near Stockton-on-Tees, provided a medieval radiocarbon date (van der Veen 1992), and was thus clearly intrusive.

6.4.20 Apart from a slight increase in the use of bread wheat towards the end of the Iron Age (van der Veen 1994), there appears to be no major difference in terms of the crops being cultivated during the Iron Age and Roman periods in the North East. Some sites, such as the military establishment at Catterick, appear to show a preference for barley (Hall and Huntley 2007), but this may be a function of differences in demand.

6.4.21 There does not appear to be any spatial patterning in the type or proportions of charred plant remains across the A66 sites, though some features contained more grain or chaff relative to weed seeds, and *vice versa*. Ditch fills *11190* (SCA8, ditch *11117*) and *14205* (SCA15, ditch *14012*), for example, were dominated by cereal grains, which may have been processing losses or represent parching/cooking accidents. At SCA15, fills *14175* (ditch *14006*), *14806* (ditch *14683*), *14912* (ditch *14943*), and *14944* (ditch *14946*), on the other hand, contained broadly similar quantities of both cereal grains and chaff fragments These could, agam, represent processmg losses, or parchıng accıdents, though the range of ıtems m many of the samples suggests that the materıal ıs lıkely to have been generated by more than one processmg or bummg event Thıs ıs especıally tme m the case of the dıtches, whıch were probably used as deposıtorıes for the dumpmg of domestıc waste Gıven the amount of chaff m some of the samples, ıt can be assumed that crop processmg was carrıed out at the sıte, though thıs ıs lıkely to have been ımdertaken m a pıecemeal fashıon as part of a local subsıstence economy

6 4 22 The evıdence for the use of turves, perhaps for roofıng, fuel or for general constmctıon purposes, has often been overlooked (Hall 2003, Hall and Huntley 2007) However, the ıdentıficatıon of a number of possıble mdıcator specıes by Hall (2003) means that there ıs a growmg body of evıdence for the use of turves m the North East (Hall 2003, Hall and Huntley 2007) The evıdence from the A66 Project ıs no exceptıon, and, together wıth the charcoal from SCA15 (*Sectıon 6 5*), whıch shows a preponderance of heather wood, the charred plant remams provıde evıdence for a hıgh dependency on heathland resources The pollen evıdence from the Scots Dyke dıtch (*Sectıon 6 3 16*) ıs consıstent wıth thıs, mdıcatmg a landscape of open grassland durmg the Iron Age, wıth pasture and heathland

6 5 THE WOOD CHARCOAL

6 5 1 Thırty-four samples were analysed, selected to provıde a dataset spannmg, where possıble, the spatıal and chronologıcal dıvısıons of the A66 road scheme In practıce, the dıstrıbutıon of samples wıth potentıal for charcoal analysıs was patchy, there were only two of research mterest from SCA13 for mstance, but a plethora from SCA15

6 5 2 ***Methodology*** a dual approach to analysıs was undertaken, 19 samples that exhıbıted the most dıverse taxonomıc composıtıon were subjected to full analysıs, whılst the remammg 15 samples were broadly characterısed Between 50 and 100+ fragments were ıdentıfied from each sample The charcoal was fractured and sorted mto groups based on the anatomıcal features observed m transverse sectıon at x7 to x45 magnıficatıon Representatıve fragments from each group were then selected for further exammatıon m longıtudmal sectıons usmg a Meıjı mcıdent-lıght mıcroscope at up to x400 magnıficatıon Identıficatıons were made wıth reference to ıdentıficatıon keys (Schwemgmber 1990, Hather 2000, Gale and Cutler 2000) and modem reference materıal The maturıty of the wood was noted where possıble and the presence of roundwood, sapwood and heartwood was noted Full quantıtıes are recorded m the archıve

6 5 3 The samples whıch were selected for detaıled analysıs were scanned under a bmocular mıcroscope at up to x45 and a selectıon of 20+ charcoal fragments were exammed m transverse sectıon only, wıth occasıonal fragments checked at hıgh magnıficatıon An estımate of the abundance of each taxa was made Thıs method provıdes a reasonable charactersatıon of the taxonomıc composıtıon of the sample, but does not gıve a complete specıes lıst Classıficatıon and nomenclature follow Stace (1997)

6 5 4 *Notes on identifications* for each site, the results by fragment count are given (*see Section 6 5 5-16*), in total, 1610 fragments were identified Preservation was generally quite poor, the charcoal being heavily infused with sediment and often very small and scrappy There were also several samples with large quantities of small-diameter roundwood fragments, which can be difficult to identify to species level The maturity of the wood was not always evident In most samples there were fragments characterised as indeterminate, usually not identifiable as a result of poor preservation or unusual cellular structure The presence of anatomically similar genera in the same samples meant that the identification process was slow The list of taxa identified is given, with details and explanations on the level of identification

Fagaceae
Quercus spp (oak), two native species, not distinguishable anatomically,

Betulaceae
Betula spp (birch), trees or shrubs, two native species, not distinguishable anatomically,
Alnus glutinosa, Gaertn (alder), sole native species,
Corylus avellana L (hazel), shrub or small tree, only native species

The last two genera have very similar anatomical structures and can be difficult to separate, hence the category *Alnus/Corylus* Since both species were positively identified, this category may represent either or both taxa *Betula* is usually easier to distinguish from the other two, but in some samples, any of the genera may be present

Salicaceae
The genera *Salix* spp (willow) and *Populus* spp (poplar) are rarely possible to separate Both are trees, although there is variation within the genera,

Ericaceae
This family includes several anatomically similar species, including *Calluna vulgaris* and *Erica* spp (heather/ling) Since most of the fragments were twiggy, it was difficult to confirm the genus from the charcoal alone, but the presence of *Calluna* spines in the charred plant remains suggests that this species may be represented,

Rosaceae
Prunus spp, trees or shrubs, including blackthorn (*P spinosa* L), wild cherry (*P avium* L) and bird cherry (*P padus* L), all native, which can sometimes be separated on the basis of ray width Blackthorn was positively identified in some samples, but there was some ambiguity in the separation between wild cherry and bird cherry, and either or both may be present,

Maloideae, subfamily of various shrubs/small trees, including several genera, pear (*Pyrus*), apple (*Malus*), rowan/service/whitebeam (*Sorbus*) and hawthorn (*Crataegus*), which are rarely distinguishable by anatomical characteristics,

Fabaceae
Broom/gorse (*Cytisus/Ulex*), shrubs, several native species, not distinguishable anatomically,

Aquifoliaceae
Ilex aquifolium L (holly), evergreen tree or shrub, native The single fragment from SCA8 (*Section 6 5 6*) could not be confirmed with certainty, since it was too small to fracture effectively to examine the radial sections,

Oleaceae
Fraxinus excelsior L (ash), sole native species

6 5 5 ***Results*** *SCA1* a single sample from SCA1 was examined The sample came from fill *10309* in ditch *10312*, the date of which is unclear (*Section 3 3 1*) The assemblage analysed was entirely dominated by broom/gorse (*Cytisus/Ulex*) roundwood fragments (50 fragments) This was the only sample to produce this species, but it is unclear whether this relates to temporal or spatial differentiation Both broom and gorse are characteristic of heathland, and are commonly found in fuelwood assemblages, as well as being traditionally used in woven artefacts (Gale and Cutler 2000)

6 5 6 *SCA8* ten samples were examined (Table 21), mostly from features of probable mid-late Iron Age date, one deposit sampled (fill *11036* of ditch *11120*) yielded a radiocarbon date of 60 cal BC-cal AD 80 (2000±30 BP, SUERC-27047, *Section 7 1*) The four posthole samples (from features *11109*, *11185*, *11187* and *11191*) yielded very large flots, these were scanned and appeared to be dominated by oak (*Quercus* sp), including heartwood fragments It is quite possible that these assemblages represent the remains of upright posts, since oak heartwood would commonly have been used in structures The dominance of oak in fill *11213* of pit *11212*, a deposit which is more likely to represent spent firewood, suggests that oak was also used for fuelwood

Feature Type		Pit	Posthole		Posthole	Posthole	Ring gully			Ditch	Ditch
Group No					*11119*	*11119*	*11083*	*11083*	*11083*	*11118*	*11118*
Feature No		*11212*	*11109*		*11185*	*11187*	*11371*		*11337*	*11191*	*11037*
Fill No		*11213*	*11107*	*11108*	*11184*	*11186*	*11369*	*11339*	*11335*	*11190*	*11036*
Sample No		39	29	28	35	36	125	121	50	37	14
Quercus sp	oak	++++h	++++h	++++h	++++	++++h	62hr	49hr	++r	15hsr	29hr
Betula sp	birch										7
Alnus glutinosa	alder						20r	3r		4r	3r
Corylus avellana	hazel						20r	11r		6r	5r
Alnus/Corylus	alder/hazel				+		13r	24r	++r	2	4
Betulaceae	birch family									2	
Populus/Salix	poplar/ willow						4	1		1r	7
Ericaceae	heather family							6r		81r	39r
Prunus spinosa	blackthorn						5r				3r
Prunus avium/padus	wild cherry/ bird cherry						2r				7r
Prunus sp	cherry-type						1r	3		1	

Maloideae	hawthorn group						5r	1r	+		
cf *Ilex aquifolium*	holly									1	
Fraxinus excelsior	ash						3	4r		2	2r
Indeterminate							8	23		11r	17r
Total		++++	++++	++++	++++	++++	144	125	+++	125	123

r= roundwood, h=heartwood, sapwood, + = present, ++ = frequent, +++ = common, ++++ = abundant

Table 21 Results of the charcoal analysis from SCA8

6 5 7 The remaining samples came from a roundhouse ring gully (building *11083*) and the boundary ditch of a rectilinear enclosure (*11118*) The samples from both groups contained similar, but very mixed, assemblages with a range of species, including alder (*Alnus glutinosa*), birch (*Betula* sp), hazel (*Corylus avellana*), heathers (Ericaceae), ash (*Fraxinus excelsior*), hawthorn group (Maloideae), poplar/willow (*Populus/Salix*), blackthorn and cherry-type (*Prunus* spp) and oak (*Quercus* sp) Both assemblages were dominated by small branches and twigs, which, together with the range of species present, suggest that the charcoal may have derived largely from fuelwood

6 5 8 *SCA10* at this site, the fills of three postholes and a possible iron-smithing hearth, all dated by radiocarbon assay (*Section 7 1*), were analysed for their charcoal content (Table *22*) Two of the postholes (*12087* in group *12057*, and *12055* in group *12059*) yielded certain or probable early neolithic dates (4240-3990 cal BC (5285±35 BP, SUERC-27608) and 3970-3790 cal BC (5100±35BP, SUERC-27609) respectively), whilst the third (*12075*, group *12058*) was seemingly of the early Bronze Age (2290-2030 cal BC, 3745±40 BP, SUERC-27607) All contained good-sized assemblages of charcoal, which upon scanning appeared to be dominated by oak, including heartwood As with the postholes at SCA8 (Table 21), it is possible that the charcoal represents burnt structural remains

	Feature Type	Posthole	Posthole	Posthole	Hearth
	Group No	*12059*	*12057*	*12058*	*12106*
	Feature No	*12055*	*12087*	*12075*	*12063*
	Fill No	*12056*	*12086*	*12074*	*12073*
	Sample No	55	59	56	52
Quercus sp	oak	++++h	++++h	++++h	29hr
Alnus glutinosa	alder				1r
Corylus avellana	hazel				24r
Alnus/Corylus	alder/hazel				1r
Populus/Salix	poplar/willow				1r
Prunus sp	cherry type				3r
Indeterminate					6
Total		++++	++++	++++	65

r= roundwood, h=heartwood, sapwood, + = present, ++ = frequent, +++ = common, ++++ = abundant

Table 22 Results of the charcoal analysis from SCA10

6 5 9 Possible iron-smithing hearth *12106* (*Section 2 3 20*), which was dated to the middle Iron Age (400-200 cal BC, 2255±30 BP, SUERC-26249), yielded a more varied assemblage of alder (*Alnus glutinosa*), hazel (*Corylus avellana*), poplar/willow (*Populus/Salix*), cherry-type (*Prunus* sp) and oak (*Quercus* sp),

though most species were represented by a single fragment, with oak and hazel forming the main component There was a fairly large quantity of small-gauge roundwood in this sample, which could be consistent with the use of charcoal in smithing However, the actual quantity of charcoal was quite low, suggesting that the hearth had been largely cleaned of burnt material prior to silting up or the subsequent dumping of material

6 5 10 *SCA13* two samples were examined from SCA13 (Table 23), one came from the fill (*13048*) of a pit (*13049*) that yielded an early Bronze Age radiocarbon date (2290-2030 cal BC, 3755±30 BP, SUERC-26250), whilst the second derived from the fill (*13052*) of ditch *13077*, which was seemingly of the early-middle Iron Age (730-390 cal BC, 2395±30 BP, SUERC-26251) The assemblage from the pit was mostly composed of oak (*Quercus* sp), but the collection was small and poorly preserved, and there were large numbers of indeterminate fragments The ditch assemblage was not much better preserved but was more varied in character, with alder or hazel (*Alnus/Corylus*), heathers (Ericaceae), oak (*Quercus* sp) and single fragments of ash (*Fraxinus excelsior*) and hawthorn group (Maloideae)

	Feature Type	Pit	Ditch
	Feature/Group No	*13049*	*13077*
	Fill No	*13048*	*13052*
	Sample No	61	62
Quercus sp	oak	27 (4h)	31 (13h, 9r)
Corylus avellana	hazel	1	
Alnus/Corylus	alder/hazel	**4**	19 (12r)
Ericaceae	heather family		11r
Maloideae	hawthorn group		1
Fraxinus excelsior	ash		1
Indeterminate		16	11 (7r)
Total		**48**	74

r= roundwood, h=heartwood, sapwood, + = present, ++ = frequent, +++ = common, ++++ = abundant

Table 23 Results of the charcoal analysis from SCA13

6 5 11 *SCA15* this site yielded the largest number of samples with the potential for charcoal analysis, 17 of which were analysed Occupation seems, on the evidence of numerous radiocarbon dates (*Section 7 1*), to have occurred largely in the period from the mid-first century BC to the late first century AD, though ceramic evidence (*Section 5 5 16*) indicates continued activity of some kind into the first half of the second century AD

6 5 12 Samples from six ditch fills (Table 24) were examined, together with the fill of a single roundhouse ring gully (*14000*) Two of the richer samples (from fill *14663* in ditch *14680*, and fill *14886* in ditch *14683*) were analysed in full, and yielded a wide range of taxa, including birch (*Betula* sp), hazel (*Corylus avellana*), probable heather (Ericaceae), ash (*Fraxinus excelsior*), hawthorn group (Maloideae), poplar/willow (*Populus/Salix*) and oak (*Quercus* sp) The scanning of other samples indicated the presence of the same species, plus a trace of alder (*Alnus glutinosa*) and cherry-type (*Prunus* sp) The assemblages were not particularly dominated by any one species, although ditches *14016* and *14683* contained large amounts of ash charcoal, and *14690* had a fairly large quantity of heather twigs

Feature Type		Ditch	Ditch	Ditch	Ditch terminus	Ditch	Ring gully terminus	Ditch
Group No		*14016*	*14012*	*14683*	*14023*	*14690*	*14000*	*14680*
Feature No			*14201*	*14882*				*14664*
Fill No		*14043*	*14202*	*14886*	*14533*	*14751*	*14235*	*14663*
Sample number		74	170	297	302	308	180	324
Quercus sp	oak			25h	+	+	+	39h
Betula sp	birch			1	+			
Alnus glutinosa	alder		+					
Corylus avellana	hazel					+	+r	15r
Alnus/Corylus	alder/hazel			4	+			19r
Populus/Salix	poplar/willow			4				
cf Ericaceae	heather family			1r		++r	+r	4r
Prunus sp	cherry-type		+					
Maloideae	hawthorn group	+r	+	13r				9
Fraxinus excelsior	ash	++r		52r	+			3
Indeterminate		++r	+r				+r	11r
Total		+++	++	100	+++	+++	++	100

r= roundwood, h=heartwood, sapwood, + = present, ++ = frequent, +++ = common, ++++ = abundant

Table 24 Results of the charcoal analysis from ditches and ring gullies at SCA15

6 5 13 A stakehole from roundhouse *14021*, in Enclosure 7 (*Sections 3 3 29-31*), was dominated by hazel (*Corylus avellana*) roundwood (Table 25) The curvature of the rings was fairly wide, suggesting that quite large roundwood was represented This assemblage was the only one to produce a single species (although the sample was scanned, not analysed in full) and may represent structural timber remains Another posthole (*14427*) associated with roundhouse *14021* was analysed in full, this also contained a large assemblage of hazel, but with a range of other species, such as alder (*Alnus glutinosa*), heather (Ericeaceae) and oak (*Quercus* sp) The whole sample was dominated by narrow roundwood fragments, including a few stems of 4-10mm radius and 7-12 growth rings This suggests that the assemblage derives from burnt fuelwood, rather than structural remains The final posthole examined (*14852*) contained chiefly wood from ash (*Fraxinus excelsior*), with some hawthorn group (Maloideae)

Feature Type		Posthole	Posthole	Stakehole	Pit	Pit		Hearth/kiln		Pit-group	
Group No		*14021*		*14021*				*14983*	*14983*	*14024*	
Feature No		*14427*	*14852*		*14031*	*14222*	*14222*	*14965*	*14960*		
Fill No		*14426*	*14851*	*14469*	*14033*	*14489*	*14491*	*14964*	*14959*	*14447*	*14448*
Sample No		268	320	279	73	282	284	328	329	273	274
Quercus sp	oak	13r					15rh	12h	17r	12r	8r
Betula sp	birch					11r	9r			5r	11r
Alnus glutinosa	alder	4r	1			19r	7r		7r	27r	11r
Corylus avellana	hazel	51r	1	+++r		3r		7r			
Alnus/Corylus	alder/hazel	16r	1	+r				18r	13r		10r
Betulaceae	birch family					9r	14r			7	
Populus/Salix	poplar/willow					1r	2r				
Ericaceae	heather family	12r			37r	7r		3r	4r	4r	
cf Ericaceae							3r	1r	2r		6r
Prunus spinosa	blackthorn				13r						
Prunus sp	cherry-type									3r	

Maloideae	hawthorn group		28r		2			4	7	33r	2
Fraxinus excelsior	ash		69hs								2r
Indeterminate		4						19		9br	
Total		100	100	+++	52	50	50	64	50	100	50

r= roundwood, h=heartwood, sapwood, + = present, ++ = frequent, +++ = common, ++++ = abundant

Table 25 Results of the charcoal analysis from features other than ditches at SCA15

6 5 14 The charcoal from two pits with quite contrasting assemblages was examined (Table 25) Pit *14031* (*Section 3 3 39*) yielded narrow roundwood fragments of heathers (Ericaceae) and blackthorn (*Prunus spinosa*), with a few hawthorn group (Maloideae) fragments Pit *14222* (*Section 3 3 22*) contained several fills with assemblages of charcoal, two of which were analysed These yielded a range of six taxa alder (*Alnus glutinosa*), birch (*Betula* sp), hazel (*Corylus avellana*), heather (Ericaceae), poplar/willow (*Populus/Salix*), and oak (*Quercus* sp) Incomplete roundwood fragments were high in number, and fill *14491* in pit *14222* contained both immature and mature oak fragments

6 5 15 Two samples from hearth/kiln *14983* (*Section 3 3 51*) were analysed (Table 25) one from a stone layer (*14959*) at the base of the chamber (*14960*), and the other from a fill (*14964*) in the adjacent flue or rake-out pit (*14965*) The condition of the charcoal was fairly poor, leading to a high level of indeterminate fragments, and the general quantity in the assemblage was not particularly high, but several taxa were identified alder (*Alnus glutinosa*), hazel (*Corylus avellana*), heather (Ericaceae), hawthorn group (Maloideae), and oak (*Quercus* sp) There appeared to be a fairly even mix of trunkwood and roundwood

6 5 16 An amorphous and irregular feature, located east of the entrance into roundhouse *14021*, may have been a group of intercutting pits (pit group *14024*), filled with virtually identical materials (*Section 3 3 36*) The charcoal from the two fills analysed (*14447*, *14448*, Table 25) was not dissimilar to the assemblage from posthole *14427*, associated with roundhouse *14021* (*Section 6 5 13*), but a greater diversity of species was present, including alder (*Alnus glutinosa*), birch (*Betula* sp), heather (Ericeaceae), ash (*Fraxinus excelsior*), hawthorn group (Maloideae), cherry-type (*Prunus* sp), and oak (*Quercus* sp) The apparent absence of hazel might be misleading, a result of difficulties in identification, since there were numerous undifferentiated alder/hazel (*Alnus/Corylus*) fragments The assemblages from *14024* almost certainly relate to domestic debris – potentially from several events – and were notably dominated by small twigs and immature roundwood

6 5 17 ***Discussion*** *Type of contexts examined* one of the main difficulties in the interpretation of the charcoal is understanding the provenance of the material, since the nature of the archaeology prohibits the easy identification of the types of fires from which the charcoal derived Hearth/kiln *14983* at SCA15 is one of the few features where it is reasonable to assume that the charcoal directly represents the remains of firewood used in the operation of this feature, though the precise purpose of the oven/hearth is not clear This assemblage is diverse in character, with roundwood fragments derived from a

number of local envıronments, encompassmg heathland (heather/lmg) and woodland or woodland margms (oak, hazel, hawthorn group), wıth some wet ground (alder)

6 5 18 In general, the samples from the sıte fall mto two dıstmct categorıes those of mıxed composıtıon (such as that from hearth/kıln *14983*) and those dommated by a smgle taxon It ıs sıgnıficant that seven out of the nme assemblages dommated by oak are from postholes, and that of the entıre record of ten postholes, nme were dommated by a smgle specıes One plausıble explanatıon for thıs ıs that these assemblages represent stmctural remams, rather than the more mıxed remams of fuelwood The presence of charıed plant remams, bumt bone and other artefacts m many of the samples analysed suggests a domestıc provenance for most of these assemblages, for whıch the gathermg of small branches from varıous habıtats ıs approprıate

6 5 19 *Perıod summarıes* the two early neolıthıc samples from SCA10 (from postholes *12087* and *12055* m feature-groups *12057* and *12059*) were both dommated by oak Thıs lack of taxonomıc dıversıty may relate to the nature of the contexts exammed (*ıe* stmctural remams from postholes), or ıt may represent a delıberate preference m fuelwood selectıon Eıther way, the samples offer lıttle msıght mto the character of the neolıthıc landscape

6 5 20 The only samples datmg to the early Bronze Age were from a posthole (*12075* m feature-group *12058*) at SCA10, and a pıt (*13049*) at SCA13 Oak formed the mam component of both assemblages The pıt sample yıelded some hazel as well, but over 30% of thıs small sample was mdetermmate, so there may have been addıtıonal specımens of hazel or other specıes Apart from the assumed presence of oak-hazel woodland m the vıcmıty, there are too few samples to merıt further mterpretatıon

6 5 21 Samples dated by radıocarbon assay to the early-mıddle Iron Age were recovered from SCA8, SCA10 and SCA13 (*Sectıon 7 1*) In addıtıon, further samples of possıble later mıddle Iron Age date came from SCA15 (*Sectıon 7 1*), however, the date ranges of these would also allow a late Iron Age or early Roman date, whıch, m vıew of the overall datmg evıdence from SCA15, seems more lıkely (*Sectıon 7 1 3*) For the most part, oak dommates the charcoal record, though the assemblages from roundhouse gully *11083* and dıtch *11118* at SCA8, and possıble ıron-smıthmg hearth *12106* at SCA10, yıelded more mıxed assemblages In the case of the former samples, the charcoal may have derıved from several bummg events, mcorporatmg, perhaps, materıal from both fuelwood and stmctural remams However, the charcoal from the hearth ıs more readıly mterpretable as the spent fuelwood from the fırmg of that feature

6 5 22 The charcoal assemblage for the Iron Age as a whole suggests an envıronment whıch supported oak-hazel woodland, wıth low-lymg areas from whıch alder and wıllow/poplar were gathered, and areas of heathland Heather/lmg burn quıte well, wıth a short-lıved mtense heat whıch would be suıtable for domestıc purposes and was also used for many artefacts, such as brooms and baskets, and also for roofing thatch (Gale and Cutler 2000)

6 5 23 The Roman-period assemblage was mostly derived from SCA15, which actually spans the transition from the late Iron Age to the early Roman period The assemblage is similar to the prehistoric assemblages, and the samples from postholes again tend to be dominated by a single species, presumably relating to structural timbers The more diverse assemblages indicate that a fairly wide variety of trees was being used for fuelwood There is no conclusive evidence for woodland management, but this is not unlikely, nor is it incompatible with the material The taxa identified suggest a fairly open environment, in which light-demanding trees or colonisers, such as ash, blackthorn and birch, would have flourished Lower-lying areas were also exploited, as indicated by the use of alder and willow/poplar In common with the pollen record, which shows heather was prevalent (***Section** 6 3 18*), heather charcoal was present in most of the samples Whether this was positively chosen for its burning properties, or because of pressure on woodland resources, is unclear Oak is the second most common taxa, but the results include the possible structural remains from the postholes

6 5 24 It is clear that various available resources were utilised Gorse/broom are similar to the heather family in terms of habitat, and were also traditionally used for fuel (Edlin 1949) It is perhaps surprising therefore, that it is not better represented in the charcoal record

6 5 25 ***Conclusions*** interpretation of the landscape of the earlier prehistoric period is hampered by the limited number of samples available and the lack of taxonomic diversity For the Iron Age and Roman period greater insight into the environment and nature of fuel use was possible The selection of fuelwood was quite wide, comprising a range of taxa, drawn from a variety of environment types, including heathland, woodland margins, hedgerow/scrub and wet ground areas The general picture is of an open environment, possibly one in which larger timber trees such as oak were chiefly used for structural purposes, with other taxa supplementing fuelwood requirements The lack of other regional charcoal evidence makes comparison with other sites difficult, however, evidence from the Roman fort at Carlisle suggests that oak was the preferred fuel for metalworking and for other industrial activities, with a diverse range of wood types being exploited for use as domestic fuel (Druce and Challinor 2009, 1523)

7 SCIENTIFIC DATING

7.1 RADIOCARBON DATING

7.1.1 In total, 23 samples were subjected to radiocarbon dating during the course of the A66 Project. Of these, two samples were taken from fills *12095* and *12097* (Table 26) in the Scots Dyke ditch (*12035*) at SCA10 (*Sections 2.3.15-18*) and 21 samples were dated from a wide variety of other prehistoric and early Romano-British features at SCA8 (*Section 1.5.11*), SCA10 (*Section 1.5.14-16*), SCA13 (*Section 1.5.19-22*), and SCA15 (*Section 1.5.23-27*) (Table 27). The sediments from the Scots Dyke ditch were processed by loss-on-ignition and were found to contain organic material, which was sent for radiocarbon assay of the humic acid content at the Scottish Universities Environmental Research Centre (SUERC). The charred and carbonised materials selected from the other 21 samples were also sent for dating at SUERC.

Site	Sample type	Context No	Feature/Group No	Feature type	Calibrated date (2σ)	Date (BP) and Lab code
SCA10	Humic acid	*12095*	*12035*	Ditch	6690-6500 cal BC	7785±35, SUERC-12528
SCA10	Humic acid	*12097*	*12035*	Ditch	5230-4860 cal BC	6130±35, SUERC-12527

Table 26 Results of radiocarbon dating of sediments in the Scots Dyke ditch, 12035, at *SCA10*

Site	Sample No	Sample type	Context No	Feature/ Group No	Feature type	Calibrated date (2σ)	Date (BP) and Lab code
SCA8	-	Carbonised accretion on pottery	*11036*	*11120*	Ditch	60 cal BC-cal AD 80	2000±30, SUERC-27047
	37	Charred cereal grains	*11190*	*11117*	Ditch	160 cal BC-cal AD 60	2025±30, SUERC-27048
	41	Charred spelt glumes	*11235*	*11124*	Ditch	370-170 cal BC	2185±30, SUERC-27049
	121	Charred cereal grains	*11339*	*11083*	Ring gully	750-390 cal BC	2405±35, SUERC-26662
SCA10	52	Charred cereal chaff	*12073*	*12106*	Possible smithing hearth	400-200 cal BC	2255±30, SUERC-26249
	55	Charred hazelnut shell	*12056*	*12055/12059*	Posthole	3970-3790 cal BC	5100±35, SUERC-27609
	56	Oak charcoal	*12074*	*12075/12058*	Posthole	2290-2030 cal BC	3745±40, SUERC-27607
	59	Oak charcoal	*12086*	*12087/12057*	Posthole	4240-3990 cal BC	5285±35, SUERC-27608
SCA13	-	Carbonised accretion on pottery	*13049*	*13048*	Pit	2290-2030 cal BC	3755±30, SUERC-26250

	62	Charred cereal grains	*13052*	*13077*	Ditch	730-390 cal BC	2395±30, SUERC-26251
	63	Alder charcoal	*13075*	*13076*	Pit	410-200 cal BC	2285±35, SUERC-27610
SCA15	93	Charred cereal grains	*14123*	*14002*	Ring gully	40 cal BC-cal AD 130	1940±35, SUERC-26661
	170	Charred cereal chaff	*14202*	*14012*	Ditch	180 cal BC-cal AD 10	2065±30, SUERC-26255
	180	Charred cereal grains	*14235*	*14000*	Ring gully	50 cal BC-cal AD 80	1985±30, SUERC-26256
	260	Charred cereal grains	*14357*	*14719/14021*	Ring gully	60 cal BC-cal AD 80	2000±30, SUERC-26257
	272	Charred cereal grains and grass seeds	*14439*	*14017*	Ditch	50 cal BC-cal AD 120	1975±35, SUERC-27606
	297	Charred plant fragments	*14886*	*14683*	Ditch (lower part of fill)	200 cal BC-cal AD 1	2080±35, SUERC-26438
	297	Charred plant fragments	*14886*	*14683*	Ditch (upper part of fill)	50 cal BC-cal AD 120	1975±35, SUERC-26439
	302	Charred *Prunus* seed	*14533*	*14023*	Ditch	60 cal BC-cal AD 80	2000±30, SUERC-26258
	324	Charred cereal grains	*14663*	*14680*	Ditch	110 cal BC-cal AD 60	2020±30, SUERC-27898
	329	Charred weed seeds	*14959*	*14983*	Hearth/kiln	100 cal BC-cal AD 70	2010±30, SUERC-26259

Table 27 Results of radiocarbon dating of sediments from features at SCA8, SCA10 SCA13 and SCA15

7 1 2 The mesolithic radiocarbon dates from the Scots Dyke ditch (SCA10) were not consistent with the other dating evidence from this feature (*Section 7 2*), and are not considered to date the deposition of the sediment from which they were obtained Instead, it was the opinion of the laboratory that the humic acid is likely to have been contaminated with older residual carbon, already present in the sediments when they were deposited in the ditch

7 1 3 The earliest evidence of activity from elsewhere at SCA10 was provided by two dates in the early neolithic period (or, in one case, the late mesolithic) from two postholes (*12055*, *12087* (*Sections 2 2 3-4*)) There was, however, no other evidence for activity of this period on this site Evidence for early Bronze Age activity was provided by two near-identical dates in the late third millennium BC, one from a carbonised accretion adhering to a Grooved ware-type potsherd from pit *13049* at SCA13 (*Section 2 2 6*), the other from the fill of posthole *12075* at SCA10 (*Sections 2 2 4-5*) Certain early/middle Iron Age

dates were provided by samples obtained from two features at SCA8 (the ring gully of roundhouse *11083* (*Section 2 3 7*) and ditch *11234* (*Section 2 3 10*)), ditch *13077* and pit *13076* at SCA13, and possible iron-smithing hearth *12106* at SCA10 (*Section 2 3 20*) With the exception of dates obtained from a carbonised accretion on a sherd of Iron Age/Romano-British 'native'-type pottery from ditch *11120* at SCA8 (*Section 2 3 12*), and a sample of charred wheat grains from ditch *11117* at the same site, all radiocarbon determinations of late Iron Age-early Roman date came from SCA15 Six dates within the period *c* 60-40 cal BC-cal AD 80-130 (at a 95 4% level of confidence) were obtained from the site, together with four others with ranges beginning in the period *c* 200-100 cal BC and ending *c* cal AD 10-70

7.2 ARCHAEOMAGNETIC DATING

7 2 1 ***Methodology*** archaeomagnetic dating was performed on a sedimentary profile through the Scots Dyke ditch (*12035*) at SCA10 (*Secion 2 3 15*, see *Appendix 4* for a full report) In total, 28 specimens were collected by carefully inserting 20 x 20mm plastic pots into the north-facing sediment section, trying to produce as little sediment disturbance as possible The left to right tilt of the top-surface of the plastic pots was kept as close as possible to zero, controlled by a spirit level attached to a specially designed insertion plate The dip of the front face of the pot was measured with an inclinometer to an accuracy of ±0 5°, the insertion direction being measured with a magnetic compass With these two measurements, it is possible to determine the *in situ* direction of the sediment magnetisation from the specimen magnetisation The now oriented specimens were removed from the sediment, immediately capped with a plastic lid, sealed by tape and kept in a fridge once back at Lancaster University, in order to minimise any changes in water content

7 2 2 In total, 26 specimens came from the sedimentary horizons between the base of *12100*, the relatively modem subsoil sealing the Scots Dyke and lying directly beneath modem topsoil, and the top of *12094*, the primary fill at the bottom of the Dyke (Fig 70), two more specimens (SC27 and SC30) came from subsoil deposit *12100* itself The lower part of the profile (comprising fills *12096* and *12095*) was finer-grained, composed of darker-coloured clayey silt The horizon within *12096* was possibly a palaeosol This part of the profile was labelled as section B, and it included 13 specimens (SC67 to SC98) between depths of 0 67m and 0 98m below the subsoil surface The upper part of the profile (fills *12099*, *12098*, and *12097*) was composed of beige-brown silty sand It was informally labelled as section A and included 13 specimens (SC33 to SC64) between depths of 0 33m and 0 64m below the subsoil surface

7 2 3 The direction and strength of natural magnetisation of the specimens were measured at the CEMP, Lancaster University, using an AGICO JR6A spinner magnetometer Low speeds were used on the JR6A in order to avoid disturbance to the specimens The low-field magnetic susceptibility was measured on a Bartington MS2 susceptibility meter at two frequencies, low (0 46kHz giving χ_{LF}) and high (4 6kHz giving χ_{HF},) The difference between these two, the frequency-dependent magnetic susceptibility (χ_{FD} %), was

calculated, as a percentage of χ_{LF} Thıs ıs a measure of the abundance of superparamagnetıc magnetıte (ultra-fıne magnetıte < ~ 0 03μm) m the samples, whıch ıs commonly a good mdıcator of topsoıl magnetıc enhancement, or ın thıs case sedıment derıved from topsoıl (Dearıng 1999)

7 2 4 Magnetıc cleanıng technıques (demagnetısatıon) were applıed to the specımens These demagnetısatıon technıques attempt to ısolate a stable magnetısatıon from each specımen, and take the most tıme and effort ın the whole datıng procedure Thıs ıs always necessary wıth natural specımens, smce sedıment magnetısatıons are to a varyıng extent tıme dependent, and acquıre addıtıonal 'magnetıc noıse' wıth ıncreasıng tıme (Lınford 2004, 2006)

7 2 5 ***Evaluatıon*** the prımary remnant magnetısatıon ın the sedıments ıs carrıed by magnetıte and ıs probably deposıtıonal ın orıgın, ındıcatıng ıt was acquıred at or very soon after the deposıtıon of the sedıment fill Twelve specımens from each sub-sectıon provıded suıtable dırectıonal data for archaeomagnetıc datıng

7 2 6 The archaeomagnetıc mean dırectıon for sub-sectıon A (corrected to Merıden) ıs D = 4 5°, I = 68 1° (α_{95} = 2 2°, N = 12, K = 401), and the archaeomagnetıc mean dırectıon for sub-sectıon B (corrected to Merıden) ıs D = 0 0°, I = 68 8° (α_{95} = 1 9°, N = 12, K = 497) These mean dırectıons and theır confidence ıntervals, when compared to the UK master curve of Clark *et al* (1988), suggest that the best estımated date for the sedıment fill ın (upper) sectıon A ıs AD 70, wıth an approxımate 95% confidence ınterval of AD 30–110 There are two possıble dates for the age of the sedıment fill ın the (lower) sectıon B, wıth an approxımate 95% confidence ıntervals of 90–70 BC, and AD 1–110 respectıvely The most lıkely estımated age ın the later date range ıs AD 40 These data suggest that the sedıment fill of the Scots Dyke dıtch was probably rapıdly formed durıng the first century AD

7.3 Optıcally Stımulated Lumınescence (OSL) Datıng

7 3 1 ***Methodology.*** three samples for Optıcally Stımulated Lumınescence (OSL) datıng were taken at dıfferent posıtıons ın the sequence of sedıments fillıng the Scots Dyke dıtch (*12035*) at SCA10 (*Sectıon 2 3 15*, for a full report see *Appendıx 5*) The samples were taken by members of the Lumınescence Datıng Laboratory, and guıded by sıte staff from OA North The lumınescence samples were prepared by sub-samplıng the ınner volume of the cores under subdued red lıghtıng ın the laboratory, quartz, ın the graın-sıze range 90-150μm, was subsequently extracted from the sedıment usıng standard procedures for the ınclusıon technıque (Aıtken 1985) The results of ınıtıal suıtabılıty tests ındıcated that all three samples were potentıally suıtable for OSL datıng

7 3 2 An OSL technıque based on a sıngle alıquot regeneratıve dose (SAR) procedure (Murray and Wıntle 2000, 2003) was used to determıne the absorbed dose accumulated sınce the last exposure of the sedıment ın daylıght (the palaeodose, P) Measurements were made usıng a Rısø TL-DA-12 automated reader, and laboratory doses were admınıstered by a calıbrated $^{90}Sr/^{90}Y$ beta source mounted on the reader OSL was observed under

stimulation by light from blue LEDs and the luminescence was detected in the ultraviolet region using an EMI photomultiplier in combination with a Hoya U340 optical filter

7 3 3 The distribution of values of P (one value per aliquot tested) for all samples indicated more uniform pre-depositional exposure to daylight in the case of samples 330-2 and 300-3 compared with the basal sample (330-1) However, this does not preclude the occurrence of incomplete zeroing of the stored charge before burial in all three samples

7 3 4 The average total annual dose, D_T, was derived from a combination of experimental techniques and calculation The beta dose-rate within the sampled sediment medium, using the β TLD technique (Aitken 1985, Bailiff 1982), and the gamma dose-rate were calculated using the concentrations of ^{238}U, ^{232}Th and ^{40}K determined using a high-resolution Ge gamma spectrometer, readings obtained using a portable NaI detector on site were also used in the assessment of the gamma dose-rate Adjustment of the beta and gamma dose-rates to account for the uptake of moisture in the sample medium was based on the assumption that the average water uptake in the sample medium during burial was ×0 8±0 2 (samples 330-2, 330-3) and ×1 0±0 2 (sample 330-1) of the value measured in the laboratory (*Appendix 5*) It was assumed that the measured radionuclide and water content of the sediments was typical of the surrounding matrix The contribution to the annual dose due to cosmic rays was estimated using data published by Prescott and Hutton (1988)

7 3 5 ***Evaluation*** the luminescence age has been calculated (using the age equation and the values indicated in Table 28) The uncertainty in the age was calculated by taking into account the propagation of errors associated with experimental measurements, and also those errors associated with the calibration and conversion factors (Aitken 1985)

$$\text{Luminescence Age (years)} = \frac{\text{Palaeodose (mGy)}}{\text{Annual dose (mGy/year)}}$$

Lab reference	Context/ sample nos	Date	Palaeodose (mGy)	Annual dose (mGy/a)	Annual dose components (%)		Water (%)
					β	γ+cosmic	
Dur06OSL Qi 330-1	*12095/* <250>	AD 65 ±150, ±240	5270 ± 400	2 89±0 06	58	42	37±7
Dur06OSL Qi 330-2	*12097/* <251>	120 BC ±70, ±220	5500 ± 140	2 59±0 05	57	43	37±7
Dur06OSL Qi 330-3	*12099/* <252>	AD 510 ±90, ±135	3210 ± 150	2 15±0 08	49	51	23±5

Table 28 Results of OSL dating of sediments in the Scots Dyke ditch (12035) at SCA10

7 3 6 After subtraction of the test year (2006) from the luminescence age, the luminescence date is given with two associated errors at the 68% level of confidence, based on the specification by Aitken (1985) Luminescence Date ± σ_A ± σ_B The first error term, σ_A, is a type A standard uncertainty obtained

by an analysis of repeated observations (*ie* random error) and should be used when comparing results with other luminescence dates from the same laboratory The second error term, σ_B, is a type B standard uncertainty based on an assessment of uncertainty associated with all the quantities employed in the calculation of the age, including those of type A (*ie* random and systematic errors) The second error, o_B, should be used when comparing luminescence dates with independent dating evidence This method of error assessment is derived from an analysis of the propagation of errors and, providing the distribution of errors is normal, the approach appears to be sufficiently robust The application of the Student's t-test indicates that the dates for samples 330-1 and 330-2 are not distinguishable at the 95% level of confidence The calculations assume that the zeroing of the luminescence before the last burial was fully effective

7 3 7 It should be noted that the archaeomagnetic results were calculated using data available in 2006 Subsequent recalibration of the measurements using more recent data and software, undertaken as part of an integrated analysis of the Scots Dyke dating evidence (*Section 7 4*), yielded broader, and rather different, date ranges at 95% probability

7 4 INTEGRATED DATING ANALYSIS

7 4 1 In this analysis, the data obtained from archaeomagnetic dating and OSL dating of sediments within the Scots Dyke ditch (*12035*) at SCA10 (*Sections 7 2* and *7 3*) were synthesised using the Bayesian statistical approach (Buck 2003, Lanos 2003, Millard 2006), which is now widely applied to sequences of radiocarbon dates and, less frequently, to other dating methods The Bayesian approach incorporates the chronometric information from the archaeomagnetic and luminescence measurements, together with the stratigraphic ordering of the samples This mathematical approach allows the calculation of date estimates for events which have not been directly dated, such as the constmction of the ditch, and its final filling

7 4 2 During the analysis, the original archaeomagnetic measurements (*Section 7 2 6*), which were obtained using data available in 2006, were recalculated following the methods of Kelker and Cmden (1980) and Noel and Batt (1990), and recalibrated to calendar years using the method of Lanos (2003), implemented in the RenDate software using the calibration curve of Zananiri *et al* (2007) This provided broader, and rather different, ranges from those established by the initial archaeomagnetic dating programme (Table 29) The dating evidence is considered in two ways firstly, as presented by the dating laboratories, with sections A and B as the units to be dated (*Section 7 2 2*), and secondly, with the archaeomagnetic data regrouped in relation to the stratigraphic sequence of excavated deposits within the ditch (*12095*, *12096*, *12097*, *12098*, *12099*)

Stratigraphic unit	Corrected mean D	Mean I	a95	D (meridian)	I (meridian)	Calibrated date ranges (95% probability)
Section A	4 64	69 29	2 17	4 45	68 13	1892-988 BC 80 BC-AD 29 AD 442-807 AD 1562-1747
Section B	0 04	69 88	1 95	0 03	68 77	1867-1170 BC 652 BC-AD 46 AD 455-755 AD 1592-1884
Fill *12095*	-0 04	70 15	3 14	-0 03	69 05	1865-1143 BC 681 BC-AD 75 AD 446-773 AD 1583-1989
Fill *12096*	0 14	69 50	2 90	0 11	68 38	1927-1140 BC 678 BC-AD 102 AD 423-763 AD 1570-1887
Fill *12097*	11 66	66 04	7 28	11 16	64 75	2164-240 BC 81 BC-AD 1322 AD 1383-1696
Fill *12098*	2 59	69 78	3 84	2 49	68 65	1925-990 BC 815 BC-AD 113 AD 416-821 AD 1555-1900
Fill *12099*	1 21	70 70	2 49	1 18	69 60	1815-1118 BC 694 BC-AD 7 AD 477-788 AD 1597-1976

Table 29 Archaeomagnetic directions (see Appendix *4), calibrated using RenDate 1 0 04 and the calibration curves of Zananiri* et al *(2007)*

7 4 3 In addition to the summary 95% probability date ranges (Table 29), plots of the probability distributions are given in *Appendix 6* The probability distributions produced by RenDate were used in the OxCal analysis This introduces some additional uncertainty because the archaeomagnetic dates share some uncertainty derived from the calibration curve Because this shared uncertainty is not accounted for in OxCal, the results presented will have ranges slightly increased in length compared to those that would be generated by an analysis that accounted for this covariance

7 4 4 The OSL dates (*Section 7 3*) are treated in OxCal as calendar dates, but there is not a convenient way to handle the systematic errors As with the archaeomagnetic dates, inclusion of the systematic errors without accounting for the covariance between dates leads to an over-estimate of uncertainty in the results The second calculation, with the archaeomagnetic data divided by context, was therefore repeated with the omission of the systematic component of the uncertainty, to give some idea of the results when uncertainty is under-estimated (Table 30)

	Model	Parameter	Calibrated date ranges (95 4% probability)
1	Two sections (A and B)	Start End	1720 BC-AD 10 AD 190-2002
2	Fills (*12095, 12096, 12097, 12098, 12099*) - context model	Start End	1120-40 BC AD 520-1600
3	Contexts, OSL dates with random errors only	Start End	970-100 BC AD 520-1330

Table 30 Posterior probability ranges for the start and end of the filling of the Scots Dyke ditch (12035)

7 4 5 All Bayesian modelling was conducted in OxCal 4 1 (Bronk Ramsey 1995, 2009) Probability distributions for archaeomagnetic dates were exported from RenDate and included using the OxCal *prior* command OSL dates were treated as calendar dates in OxCal All results have been rounded outwards to the nearest ten years

7 4 6 ***Results*** all three models ran well in the OxCal software, with convergence and agreement measures within the acceptable range specified in the manual (*Appendix 6*) Table 30 summarises the results for the start and end dates relating to ditch construction and filling As there were no usable chronometric measurements on the earliest ditch fill (*12094*) and on the latest fill (*12100*), the actual dates are likely to be earlier and later than those given

7 4 7 The Two Section model (Table 30, *Appendix 6*) gives very vague results, which improve little upon the initial ranges of the OSL and archaeomagnetic dates, with the 95% probability indicating that filling of the ditch started sometime between 1720 BC and AD 10, and ceased between AD 190 and 2002 The Context model (Table 30, *Appendi 6*) uses data from each individual context and therefore includes much more stratigraphic information, as well as a more detailed consideration of the changing magnetic pole direction recorded in the sediments This yields more precise estimates, suggesting that filling started between 1120 BC and 40 BC, and ceased between AD 520 and 1600 The third model (Table 30, *Appendix 6*), with only random errors of the OSL dates included, is, as expected, more precise again, with filling calculated as starting between 970 BC and 100 BC, and ceasing between AD 520 and 1330

7 4 8 ***Conclusions*** the three models allow a general conclusion that the filling of the Scots Dyke ditch (*12035*) most likely started in the first millennium BC The completion of the filling is less clearly dated by the Two Section model than the others The Context model is preferable for interpretation, as it maximises the amount of information included in the model, but, as it does not take account of covariance of uncertainty between dates, it somewhat over-estimates the time uncertainty The Third model, incorporating only the random errors in the OSL dates, indicates very similar conclusions

7 4 9 The most likely interpretation is, therefore, that this element of the ditch, at any rate, was constructed in the Iron Age, before *c* 100 BC Filling of the ditch continued for at least several hundred years, with the later parts of the sedimentary sequence clearly being post-Roman Filling was wholly or largely

complete by the mid-fourteenth century, though this could have occurred as early as the sixth century AD

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