Chapter 7

The vertebrate remains from Southfleet Road: introduction, taphonomy and palaeoecology

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INTRODUCTION

Vertebrate fossils are preserved in the majority of sedimentary beds containing Clactonian archaeology, but not in the upper part of the sequence, where the deposits with Acheulian artefacts are decalcified and burial conditions did not favour bone preservation. Lower Palaeolithic artefacts and vertebrate fossils were first discovered at Southfleet Road in 2003, during construction of the HS1 international railway station at Ebbsfleet. In 2004, the remaining undisturbed sediments were the focus of a nine-month archaeological investigation, which produced a large collection of vertebrate remains. The artefact assemblage with two distinct superposed industries (ie Acheulian and Clactonian), invites correlation of the Southfleet Road deposits with the internationally famous site at Swanscombe, some 2km to the north-west. A more complete faunal succession is present in the Thames Valley sequences at Barnfield Pit, Swanscombe and a nearby pit at Ingress Vale, whereas vertebrate remains from its tributary at Southfleet Road come solely from the Clactonian levels. Most of the vertebrate fossils from the Swanscombe area do not come from controlled archaeological excavations, but were instead recovered from working faces of pits and quarries as they were being dug for sand, gravel and chalk. As a consequence, these collections include many specimens lacking stratigraphical information. The vertebrate assemblages are inevitably biased in favour of larger specimens and animals, resulting in a fragmented and tantalisingly incomplete picture of the contemporary fauna and confounding efforts to understand human-animal interactions at Swanscombe (cf. Binford 1985). With this in mind, one of the primary objectives of the fieldwork at Southfleet Road was to maximise the recovery of biological remains, in particular those of small mammals, birds, amphibians, reptiles and fishes, which are so important for palaeoecological reconstructions and dating. The combined hand-retrieved and sieved vertebrate assemblage is impressive and the identified sample comprises 18,146 vertebrate specimens. These have been assigned to at least 46 taxa, ranging from isolated teeth of pygmy shrews and bats to the scattered remains of a straight-tusked elephant skeleton. Primary aims of the post-excavation research were to characterise and reconstruct the landscape and environment setting of the human occupation based on the vertebrate fauna, and to contribute to the dating of the deposits using evidence from mammalian biostratigraphy.

The analysis of the vertebrate remains falls naturally into three chapters. This chapter outlines the methods employed during the analysis of the animal bones and explores the interpretation of the assemblages in terms of depositional history and past environmental conditions. Evidence for faunal change through the sequence is combined with information from bone taphonomy to unravel the origin of the Southfleet Road vertebrate assemblages, providing the basis for understanding the landscape setting and climate at the time of the Clactonian occupation of the site. Chapter 8 explores the question of human exploitation of large mammals, focussing on a description and interpretation of taphonomy of the straight-tusked elephant from Phase 6. Cut marked bones from other contexts are also described. The correlation and age of the deposits are explored from a mammalian biostratigraphical perspective in Chapter 9. The key elements of the biostratigraphic evidence are the recognition of peak interglacial conditions and detailed biometrical comparisons of the large mammal remains with those from other interglacial sites in the Thames valley and the British sequence in general. The mammalian evidence provides strong grounds for linking the Phase 5-6 deposits in the Ebbsfleet Valley at Southfleet Road with the Clactonian levels in the Thames Valley at Swanscombe (Kent) and Clacton (Essex). Taken together, these sites form a transect along a Lower Palaeolithic riverine landscape, from the lower reaches of the Thames in the Swanscombe area to its estuary at Clacton-on-Sea. The discussion in this chapter concludes with discussion of the mammalian evidence for the landscape setting and environmental context of early humans in southern England during the Hoxnian interglacial, some 400,000 years ago.

MATERIAL AND METHODS

The excavated assemblage comprised approximately 1,370 individually-numbered large mammal bones (Table 7.1). Of these specimens, the vast majority comprised unidentifiable, or minimally identifiable fragments of bone and teeth. Most of the material recovered by hand

Table 7.1 Counts and stratigraphical occurrence of hand-collected vertebrate remains from Southfleet Road

Phase	*3*	*3*	*3*	*5*	*5*	*6a*	*6a*	*6a*
Context	*40028*	*40062*	*40159*	*40025*	*40072*	*40039*	*40103*	*40103/039*
No. frags (large mammal)	*1*	*2*	*1*	*15*	*1*	*236*	*20*	*1*
AMPHIBIA								
Anuran indet.								
AVES								
Indet. bird								
MAMMALIA								
Lipotyphla								
Neomys sp., water shrew								
Talpa minor, extinct mole								
Rodentia								
Castor fiber, beaver								
Arvicola cantianus, water vole								
Indet. vole						1		
Lagomorpha								
Oryctolagus cuniculus, rabbit				2		2		
Carnivora								
Panthera leo, lion				1				
Proboscidae								
Palaeoloxodon antiquus, straight-tusked elephant				1				
Elephantidae gen. et sp. indet., indeterminate elephant								
Perissodactyla								
Stephanorhinus hemitoechus, narrow-nosed rhinoceros						23		
Stephanorhinus kirchbergensis, Merck's rhinoceros								
Artiodactyla								
Sus scrofa, wild boar						1		
Dama dama, fallow deer				(1 cf)		1, (3 cf)	1	
Cervus elaphus, red deer						3, (1 cf)	2	(1 cf)
D. dama or *C. elaphus*, fallow or red deer				4		29	5	
Capreolus capreolus, roe deer								
Cervidae gen. et sp. indet, indeterminate deer						2		
Bos primigenius, aurochs		1		1				
Bos primigenius or *Bison priscus*, aurochs or bison				2		2		
Large mammal (fox size)								
Large mammal (Roe deer size)							1	
Large mammal (smaller than fallow deer)						2		
Large mammal (Red/fallow deer size)		1		2		6		
Large mammal (larger than red deer)	1					64		
Large mammal (*Bos* or larger)						19		
Large mammal (rhino size)						1		
Large mammal (rhino or larger)						1		
Large mammal (elephant size)								
Indet large mammal			1	1	1	74	3	
Indet small vertebrate								
Indet vertebrate						1		

Counts refer to the number of identified specimens (NISP); where two values are given, the second refers to specimens tentatively identified; bones that could not be identified to taxon were assigned to a size category

6a/6b	*6b*	*6b*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*7*	*8*	*8*	*?*	*?*	
40039/070	*40070*	*40144*	*40099*	*40160*	*40162*	*40078*	*40100*	*40158*	*40068*	*40167*	*40048*	*40049*	*40028*	*40089*	*Unstratified*
2	*165*	*42*	*2*	*3*	*5*	*508*	*293*	*6*	*1*	*1*	*3*	*1*	*1*	*1*	*25*
	2														
	1														
						1									
							1								
							1								
	5					1	1								
	1					1	2								
		1				2									
						61									
		(2 cf)				3	3								
						1	6								
							1								
	2						2, (1 cf)								
	8	1				6	9, (2 cf)								
2	74	23		2	2	50	57	2							9
	1	1					1								
	15	3				18	5	1							
						1									
						2		1		1				1	
							1								
	1	2				3	5								
	4	3		1	1	13	18					1			3
	14					11		1					1		3
	2	1				46	40				2				1
	1						1								
					1	1	38								
			1			172	5								
	40	4	1		1	117	89	1	1		1				9
	1														
	2	1				1									

Table 7.2 Counts and stratigraphical occurrence of vertebrate taxa in sieved samples

Phase	5	5	5	5	5	5	5	5
Context	40025	40025	40025	40025	40025	40025	40025	40025
Sample	40145	40286	40303	40343	40348	40380	40382	40411
Volume (L.)	<1	60	19	-	-	-	-	200
Sieved on site				SOS	SOS	SOS	SOS	
Mollusc sample								
Part sorted								
Lipotyphla								
Sorex minutus, pygmy shrew					+	+		
Sorex sp(p)., shrew				1	+			
Neomys sp., water shrew				1	+			
Soricidae gen. et sp. indet., shrew								
Talpa minor, extinct mole								
Chiroptera								
Myotis daubentonii, Daubenton's bat								
Primates								
Macaca sylvanus, Barbary macaque								
Lagomorpha								
Oryctolagus cuniculus, rabbit				1	1	1		
Rodentia								
Sciurus sp., squirrel								
Spermophilus sp., ground squirrel								+
Clethrionomys glareolus, bank vole				+	+	+		+
Arvicola cantianus, water vole				+	2	1		+
Microtus (Terricola) cf. *subterraneus*, common pine vole						2		
*Microtus agrestis**, field vole								
*Microtus agrestis/M. arvalis***, field or common vole				1	1	2		
Microtus oeconomus, northern vole					1	1		
Microtus sp., vole	+			+	+			+
Apodemus maastrichtiensis, mouse (extinct)								
Apodemus sylvaticus, wood mouse								+
Apodemus sp., mouse					+			+
Carnivora								
Mustela cf. *putorius*, polecat								
Mustela sp., mustelid								
Artiodactyla								
Dama dama, fallow deer								
Cervus elaphus, red deer								
D. dama or *C. elaphus*, fallow deer or red deer								
Capreolus capreolus, roe deer								
Small vertebrates (NISP)								
Fish	5		1	190	207	141		129
Amphibian		2		108	161	77		70
Reptile								
Bird						1		
Small mammal	1			106	107	69	1	70
Pre-Pleistocene fish	3			76	72	109	28	79

+ — present; counts for small mammals refer to the minimum number of individuals (MNI); counts for fishes, amphibians, reptiles, birds, and pre-Pleistocene fish remains (principally shark teeth) refer to the number of elements identified

** Identifications of *M. agrestis* are based on the presence of diagnostic M^2s

* *Microtus agrestis* and *M. arvalis* are difficult to separate using M_1s and are therefore grouped

6a	6a	6a	6a	6a	6a	6a	6a	6a	6b	6b	6b	6b
40039	40039	40039	40103	40103	40103/039	40103	40103/039	40103/039	40070	40070	40070	40070
40238	40261	40278	40300	40300c	40301	40312	40320	40325	40035	40162	40252	40277
40	60	0.5	17	-	33	17	20	19	30	50	1	10
				Y								
									+			+
			+			+			1	4		+
			+							1		1
		+										
		+						+	1		+	
1		+	1		+	1			2	3	+	3
1	1	+	1			+	1		3	3		2
									1			
									+			
		1							1	3	1	1
+	+			+		+						
												+
1			2			+			1	2		2
		1	+					+				
										1		
												1
		3	9	1		1	1		48	148	2	38
4		14	56	5	1	49	3	1	135	284	15	100
						2			3	9		1
									3	9		
165	69	28	95	3	11	55	12	17	208	454	7	291
								1	1	8		4

Table 7.2 (continued 1)

Phase	6b	6b	6b	6b	6b	6b
Context	40070	40070	40070	40070	40070	40070
Sample	40282c (8-15 cm)	40282c (15-22 cm)	40296	40298	40298c	40299
Volume (L.)	-	-	3	20	-	16
Sieved on site						
Mollusc sample	Y	Y			Y	
Part sorted						
Lipotyphla						
Sorex minutus, pygmy shrew						
Sorex sp(p)., shrew				3		1
Neomys sp., water shrew				1		1
Soricidae gen. et sp. indet., shrew						
Talpa minor, extinct mole			+	+	+	+
Chiroptera						
Myotis daubentonii, Daubenton's bat						
Primates						
Macaca sylvanus, Barbary macaque						
Lagomorpha						
Oryctolagus cuniculus, rabbit						
Rodentia						
Sciurus sp., squirrel						
Spermophilus sp., ground squirrel						
Clethrionomys glareolus, bank vole	+		+	3	2	2
Arvicola cantianus, water vole	+	+	+	4		1
Microtus (Terricola) cf. *subterraneus*, common pine vole				1		
*Microtus agrestis**, field vole						
*Microtus agrestis/M. arvalis***, field or common vole				3		
Microtus oeconomus, northern vole						
Microtus sp., vole	+		+			+
Apodemus maastrichtiensis, mouse (extinct)						
Apodemus sylvaticus, wood mouse			1	1		2
Apodemus sp., mouse						
Carnivora						
Mustela cf. *putorius*, polecat						
Mustela sp., mustelid						
Artiodactyla						
Dama dama, fallow deer						
Cervus elaphus, red deer						
D. dama or *C. elaphus*, fallow deer or red deer						
Capreolus capreolus, roe deer						
Small vertebrates (NISP)						
Fish	9		23	137	3	57
Amphibian	6	1	22	224	20	96
Reptile				2		5
Bird						
Small mammal	6	7	22	340	7	151
Pre-Pleistocene fish				2		

+ — present; counts for small mammals refer to the minimum number of individuals (MNI); counts for fishes, amphibians, reptiles, birds, and pre-Pleistocene fish remains (principally shark teeth) refer to the number of elements identified
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6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6b
40070	40070	40070	40070	40070	40070	40070	40070	40070	40070	40070	40070	40070
40299c	40306	40306c	40307	40307c	40308	40308c	40309	40309c	40310	40313	40314	40314c
-	16	-	17	-	11	-	27	-	7	10	28	
Y		Y		Y		Y		Y				Y
											1	
	+	+	1				1					
	1		1				2					
	+		+				+					
2	+		1		+		1			+	1	
+	1		+		+		5	+		1	1	
							1					
							1				+	
							1					
	+				+							
	1		1		+							
			1									
4	51	11	81		27		66		43	4	15	7
10	151	6	71	1	47	4	181	4	14	12	11	16
		1					1		1	1	2	
			3		1						4	
10	96	2	85	1	43	2	215	7	13	11	47	4

Table 7.2 (continued 2)

Phase	6b	6b	6b	6b	6b	6b	6b
Context	40070	40070	40070	40070	40070	40070	40070
Sample	40315	40315c	40316	40316c	40317	40317c	40318
Volume (L.)	28	-	28	-	26	-	28
Sieved on site							
Mollusc sample		*Y*		*Y*		*Y*	
Part sorted							
Lipotyphla							
Sorex minutus, pygmy shrew					+		
Sorex sp(p)., shrew	1	+	1	+	3		1
Neomys sp., water shrew	1		+		2		
Soricidae gen. et sp. indet., shrew							
Talpa minor, extinct mole	+		+		+		+
Chiroptera							
Myotis daubentonii, Daubenton's bat							
Primates							
Macaca sylvanus, Barbary macaque							
Lagomorpha							
Oryctolagus cuniculus, rabbit							
Rodentia							
Sciurus sp., squirrel							
Spermophilus sp., ground squirrel							
Clethrionomys glareolus, bank vole	2		1		2	+	1
Arvicola cantianus, water vole	2		2		2		2
Microtus (Terricola) cf. *subterraneus*, common pine vole							
*Microtus agrestis**, field vole							
Microtus agrestis/*M. arvalis***, field or common vole	1				2		1
Microtus oeconomus, northern vole	1						
Microtus sp., vole							
Apodemus maastrichtiensis, mouse (extinct)					+		
Apodemus sylvaticus, wood mouse	1	2	3				
Apodemus sp., mouse							
Carnivora							
Mustela cf. *putorius*, polecat							
Mustela sp., mustelid	+						
Artiodactyla							
Dama dama, fallow deer							
Cervus elaphus, red deer							
D. dama or *C. elaphus*, fallow deer or red deer							
Capreolus capreolus, roe deer							
Small vertebrates (NISP)							
Fish	244	6	88	1	170	1	1
Amphibian	404	14	216	8	379	4	76
Reptile	11		6		9		6
Bird	2				3		
Small mammal	249	8	174	7	294	6	61
Pre-Pleistocene fish	1						1

+ — present; counts for small mammals refer to the minimum number of individuals (MNI); counts for fishes, amphibians, reptiles, birds, and pre-Pleistocene fish remains (principally shark teeth) refer to the number of elements identified

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6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6b
40070	40070	40070	40070	40070	40070	40070	40070	40070	40070	40070	40070	40070
40318c	40319	40319c	40339	40347	40351	40381	40329	40330	40331	40332	40335	40337
-	13	-	10	-	-	-	-	-	-	-	-	-
			SOS	SOS	SOS	SOS	SOS	SOS	SOS	SOS	SOS	SOS
Y		*Y*										
	Y						*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
						+						
				1			1	+	+	+	2	+
				1		1	2	4	1	1	3	
	+				+							
	+			+	+	+	+	+	+	+	+	
							1					
							1	1				
				1		+					1	
+				3	+	2	4	2		1	6	
+	1			7	+	1	7	8	5	1	4	1
							1				1	
				6		2	2	3	3	2	5	
					+							
				2		3	2				5	
				1								
											1	
											3	
1	3	1	5	108	11	78	*	*	*	*	*	*
3	35	3	2	522	64	237	*	*	*	*	*	*
				2	1	9	*	*	*	*	*	*
	1			8		5	*	*	*	*	*	*
4	18	1		525	39	248	*	*	*	*	*	*
				3			*	*	*	*	*	*

Table 7.2 (continued 3)

Phase	6b	6b	6b	6b	6b	6b
Context	40070	40070	40144	40144	40144	40144
Sample	40338	4033x	40282c (2-8 cm)	40294	40297	40305c
Volume (L.)	-	-	-	10	20	-
Sieved on site	SOS	SOS				
Mollusc sample			Y			Y
Part sorted	Y	Y				
Lipotyphla						
Sorex minutus, pygmy shrew				+		
Sorex sp(p)., shrew				1	2	
Neomys sp., water shrew					+	
Soricidae gen. et sp. indet., shrew						
Talpa minor, extinct mole					1	
Chiroptera						
Myotis daubentonii, Daubenton's bat						
Primates						
Macaca sylvanus, Barbary macaque						
Lagomorpha						
Oryctolagus cuniculus, rabbit						
Rodentia						
Sciurus sp., squirrel						
Spermophilus sp., ground squirrel						
Clethrionomys glareolus, bank vole	+			1	1	
Arvicola cantianus, water vole	+				1	
Microtus (Terricola) cf. *subterraneus*, common pine vole						
*Microtus agrestis**, field vole						
*Microtus agrestis/M. arvalis***, field or common vole						
Microtus oeconomus, northern vole						
Microtus sp., vole	+			+		+
Apodemus maastrichtiensis, mouse (extinct)						
Apodemus sylvaticus, wood mouse				1	3	
Apodemus sp., mouse						
Carnivora						
Mustela cf. *putorius*, polecat						
Mustela sp., mustelid						
Artiodactyla						
Dama dama, fallow deer		1				
Cervus elaphus, red deer						
D. dama or *C. elaphus*, fallow deer or red deer		1				
Capreolus capreolus, roe deer						
Small vertebrates (NISP)						
Fish	*		4	6	157	1
Amphibian	*		5	15	269	9
Reptile	*				3	
Bird	*		2	26	228	5
Small mammal	*					
Pre-Pleistocene fish	*					

+ — present; counts for small mammals refer to the minimum number of individuals (MNI); counts for fishes, amphibians, reptiles, birds, and pre-Pleistocene fish remains (principally shark teeth) refer to the number of elements identified

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6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6b	6
40144	40144	40144	40144	40144	40144	40143	40143	40143	40143	40078	40008
40311	40333	40336a&b	40336a	40336b	?	40253	40267	40282c (0-2 cm)	40284c	40293	40327
10	-	-	-	-	-	1	100	-	-	30	20
	SOS	SOS	SOS	SOS							
								Y	Y		
			4	1			1		1		
1	2		2				+				
1	1		2	1			3				
+	1		+	+			+				
			1								
			1								
+	2		6	5			1				
+	3		7	4			1				
	1			1			2				
	cf		3	1							
			1								
+	+										
			cf								
2	3		4	4			3				
			1								
	1										
	1				2						
8	138	1026				15	226	5	104		
38	309	1116				45	778		30		1
	3	21				21	9		1		
24	300	869				2	269		9	1	3
	1	12									

excavation was assigned a unique find number in the field and their positions were recorded using a 'total station'. Dense clusters of large mammal bone and the larger elephant remains were recorded on plans and with vertical photographs. Some of the bones were in good condition, and because they were buried in sandy sediment could be excavated without any problem. However, many of the fossils, chiefly those buried in clayey sediments, were poorly preserved. Particularly fragile pieces were consolidated on site with a polyvinyl acetate (PVA) solution and lifted in blocks of sediment for transport to the laboratory. Some of the larger bones were too large to lift in sediment blocks and had to be plaster-jacketed before removal. In addition to the hand-retrieved sample, large mammal material was also recovered from wet-sieved sediment samples (see Table 7.2).

One of the major objectives of the fieldwork was to obtain small vertebrates remains to aid reconstruction of the depositional setting and palaeoecology of the human occupation. The small vertebrates were recovered from bulk samples that were wet-sieved to 0.5mm and 1mm. Samples totalling more than 5,700L of sediment were collected as spot samples or in columns and transported to the laboratory for processing. Test samples (usually 10L) were sieved to assess small vertebrate abundance and to identify promising samples for further processing. The resulting residues were air-dried and the graded through a nest of sieves, with sorting aided by binocular microscope to recover the smallest bones and teeth. The presence of other biological remains was noted, and ostracods and molluscs were picked to boost samples in contexts where these remains were uncommon (see Chapters 10 and 11). No artefacts or microdebitage were recovered from the sieved samples. In total, 2,643L of sediment was wet-sieved and sorted under laboratory conditions. On-site sieving concentrated on the tufaceous-channel fill deposits (40070) and the underlying sands (40025), which were sieved through coarser meshes. This processing regime was successful in extending the sample of the rarer small vertebrate taxa and adding significantly to the sample of medium-sized vertebrates, which were otherwise under-represented in the hand-excavated assemblage. Some of the tufa samples proved to be spectacularly rich in small vertebrate material, which included bones of fish, amphibians (newts, frogs, toads) snakes, lizards and birds, as well a diverse range of small mammal taxa (principally voles, mice and shrews). Exceptionally rare elements include a small carnivore, provisionally identified as European polecat (*Mustela* cf. *putorius*) and Daubentons' bat (*Myotis daubentonii*), both of which are first records for the British Middle Pleistocene. In all, about 16,800 small vertebrate remains were identified and counted (Table 7.2), making this one of the largest stratified assemblages of late Middle Pleistocene small vertebrates from Britain.

After cleaning and conservation, the bones were identified by direct comparison with modern skeletal material at the Natural History Museum (London) as well as Pleistocene fossils in the NHM palaeontology collections. Detailed comparisons were made with other Hoxnian samples, including large mammals from Swanscombe and Clacton, and small mammals from Beeches Pit and Barnham (Suffolk). Specific details of the large mammal identifications are given in Chapter 9. Bones that were too fragmentary for positive species attribution were assigned to a size category (for example, rhino-sized, bovid-sized, red/fallow deer-sized) based on the presence of known large mammal taxa in the assemblage (Table 7.1). Bone fragments assigned to the 'elephant-sized' category can only have come from elephants, based on large size and their characteristic cortical structure.

A variety of attributes was recorded for each specimen, these included (in addition to standard anatomical and taxonomic identification), bone portion, fusion-state in postcranial bones and tooth wear (to determine ontogenetic age), as well as standard anatomical measurements (see Chapter 9). Taphonomic analysis of the large mammal remains included investigation of skeletal element representation, breakage patterns and bone surface modifications that occurred between the death of the animal and burial (such as climatically induced weathering, trampling, chewing marks from predator activity and grooves). Also recorded were modifications that occurred during burial, such as root-etching, manganese and iron staining, fracturing through soil movements and compression. Each bone was examined under a variable magnification binocular microscope and illuminated with a strong oblique light from a fibre-optic source. This revealed occasional striations and incisions, some of which are interpreted as cut-marks. To aid in the interpretation of these incisions, high-resolution images were recorded with an Alicona variation focus microscope, which generates three-dimensional models of bone surfaces (see Bello and Parfitt, Chapter 8). The assemblage was also searched for joins between fragments of the same bone and articulation between elements. A taphonomic study was conducted on the small mammal remains to determine the accumulating mechanisms that influenced and potentially biased the assemblage and to provide additional information on site formation processes. The methods of small mammal taphonomic analysis as applied to fossil assemblages are fully described by Andrews (1991).

Quantification of the vertebrate remains uses the number of identifiable specimens (NISP). Quantification of the small mammal abundance is based on NISP and the minimum numbers of individuals (MNI) calculated from counts of the most common element (usually upper or lower first molars for rodents, mandibles for soricids and postcrania (humeri) for moles). Ecological interpretations are based on the habitats, ecology and geographical ranges of extant mammal species (Corbet and Southern 1977; Bjarväll and Ullström 1986; Mitchell-Jones *et al.* 1999; ICUN Red List of Threatened Species).

Material and data archives are housed at the Natural History Museum, London and copies of data lists have additionally been lodged with Oxford Archaeology.

Table 7.3 Stratigraphical distribution of mammal taxa from Southfleet Road by phase. Shrews from the tufa (Phase 6b, context 40070) include at least four species of *Sorex*: pygmy shrew (*Sorex minutus*), two medium-sized species (the largest of which is similar in size to common shrew *S. araneus*) and a large species represented by a mandible fragment that is indistinguishable from that of the Early-Middle Pleistocene *Sorex* (*Drepanosorex*).

Phase	*3*	*5*	*6a*	*6b*	*6*	*7*
PISCES						
Anguilla anguilla, eel		+		+		
Esox lucius, pike		+		+		
Salmonidae, salmon family		+		+		
Rutilus rutilus, roach				+		
Scardinius erythrophthalmus, rudd				+		
cf. *Phoxinus phoxinus*, minnow				+		
Tinca tinca, tench		+		+		
Cyprinidae indet., carp family		+	+	+		
Pungitius pungitius / *Gasterosteus aculeatus*, nine-spined or three-spined stickleback		+	+	+		
Gymnocephalus cernuus / *Perca fluviatilis*, ruffe or perch		+				
AMPHIBIA						
Triturus sp., newt		+	+	+		
Bufo sp., toad		+	+	+		
Hyla sp., tree frog				+		
Rana sp., frog		+	+	+		
REPTILIA						
Lacertidae, undetermined lizard				+		
Anguis fragilis, slow worm				+		
Ophidia indet., snake				+		
AVES						
Anatidae sp., undetermined duck				+		
Turdus philomelos / *T. iliacus*, song thrush or redwing				+		
Aves indet., bird		+		+		
MAMMALIA						
Lipotyphla						
Sorex minutus, pygmy shrew		+		+		
Sorex sp(p)., shrew		+	+	+		
Neomys sp., water shrew		+	+	+	+	
Soricidae gen. et sp. indet., shrew			+	+		
Talpa minor, extinct mole			+	+	+	
Chiroptera						
Myotis daubentonii, Daubenton's bat				+		
Primates						
Macaca sylvanus, Barbary macaque				+		
Homo sp., hominin (C = Clactonian)	+	C?	C	C	C	C
Lagomorpha						
Oryctolagus cuniculus, rabbit		+	+	+		
Rodentia						
Sciurus sp., squirrel				+		
Spermophilus sp., ground squirrel		+				
Clethrionomys glareolus, bank vole		+	+	+		
Castor fiber, beaver					+	
Arvicola cantianus, water vole		+	+	+	+	
Microtus (Terricola) cf. *subterraneus*, common pine vole		+		+		
Microtus agrestis, field vole				+		
Microtus agrestis / *M. arvalis*, field or common vole		+	+	+		
Microtus oeconomus, northern vole		+		+		
Microtus sp., vole		+	+	+		
Apodemus maastrichtiensis, extinct mouse				+		
Apodemus sylvaticus, wood mouse		+	+	+		
Apodemus sp., mouse		+	+	+		

Table 7.3 (continued)

Phase	*3*	*5*	*6a*	*6b*	*6*	*7*
Carnivora						
Mustela cf. *putorius*, polecat				+		
Mustela sp., mustelid				+		
Panthera leo, lion		+				
Proboscidae						
Palaeoloxodon antiquus, straight-tusked elephant		+		+	+	
Elephantidae gen. et sp. indet., indeterminate elephant					+	
Perissodactyla						
Stephanorhinus hemitoechus, narrow-nosed rhinoceros			+	cf	+	
Stephanorhinus kirchbergensis, Merck's rhinoceros					+	
Artiodactyla						
Sus scrofa, wild boar			+		+	
Dama dama, fallow deer		cf	+	+	+	
Cervus elaphus, red deer		+	+	+	+	
D. dama or *C. elaphus*, fallow deer or red deer		+	+	+	+	
Capreolus capreolus, roe deer				+	+	
Cervidae gen. et sp. indet, indeterminate deer			+	+	+	
Bos primigenius, aurochs	+	+			+	
Bos primigenius or *Bison priscus*, aurochs or bison		+	+		+	+

RESULTS

The following account provides a summary of the bone assemblages recorded within the stratigraphical framework of the site (Table 7.3). The Minimum Number of Individuals (MNI) was estimated for large mammal assemblages for the main phases. For post-crania, MNIs calculations were based on most numerous non-reproducible skeletal element (excluding shed antlers), with pairing for age (cf. Chaplin 1971; Klein and Cruz-Uribe 1984).

The only species with an MNI of more than one per context is red deer *Cervus elephus* from context 40100, which has two individuals based on scapulae. Specimens not identified to taxon were placed into animal size-groups using bone size and cortical thickness.

Phase 3

Very few vertebrate fossils were recovered from the gravelly sands and silts (Phases 1-4) at the base of the succession. The only identifiable specimen is the posterior part of an aurochs *Bos primigenius* skull with both horncores, from context 40062 (Fig. 7.1; Fig. 9.17). The occurrence of aurochs, which is only known from temperate periods in the British Pleistocene, implies that the prevailing climate was not unduly severe. Its favoured habitats probably included parkland with scattered trees, grassy meadows and wetland habitats, supporting rich herbaceous vegetation (Legge 2010). This provides the only indication from the mammalian evidence of local vegetation conditions during the deposition of this early phase of the site sequence.

Phase 5 (context 40025)

The sediments of Phase 5 are bedded sands with silty clay laminae, which show clear evidence of water transport. Numerous Tertiary shark teeth (Table 7.2) and mollusc fragments were present in most of the sieved residues, supporting the conclusion that the deposit had received substantial input from Tertiary deposits (particularly Woolwich Beds) from high ground to the west (Chapter 4). Hand-collected large mammal material comprises a low density of larger mammal bones, which were dispersed through the deposit (Fig. 7.2). All but one of these was excavated from the area between Trenches B and C. There are no obvious concentrations or anatomically associated (refitting or articulating) specimens. Surfaces of some of the large mammal bones show cracking and splitting (37%) indicating that they were exposed on a land surface. The condition of the bones is variable; some are well preserved (for example the complete lion *Panthera leo* astragalus, Fig. 9.3), but most are fragmentary or weathered (for example the aurochs maxilla and teeth, Fig. 9.18). More than half are iron-stained, but none show evidence of water transport.

Bulk sieving yielded a relatively rich assemblage of small-vertebrate remains (Table 7.2). These appear to be concentrated in localised patches with immediately adjacent samples yielding much lower concentrations. Other samples were totally devoid of Pleistocene faunal material. Fish bones were by far the most abundant small vertebrate specimens, comprising almost 46% of the identifiable remains (Fig. 7.3). Taxa represented included pike *Esox lucius*, eel *Anguilla anguilla*, salmonid (Salmonidae), stickleback (Gasterostidae), ruffe *Gymnocephalus cernuus* or perch *Perca fluviatilis*, and undetermined cyprinids (Cyprinidae: carp family). The assemblage reflects a freshwater environment, probably a large slow-moving watercourse. A fully temperate climate is indicated by the presence of thermophilous fish species (for example tench *Tinca tinca*). Aquatic environments, marsh and other damp habitats are indicated by anurans

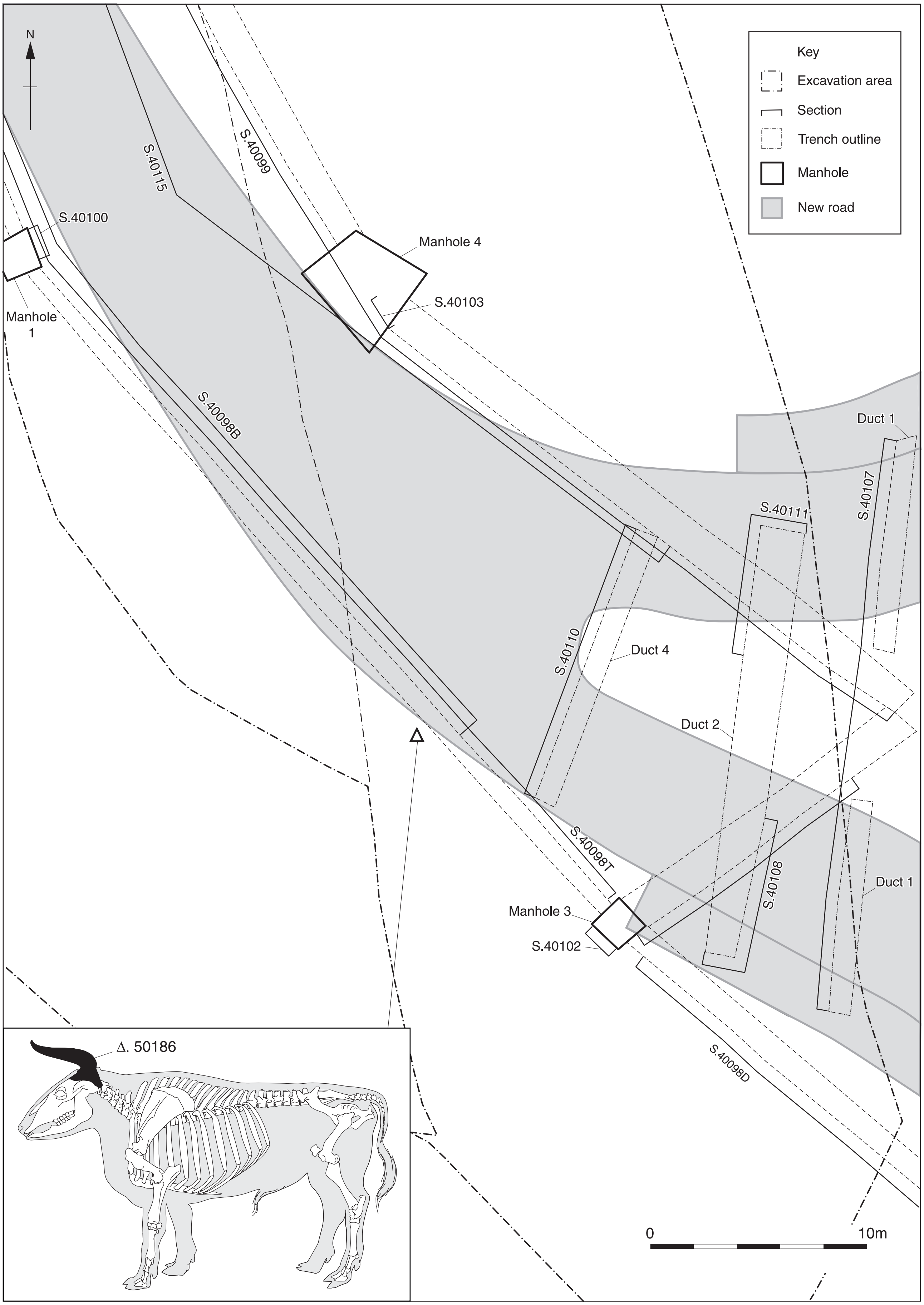


Figure 7.1 Plan showing the location of the aurochs frontal found during machining south of the road cutting near the roundabout at *c* 23m OD. Inset shows the outline of an auroch's skeleton with the frontal (Δ. 50186) indicated

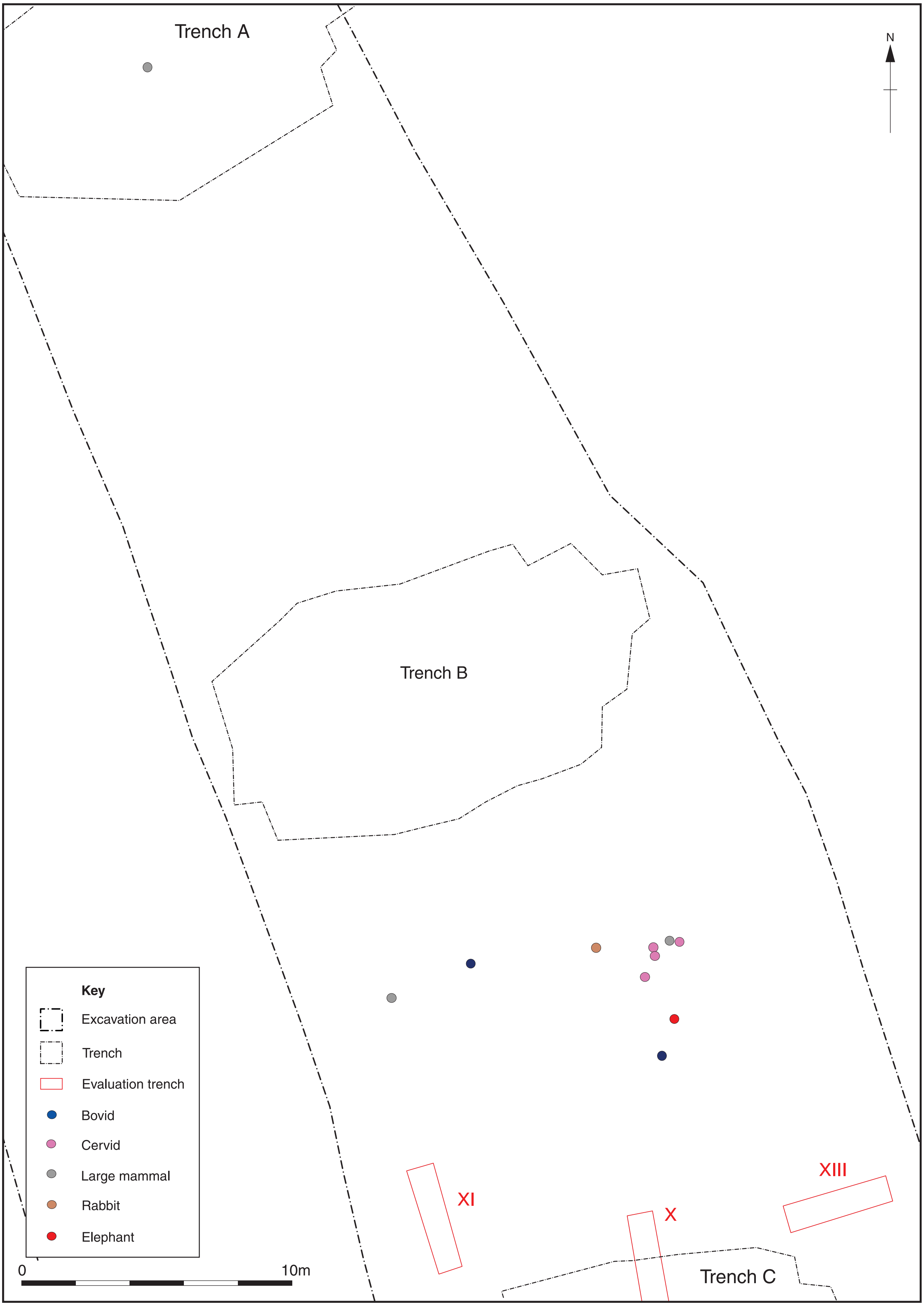


Figure 7.2 Distribution of large mammal bones in Phase 5

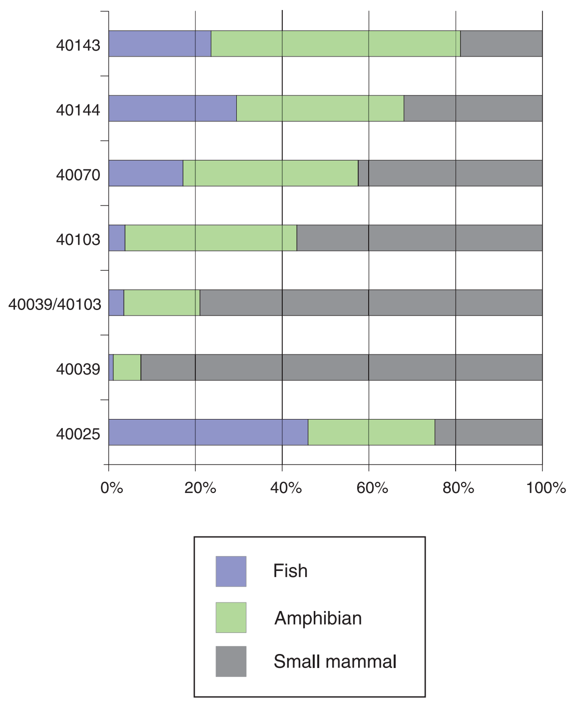
(frogs and toads) and newts, which make up 29% of the small vertebrate assemblage (Fig 7.3).

The small number of identifiable large mammal remains (Table 7.4) precludes any meaningful study of taxonomic abundance and ecology, therefore counts are given for identifiable specimens (NISP), rather than minimum number of individuals (MNI). The assemblage does, however, include several species that have specific environmental requirements. These include aurochs and fallow deer *Dama dama*, both of which probably favoured open deciduous or mixed woodland, grassy meadows and wetland habitats. The medium and large-sized ungulates would have provided prey for lions, which prefer to hunt in open grassland or parkland. Turner (1997) has suggested that the greater size of the Pleistocene lions may mean that large bovids, such as aurochs, were also hunted. Rabbits *Oryctolagus cuniculus* build warrens in soft, well-drained, soils. They prefer mixed habitats of grassland with scrubby woodland providing shelter from predators, but avoid coniferous woodland and cold or humid habitats. Dry grassland is also indicated by ground squirrel, *Spermophilus* sp., which is represented by a fragmentary upper cheek tooth. This constitutes the only record to date from the Hoxnian of a species that is more commonly found in cold stage contexts.

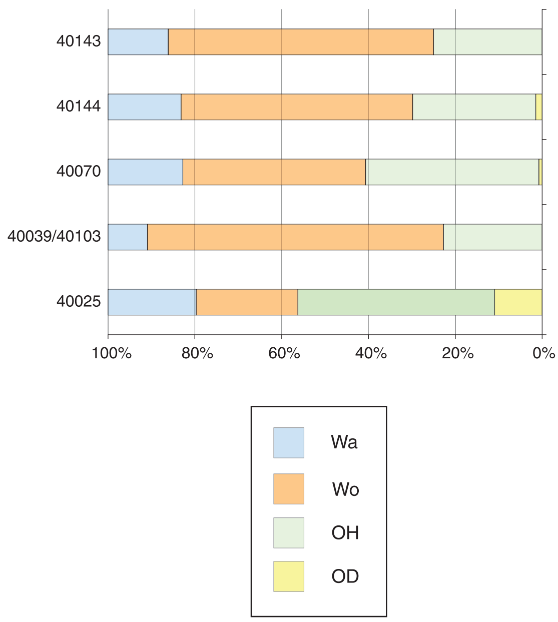
The tusk of a straight-tusked elephant *Palaeoloxodon antiquus* was also recovered (Fig. 9.4). Most of the bones are crushed and stained with iron or manganese. The surface layers of the tusk have longitudinal and circumferential flaking from exposure to weathering, but the surfaces of the other bones are generally well preserved. Crushing from sediment pressure had deformed the tusk, giving it an apparent curvature that was the basis for its erroneous preliminary identification as *Mammuthus* (Wenban-Smith *et al.* 2006).

The small mammal assemblage includes voles, mice and insectivores and is notable for the relatively high proportion of rodents that prefer damp grassland and other waterside habitats (Fig. 7.3b). Of these the water vole, *Arvicola* , is generally a semi-aquatic species, which burrows into the banks of ponds and slow rivers wherever there is dense vegetation to provide food and cover. Marshes, reedbeds and damp grassland are also a favoured habitat of the northern vole *Microtus oeconomus*, while bank vole *Clethrionomys glareolus* would have preferred scrub or woodland. Rabbits favour open grassland, specifically areas with drier soils and warm microclimates. Overall, the fauna is consistent with extensive open floodplain grassland in a temperate climate.

The mammal assemblage appears unusual as it consists of thermophiles (rabbit and fallow deer) together with ground squirrel and northern vole which are generally thought of as indicators of cool/cold climates in a north-western European context. This association has not previously been found in the British Pleistocene. Today, the natural ranges of rabbit, northern vole and ground squirrels do not overlap, although areas of congruence result from human intervention (Mitchell-



(a): number of identified fragments for fish, amphibians and small mammals as a percentage of the total small vertebrate assemblage.



(b): groupings of small mammals into ecological categories (following Cuenca-Bescos *et al.*, 2005 and Rodríguez *et al.* 2011):
Wa - semi-aquatic favouring waterside habitats,
Wo - woodland including margins and glades with ground cover,
OH - open humid grassland,
OD - open dry grassland

Figure 7.3 Summary diagram of the vertebrate succession at Southfleet Road, showing changes in the composition and ecology of the small vertebrate assemblages

Table 7.4 Phase 5 (context 40025). Taxonomic list of large mammals with body-part data and number of fragments (NISP)

Taxon	*NISP*	*Body parts*
Oryctolagus cuniculus	2	Upper molar, L ischium frag
cf. *Dama dama*	1	L antler frag (shed)
Cervidae gen. et sp. indet. (red/fallow deer sized)	4	3 antler frags., R innominate frag
Panthera leo	1	R astragalus
Palaeoloxodon antiquus	1	Tusk
Bos primigenius	1	R premaxilla, maxilla with $M^{1\text{-}3}$ (mid-wear)
Bovidae gen. et sp. indet.	2	L nasal, skull frag
Indet. large mammal (red/fallow deer size)	2	Sacrum frag, long bone shaft frag
Indet. large mammal	1	Indet. bone frag

Table 7.5 Phase 6a. Taxonomic list of large mammals with body-part data and number of fragments (NISP) from contexts 40039 and 40103

Taxon	*NISP*	*Body parts*
Context 40039		
Oryctolagus cuniculus	1	L $M_{1\text{-}2}$
S. hemitoechus & *S.* cf. *hemitoechus*	23	Teeth (R P^3, R P^4, R M^1 frag, L P^4, 3 L M^1 frags., R M^2 , R M^3, maxilla frags, 2 L P^4 frags, L M^2, L M^3, L. upper premolar frag, 5 cheek tooth frags), L & R petrosal, occipital condyle & skull frags, R lunar
Sus scrofa	1	L upper canine tip (unworn)
Dama dama & cf. *Dama dama*	4	Teeth (L$M^{1 \text{ or } 2}$, L M^3 – mid wear), L astragalus, L distal tibia
Cervus elaphus & cf. *Cervus elaphus*	4	Axis frag, R distal scapula, R astragalus, L astragalus frag
Cervidae gen. et sp. indet. (red/fallow deer sized)	33	R occipital condyle, frontal with part of antler below base, antler base frag (shed), 15 antler frags, teeth (L M^3, upper molar & maxilla frag, lower molar frag, molar frag, 3 cheek tooth frags), L distal humerus, distal humerus frag, R femur proximal epiphysis (fused), L metatarsal prox & shaft, L metatarsal shaft frag, metapodial shaft frag, metapodial distal condyle
Bovidae gen. et sp. indet.	3	L scaphoid, pisiform, lunate
Indet. large mammal (rhinoceros or larger)	3	2 tooth frags, indet. bone frag
Indet. large mammal (*Bos* or larger)	18	4 skull frags, condyle, long bone shaft frag, 12 indet. bone frags
Indet. large mammal (red deer or larger)	64	Tooth frag, 2 skull frags, long bone shaft frag, 60 indet. bone frags
Indet. large mammal (red/fallow deer size)	5	Petrosal, vertebra frag, 3 long bone shaft frags
Indet. large mammal (smaller than fallow deer)	2	2 long bone shaft frags
Indet. large mammal	71	2 long bone shaft frags, 69 indet. bone frags
Indet. vertebrate	1	Indet bone frag
Context 40103		
Dama dama	1	L antler base with brow tine (shed)
Cervus elaphus	1	R antler base with brow tine (shed), L metatarsal (prox. & shaft) frag
Cervidae gen. et sp. indet. (red/fallow deer sized)	5	Upper cheek tooth frag, molar frag, 2 antler frags, L humerus shaft frag
Indet. large mammal (roe deer size)	1	Rib frag
Indet. large mammal	2	2 indet. bone frags
Context 40103/039		
cf. *Cervus elaphus*	1	L scapula frag

Jones *et al.* 1999). Ground squirrels are restricted to steppe grassland in continental parts of Eurasia (Mitchell-Jones *et al.* 1999). Although common in cold stage assemblages from Britain, ground squirrel also occurs during warm periods in the Thames Valley in the Late Middle Pleistocene. Similarly, northern vole (a common member of cold stage assemblages in Britain) is also found in association with peak interglacial conditions (Stuart 1982) during the Last Interglacial (MIS 5e) and during temperate peaks of the previous interglacial (MIS 7) in the Ebbsfleet Valley (Wenban-Smith *et al.* forthcoming).

Phase 6a (Contexts: 40039, 40103)

Overlying the sand sequence of Phase 3 is a thick accumulation of non-calcareous clay with an interbedded silty tufaceous deposit that makes up Phase 6. The basal clay

Figure 7.4(a) Distribution of large mammal bones in Phase 6a: context 40039

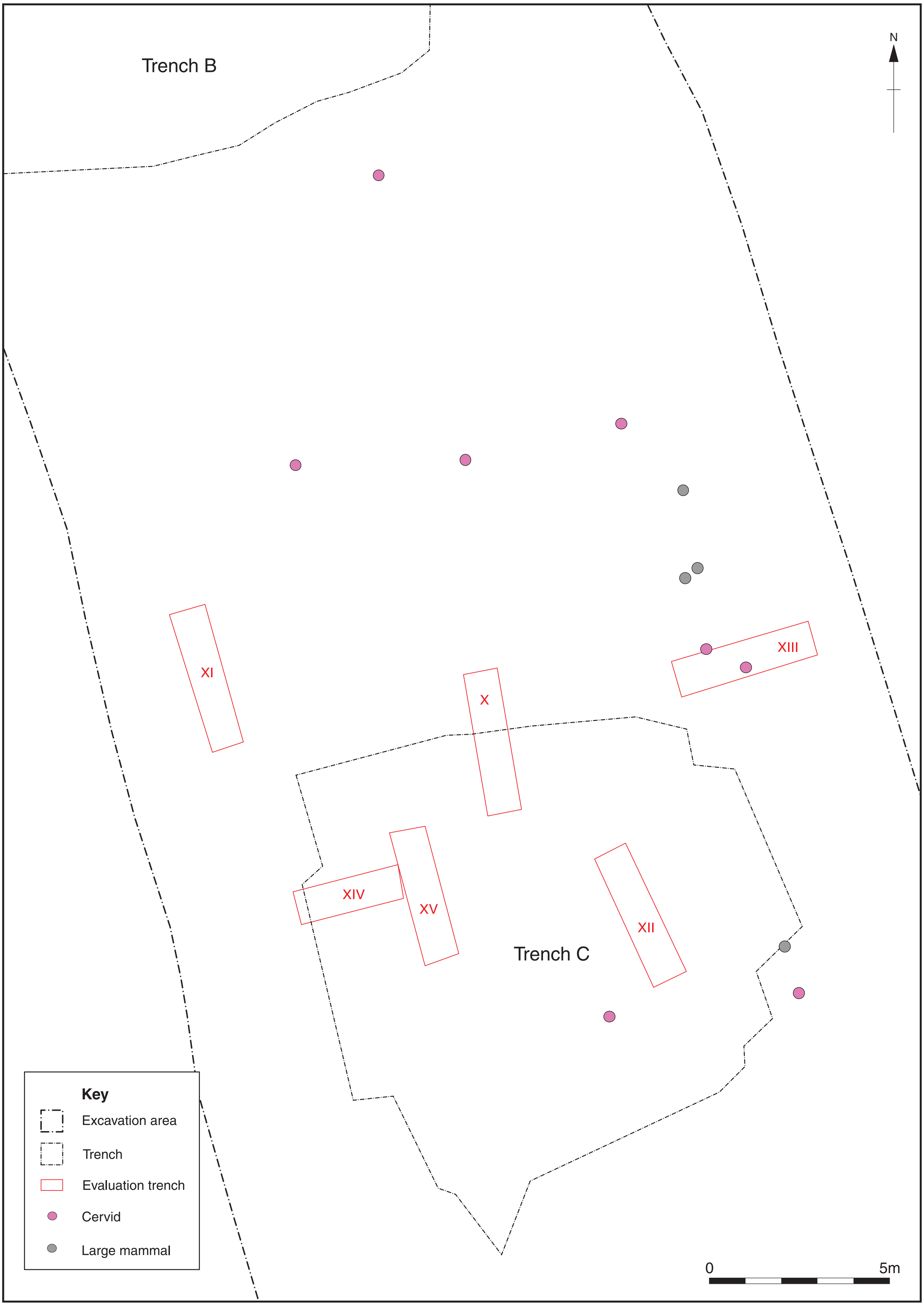


Figure 7.4(b) Distribution of large mammal bones in Phase 6a: context 40103

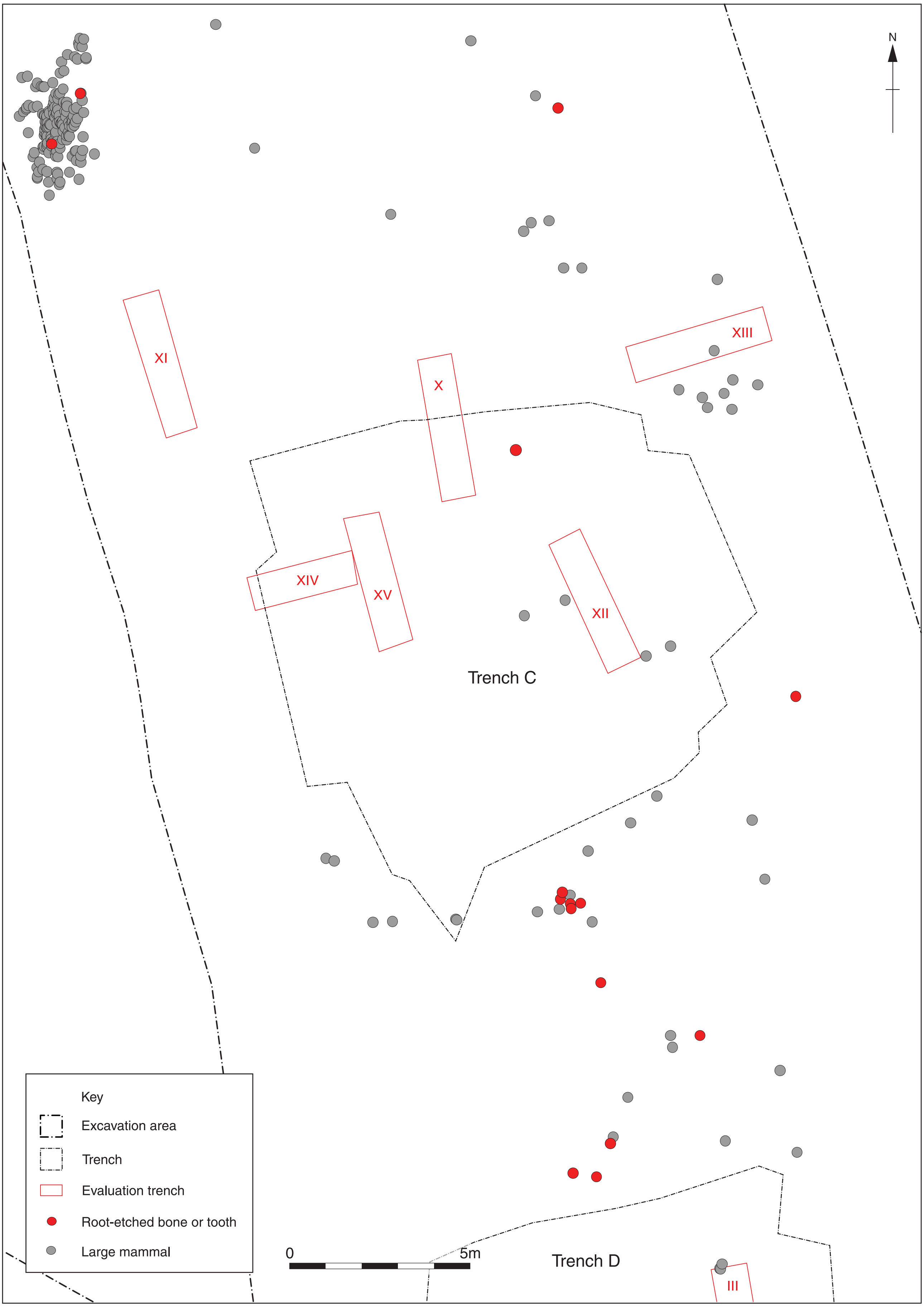


Figure 7.5 Distribution of root-etched bones from context 40039

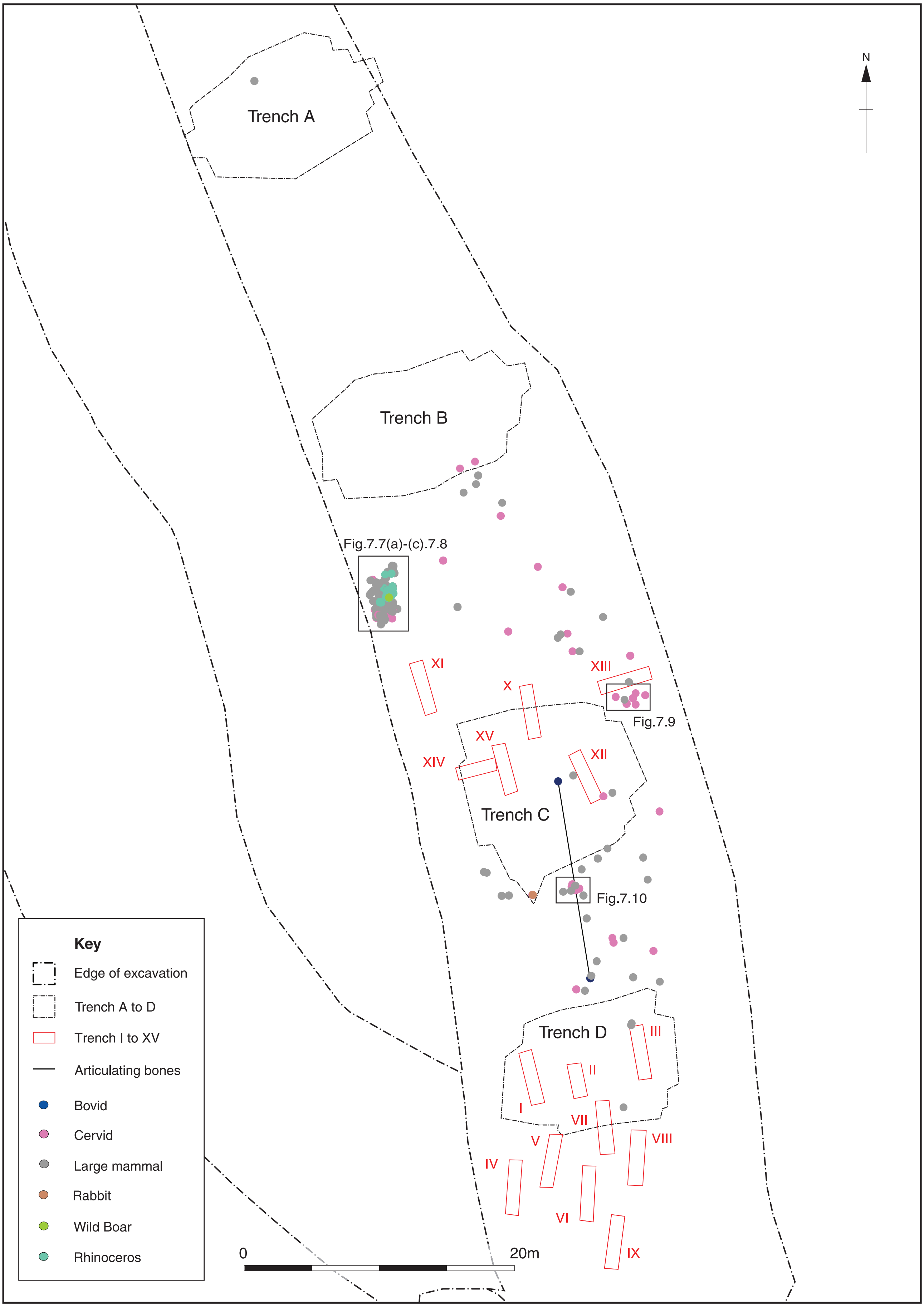


Figure 7.6 Distribution of large mammal bones from context 40039, showing locations of associated bones from the same individual. For detailed plots see Figs 7.7–7.10

unit (40039) in this sequence is characterised by iron staining and micromorphological features that indicate woodland soil formation. This unit is overlain by mottled clay (interpreted as a flood deposit), which has similarly indications of pedogenesis (Chapter 5 and Appendix 7).

Large mammals are infrequent in context 40103 (NISP = 13), but the assemblage from 40039 is more substantial (NISP = 234) (Table 7.5). Small vertebrates occur in nearly equal numbers in both units (context 40039: NISP = 283; context 40103: NISP = 276). The assemblages from the two contexts are described separately below and the spatial distribution of the large mammal bones is plotted in Figure 7.4a-b.

Bone material from context 40039 is poorly preserved due to decalcification and compaction of the sediments and in general is hard to identify (27.5% identified to taxon). Most fragments are smaller than 50mm in length (68.2%) and often disintegrating and corroded with pitted surfaces as a result of chemical leaching of bone. These corrosive processes have removed much of the outer cortical bone in many specimens (only 40% have more than 75% of the original outer surface preserved). In these cases, all but the most recent stages of surface modifications will have been removed by post-depositional corrosion and rooting, which has resulted in pitting of the bone surfaces. There are, however, indica-

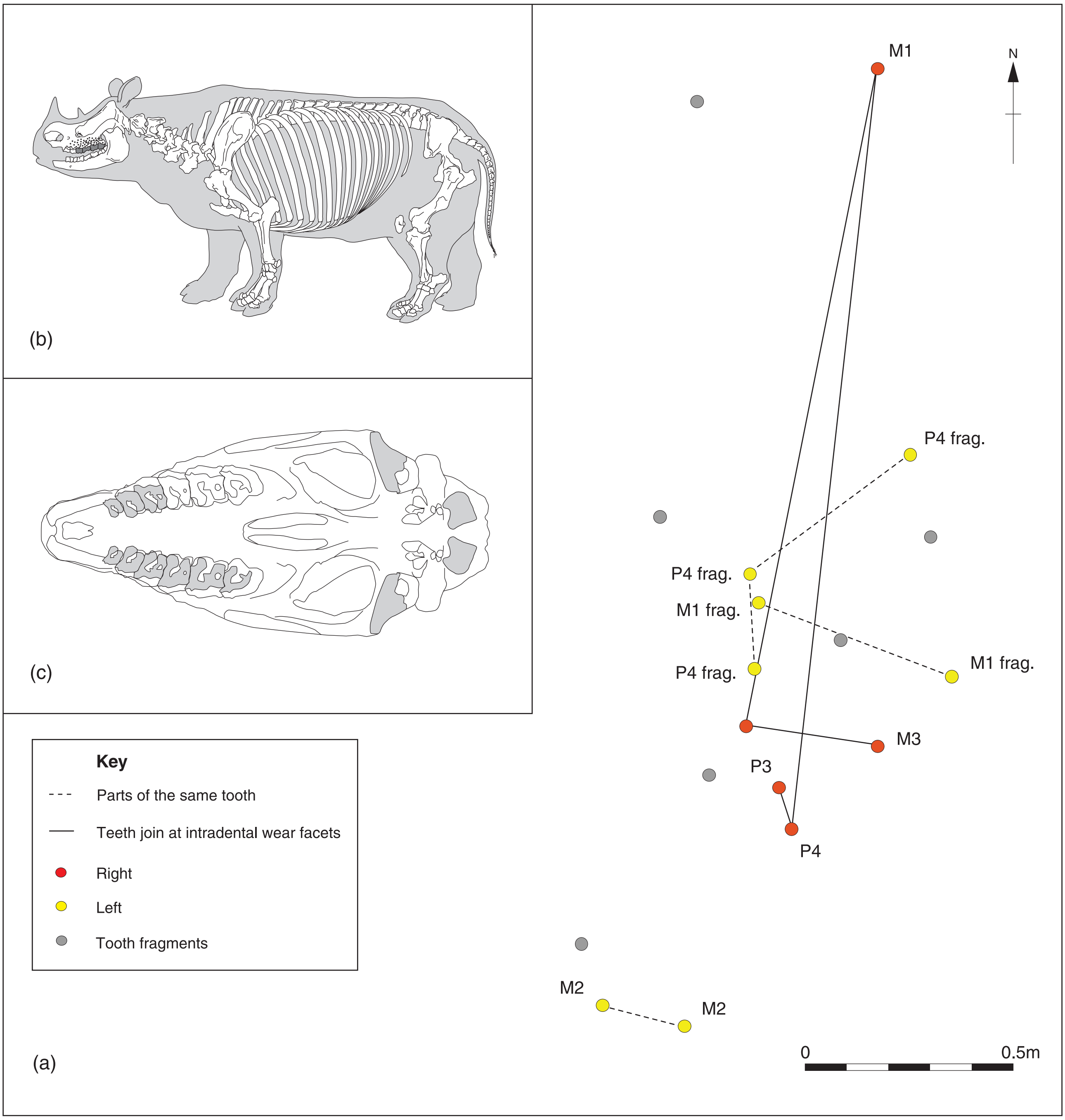


Figure 7.7 (a) distribution of rhinoceros teeth and refits; (b) outline of rhinoceros skeleton with pieces recovered (shaded) from the 'rhinoceros scatter'; (c) outline of rhinoceros skull (occlusal view), showing associated teeth and tooth fragments (shaded)

tions that the bones were modified by carnivores (1.7%) and exposed to weathering (25.1%). Root-etching (6.9%) indicates vegetation cover and burial in a soil (Fig. 7.5). The colour of most of the bones is reddish brown (iron-stained), but colour ranges from white to dark brown. Over half of the bones are iron-stained, but less than one percent have any surface deposits of manganese.

In some cases it has been possible to identify refitting and associated skeletal remains from the same individual. There are four groups of spatially and stratigraphically associated remains (Fig. 7.6). These are a crushed and poorly preserved cranium of narrow-nosed rhinoceros *Stephanorhinus hemitoechus* with most of the upper dentition, two articulating bovid foot bones, the hind-limb bones of a fallow deer and parts of a broken fallow deer antler. The identifiable parts of the rhinoceros skull include the crushed left maxilla with associated M^2 and M^3, an occipital condyle, both perotic bones and several complete and broken cheek teeth (Fig. 7.7 a-c). The associated scatter of comminuted bones includes pieces that are almost certainly parts of the rhinoceros cranium, but they are too fragmentary to identify with certainty. A rhinoceros lunate was found 5m to the east, but it is not possible to say whether this bone is from the same individual. The other cranial pieces and teeth form a dispersed scatter covering about 7 m^2, (Figs 7.7a and 7.8) and the longest refit distance is 0.5m. The state of wear of the teeth (early-mid wear) implies a prime-aged individual. The cluster also includes the axis vertebra of a red deer, a third upper molar of fallow deer and the tip of a wild boar canine; these are likely to represent part of the background scatter of bones. One curious aspect is breakage of the teeth that occurred before they were buried. This breakage includes chipping and flaking of the enamel, and several of the teeth have been broken into pieces. The latter group includes pieces that can be refitted, but the some of the smaller pieces are missing.

The second group of associated bones includes a metatarsal, tibia and astragalus from the left hind-leg of a fallow deer (Fig. 7.9). The pieces form a tight cluster (*c* 1 m^2), with large carnivore gnawing on one of the metatarsal fragments. Studies of carcass decay in natural situations shows that lower hind-limbs are often the last parts to separate into individual bones. This is because the foot bones are tightly bound by tendons and ligaments, which are themselves attached by strong tissue-attachments to the long bones. The third associated group is a cluster of five antler fragments surrounding a frontal bone with the attached basal part of the antler (Fig. 7.10). One of the antler fragments can be positively identified as fallow deer, and the other pieces are not inconsistent with this identification. This cluster covers about 2 m^2. The final associated group is a bovid left scaphoid that articulates with the lunate; these bones are 15m apart (Fig. 7.6).

The associated groups from context 40039 capture moments in the taphonomic history of the assemblage and help to answer questions about the dispersal and destruction of bones at the site. The main processes operating on the bones were clearly destructive, through the actions of mammalian predators, combined with weathering and trampling. These pre-burial processes acted to disperse and fragment the disarticulated bones. The general low-density of bone finds throughout this unit supports this interpretation and shows that there no significant accumulating agencies (eg, denning carnivores). Post-depositional processes were responsible for further fragmentation and probably also account for the loss of bones through soil corrosion. All of these processes are indicative of taphonomic alterations occurring on a stable land surface.

The small vertebrate faunas of contexts 40103 and 40039 differ from Phase 5 in a number of respects. The most conspicuous difference is the rarity of fish remains, accounting for no more than 1% of the total small vertebrate assemblage in context 40039 and about 4% in context 40103. This is substantially lower than in Phase 5, where fish account for about 46% of the total (Fig. 7.3a). The abrupt decline in fish remains implies that the waterbody had dried-up or that the river had migrated away from the site. The proportion of amphibian (newt, frog and toad) bones increases steadily from context 40039 to 40103 (Fig. 7.3a). This may indicate a return to damper (marshy) conditions, possibly heralding the inundation of the area by flushes and spring-fed streams in Phase 6b.

The small mammal faunas differ from that of Phase 5 in the abundance of woodland taxa (bank vole, wood mouse *Apodemus sylvaticus*) and in the much lower frequency of open-ground and semi-aquatic small mammals (Fig. 7.3b). The later group includes water shrew *Neomys* sp., but the small mole *Talpa minor* would have favoured dry habitats with rich soils supporting abundant invertebrates (earthworms, insects and insect larvae). Areas of herbaceous vegetation would have supported the field/common vole and water vole.

The large mammal fauna is also consistent with the presence of a mixture of woodland and water-edge habitats. Wild boar *Sus scrofa* occurs throughout steppe and broadleaved zones of the Palaearctic. In the western part of its range it favours temperate woodland bordered by open marshy habitats and grassland. It avoids taiga and areas with persistent winter snow cover. Most British Pleistocene records are from interglacials, generally in association with deciduous forest, but aurochs is also recorded from interstadials with open birch woodland (Currant 1986a). In the early Holocene aurochs was present in association with open birch and pine woodland. Fallow deer (found in both 40039 and 40103) is also an indicator species for interglacial conditions. It would have lived in sparse deciduous woodland, grassland and marshes. Deciduous woodland also provides the optimum habitat for red deer, although they can also thrive in open conditions. Open temperate grassland with areas of cover provided by trees or scrub is indicated by the presence of rabbit in context 40039. Finally the narrow-nosed rhino would have grazed in woodland glades or grassland.

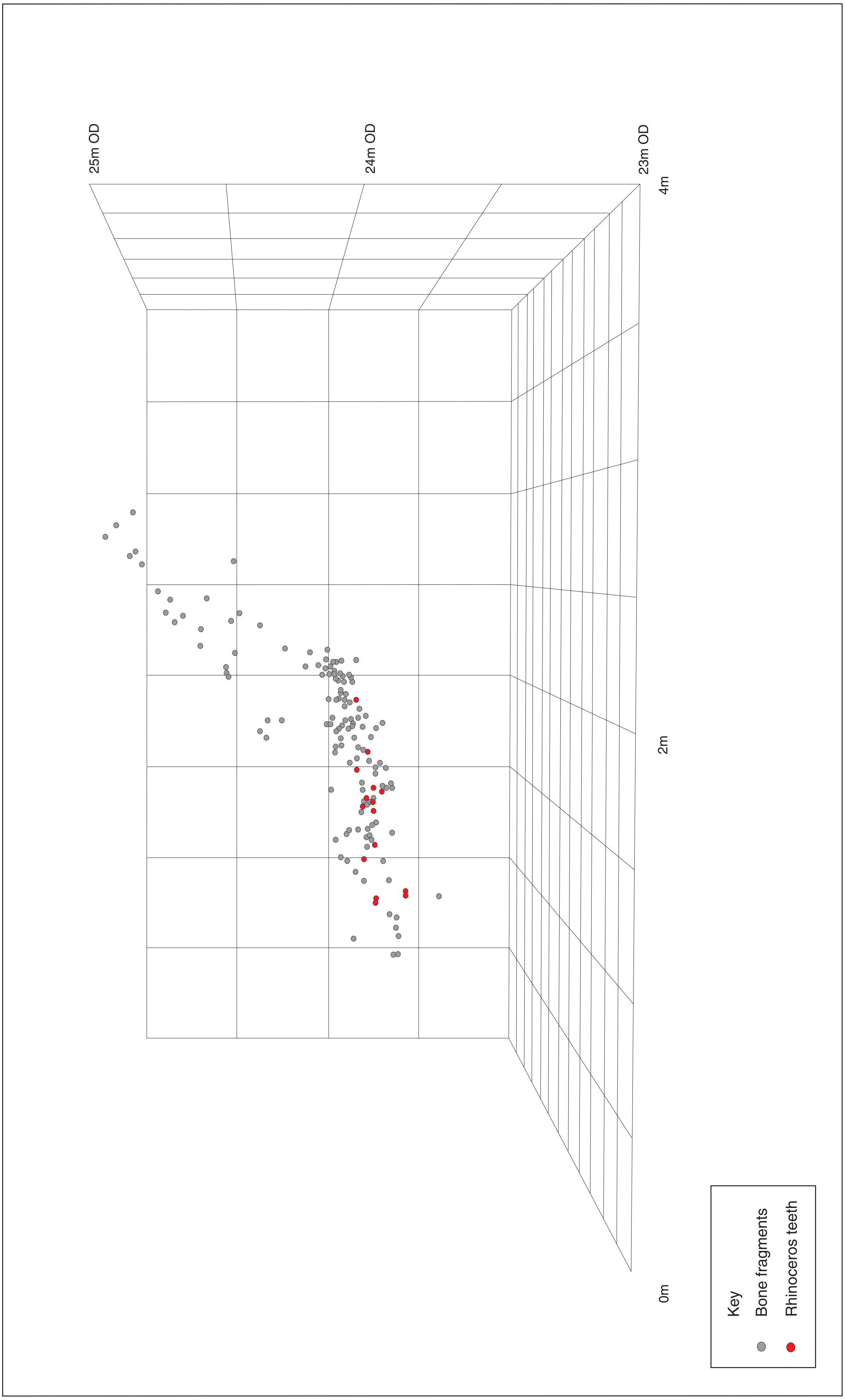


Figure 7.8 3-D plot of rhinoceros teeth (red) and associated bone fragments from context 40039

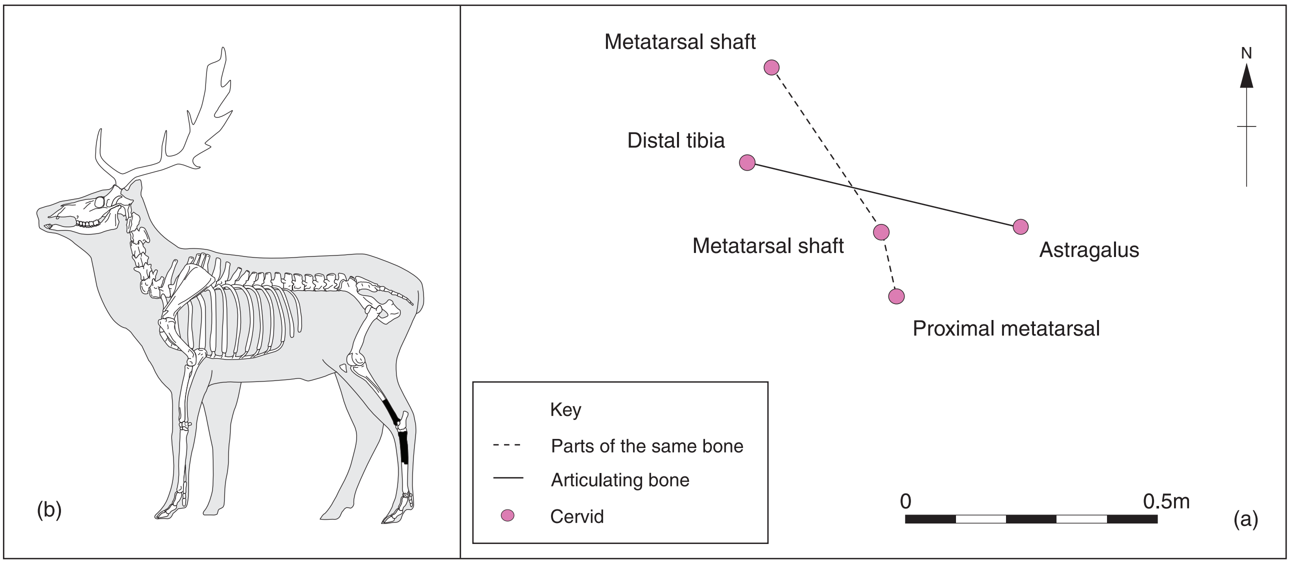


Figure 7.9 Distribution of articulating and refitting hind-limb bones of fallow deer from context 40039. Inset (b) is an outline of a fallow deer skeleton with pieces recovered (shaded)

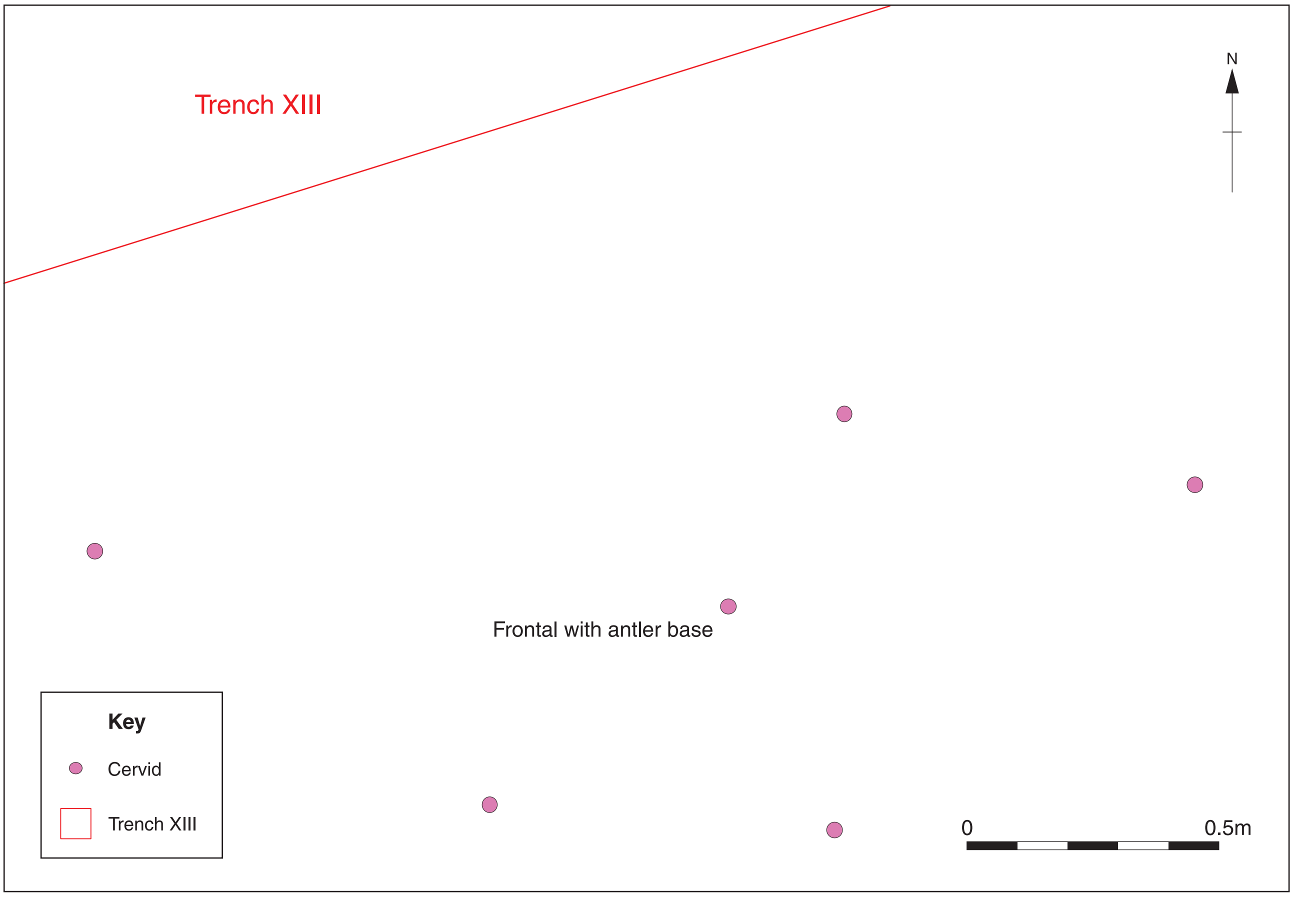


Figure 7.10 Distribution of antler fragments associated with the fallow deer frontal and antler base from context 40039

In conclusion, the mammal fauna indicate a drier more wooded habitat than that of Phase 5. Locally, the environment would have included a mixture of grasslands and woodland. Climatic conditions were probably similar to the present day.

Phase 6b (Contexts: 40070, 40143, 40144)

Immediately above the clays of Phase 6a is a calcareous silt (40070) with tufa oncoliths, rich in shell material and small vertebrates. These sediments fill a linear channel and are overlain by a thin horizon of fine sand (40144), with lenticular patches of white silt (40143) at the top of this succession. As well as being extremely rich in small vertebrate remains, the sediments are also notable for the excellent preservation of most of the vertebrate bones and teeth. Another notable feature of this sequence is the clear ecological succession represented by changes in the composition of the small vertebrates through the sequence. The fact that the same pattern is recorded in different parts of the channel rules out any possibility that the deposit has been mixed or disturbed after deposition.

Context 40070

Although relatively limited in extent, this tufaceous deposit is particularly rich in well-preserved vertebrate fossils (Table 7.6). Large mammal remains are scattered throughout the deposit, with no apparent differentiation (Fig. 7.11). The assemblage consists for the most part of extremely comminuted antlers, but includes teeth and fragments of limb bones and other postcranial elements (Fig. 7.12). Nearly all of the bone fragments are smaller than 50mm. Bone surfaces are well preserved and cortical bone surfaces are generally intact, with about 60% of the pieces retaining 75% or more of the original outer surface. Surface damage is from a combination of subaerial exposure (5%), root-etching (8.6%) and post-depositional corrosion. In addition, edge-rounding was noted on eight of the pieces, but it was not possible to determine whether this was from fluvial transport or some other taphonomic process. Large mammal bones and teeth are typically purple-brown in colour and about 20% exhibit staining by manganese (10%) or iron (9.8%).

Two bones from the tufa have probable artefact-induced cut marks on them; these are the only specimens with linear striations that could possibly indicate butchery of large mammal carcasses at the site (see Chapter 8).

Table 7.6 Phase 6b. Taxonomic list of large mammals with body-part data and number of fragments (NISP) from contexts 40070 and 40144

Taxon	*NISP*	*Body parts*
Context 40070		
Macaca sylvanus	1	1st phalanx
Capreolus capreolus	1	R astraglus
Dama dama & cf. *Dama dama*	2	L antler base (shed), L antler base with brow tine and beam (shed)
Cervus elaphus & cf. *Cervus elaphus*	8	R P^2 (early wear), R $M^{1 \text{ or } 2}$ (early wear), L P_2 (early mid-wear), L P_4 (mid-late wear), L antler base with brow and bez tines (shed), R lunate, L scaphoid, 2nd phalanx
Cervidae gen. et sp. indet. (red/fallow deer sized)	75	L maxilla with deciduous P^{3-4} (early wear), 3 upper molar frags. (early wear), upper molar frag (mid wear), cheek tooth frag, molar frag, tooth frag, L petrosal, occipital condyle, temporal with antler base, 2 antler bases (shed), 51 antler frags, rib frag, R scapula frag, R scapula frag (distal fused), L scapula frag (dist. fused), R humerus shaft (dist. Fused), R humerus (unfused prox. epiphysis), innominate frag, R tibia shaft, 2 left metatarsal frags, 2nd phalanx (unfused proximal epiphysis)
Cervidae gen. et sp. indet.	14	14 antler frags
Indet. large mammal (rhinoceros or larger)	1	Thoracic vertebra frag
Indet. large mammal (*Bos* or larger)	2	Vertebral centrum (cranial and caudal epiphyses fused), skull frag
Indet. large mammal (red deer or larger)	14	14 indet. bone frags
Indet. large mammal (red/fallow deer size)	4	2 skull frags, rib frag, long bone shaft frag
Indet. large mammal (smaller than fallow deer)	1	Long bone shaft frag
Indet. large mammal	39	39 indet. bone frags
Indet vertebrate	2	2 indet. bone frags
Context 40144		
cf. *Palaeoloxodon antiquus*	1	R cuneiform
Stephanorhinus cf. *hemitoechus*	2	R innominate frag (acetabulum), L innominate frag (pubis)
Capreolus capreolus	1	Metacarpal shaft frag
Cervidae gen. et sp. indet. (red/fallow deer sized)	8	R. deciduous P_3 (mid wear), 3 antler bases (shed), R radius (unfused distal epiphysis), L pisiform, R unciform (juvenile), metacarpal shaft frag (juvenile)
Cervidae gen. et sp. indet.	19	19 antler frags
Indet. large mammal (*Bos* or larger)	1	Vertebral centrum (cranial and caudal epiphyses unfused)
Indet. large mammal (red/fallow deer size)	3	Thoracic vertebra frag (cranial and caudal epiphyses unfused), 2 long bone shaft frags
Indet. large mammal (smaller than fallow deer)	2	Thoracic vertebra frag, vertebral centrum (cranial epiphysis unfused)
Indet. large mammal	3	3 indet. bone frags
Indet. vertebrate	1	4 indet. bone frags

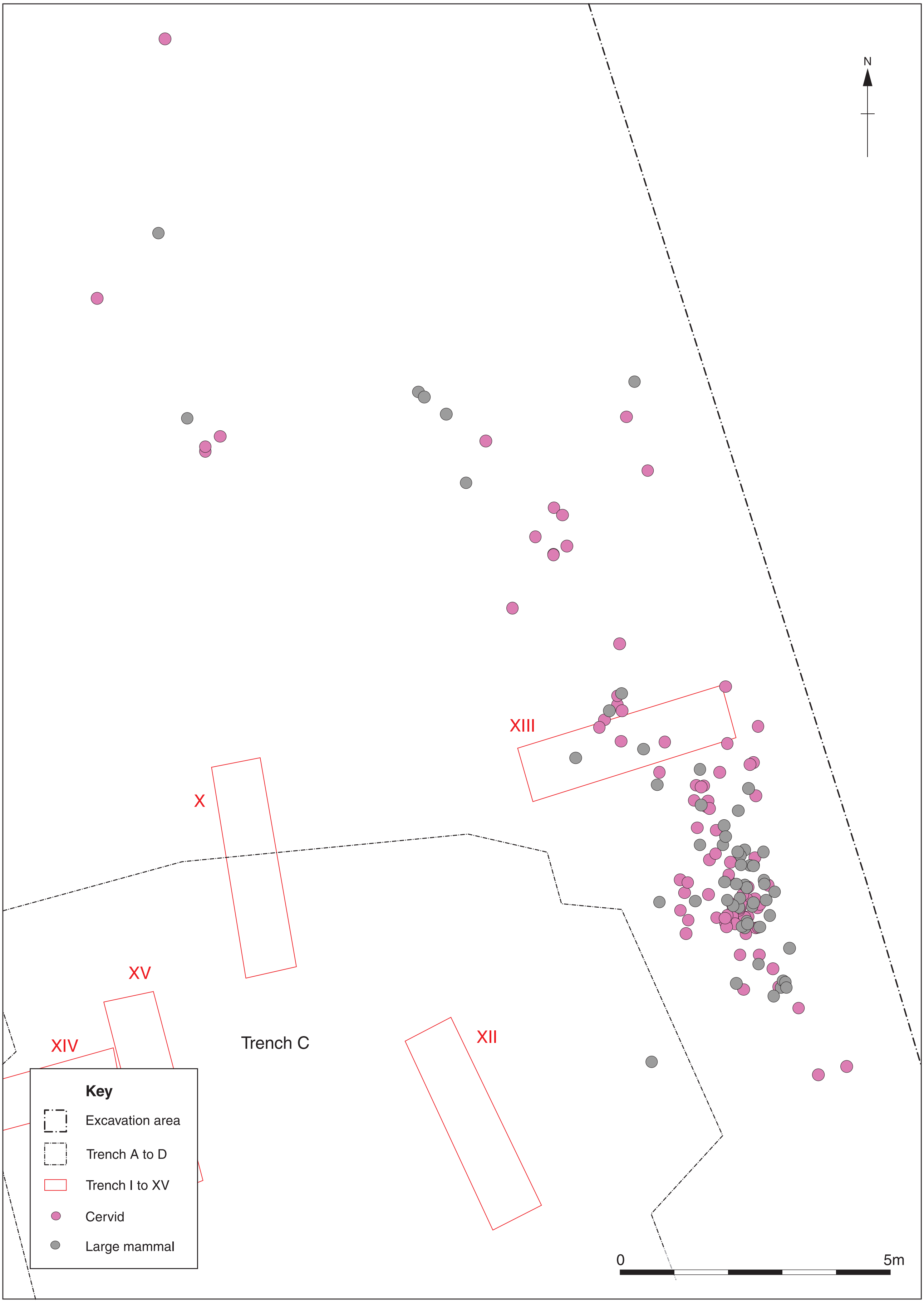


Figure 7.11 Distribution of large mammal bones in Phase 6b, context 40070

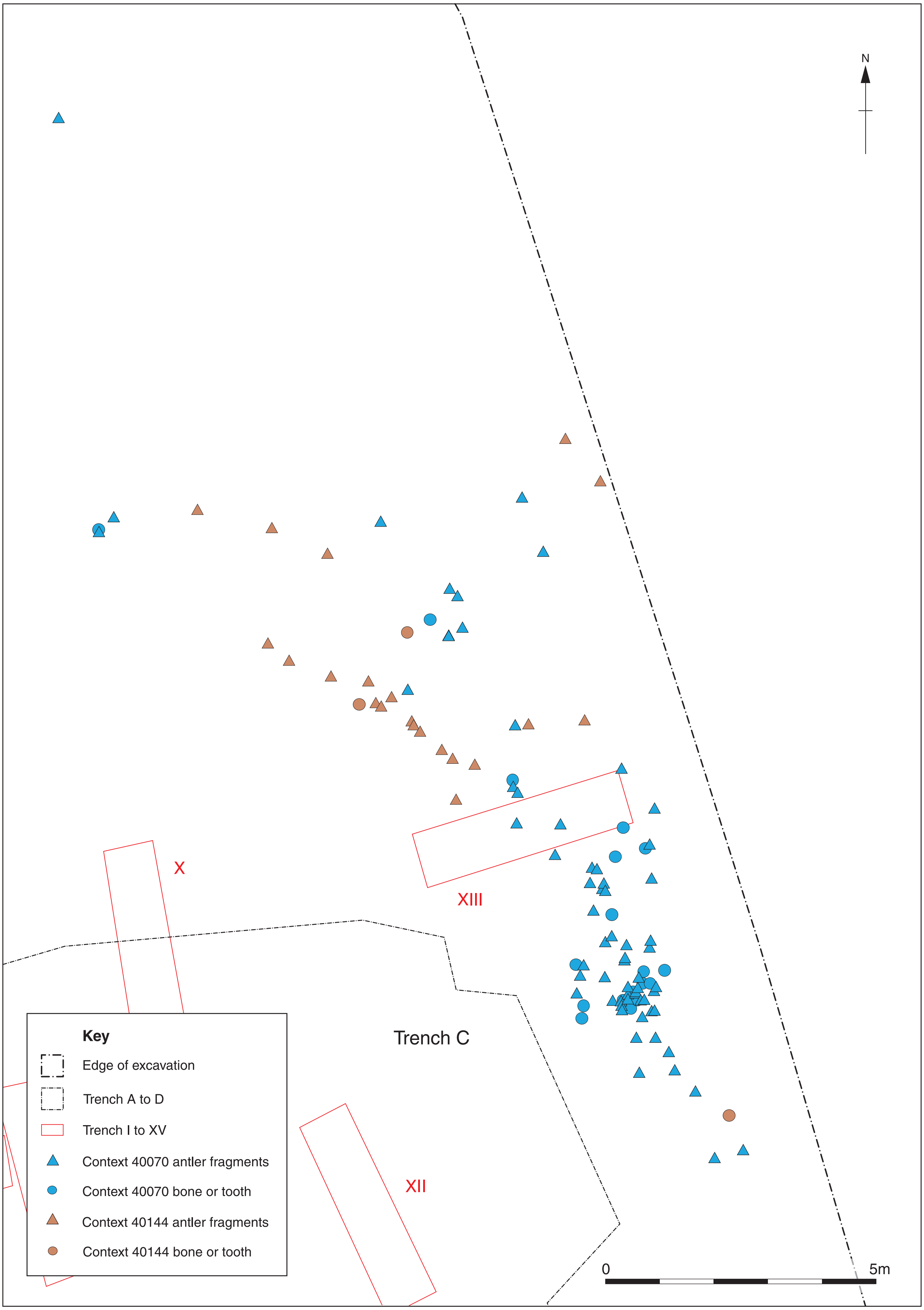


Figure 7.12 Distribution of antler fragments from context 40070 and 40144. No refits were found between vertebrate remains in the channel

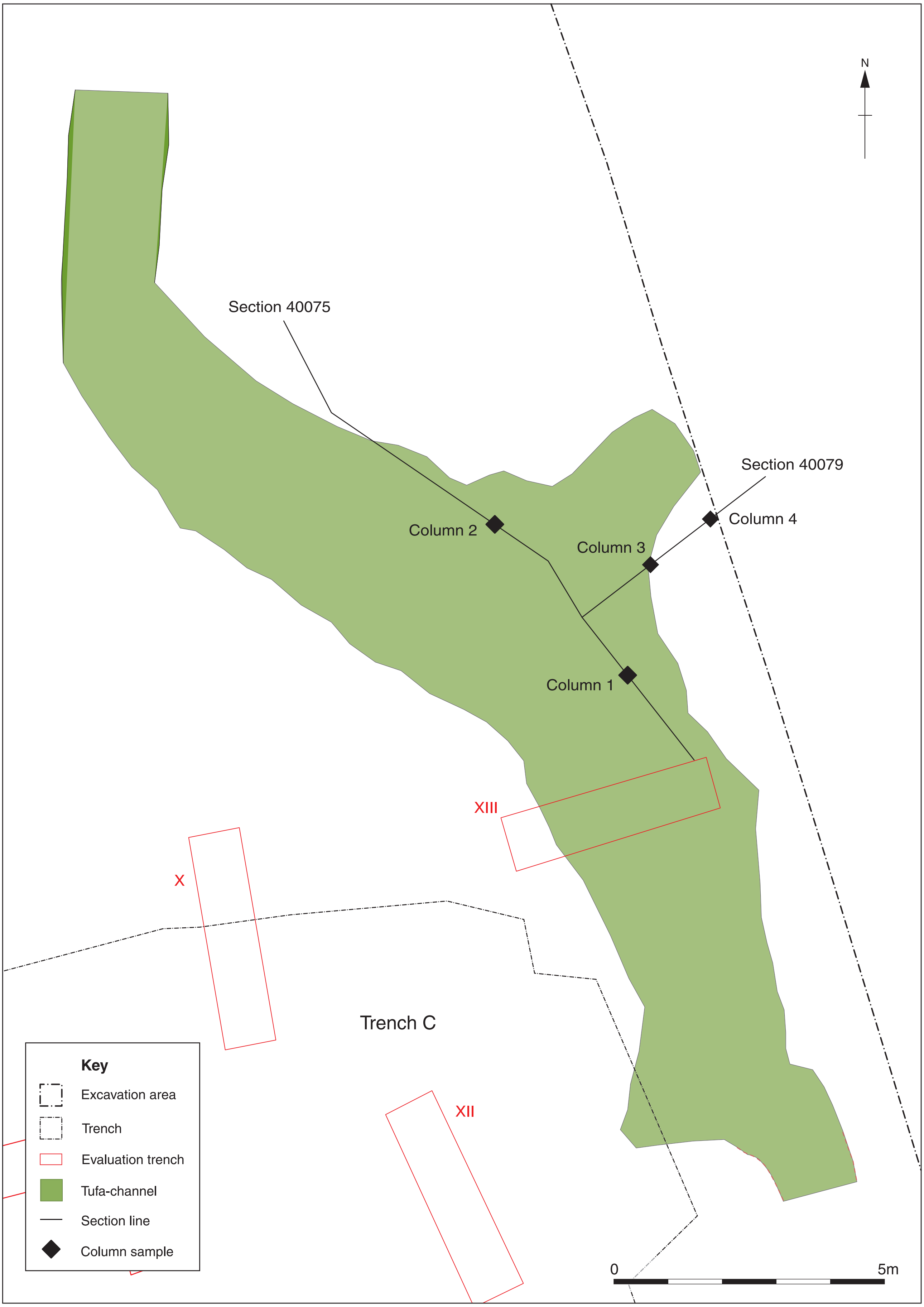


Figure 7.13 Plan of the tufaceous channel (shaded), showing the locations of sections and column samples

Despite the relatively high concentration of large mammal fossils, the hand-excavated large mammal fauna is not particularly diverse (Table 7.1). Of the 100 identifiable specimens, all but one belong to cervids. At least three species are represented, in increasing order of size these are: roe deer (NISP = 1); fallow deer (NISP =2); and red deer (NISP = 8). The remainder cannot be identified to species, but all come from medium-sized deer. In terms of body part representation, most of the cervid remains are highly comminuted pieces of antler beams and tines (n = 70), but five shed antler bases were also identified. The presence of three species of deer is consistent with woodland. Both fallow deer and red deer are to be found in woodland as well as parkland, but roe deer *Capreolus capreolus* is more closely associated with dense woodland. Additional large mammal remains were recovered from wet-sieved samples, including the particularly noteworthy record of macaque *Macaca sylvanus* identified from a single first phalanx. Fossil remains of macaque are exceptionally rare in northern Europe and only one other Hoxnian specimen is known from the Lower Loam at Swanscombe (see Chapter 9). Today, Barbary macaques live in relict populations in North Africa, where they are found among sparse forests of cedar, pine and oak. In the British Pleistocene, they are associated with temperate (deciduous and mixed) woodland phases and local habitats that included a mixture of open woodland and grassland on river floodplains.

The rich small vertebrate faunas from the channel sequence allow a detailed interpretation of the palaeoecology during the infilling of the channel, based on a quantitative study of the faunal succession and taphonomy. Most of the samples analysed were collected from open trench sections from four locations (see Fig. 7.13 for position of samples and Fig. 10.1 for a drawing of the sections showing where the samples were taken). One of the profiles (Column 2) sampled the deepest part of the channel, a second column (Column 1) recovered a somewhat shallower sequence, and spot samples (Columns 3 and 4) were collected from discrete units at the edge of the tufa spread. Samples in Columns 3 and 4 from the margin of the tufa-channel were taken as spot samples from discrete units. Although the spot samples were not taken as a column in a sequence, the samples can nevertheless be arranged in stratigraphical order within each column. The results are summarised as percentage frequency histograms showing the faunal spectra from the four profiles (Figs 7.14-17).

Column 2 (Fig. 7.14)
Six samples were taken at 100mm intervals through the full thickness of the shelly tufaceous sediments in Column 2. Five of the samples were about 28L, but the thinner basal sample was less than half the volume of the other samples. The small vertebrate spectra shows a steady increase in the number of fish remains from about 5% at the base to about 25% in sample <40315>. This is followed by a dramatic decrease in fish remains in the top sample (<40314>). Small mammal abundance decreases slightly through the upper sequence, but amphibians (frogs, toads and newts) are dominant throughout, with the highest number of amphibian bones (*c* 60 %) occurring in the basal and top samples respectively. The overwhelming dominance of amphibians in the top sample, together with the decline in fish remains, argues for a shallowing of the waterbody and a change to more marshy conditions.

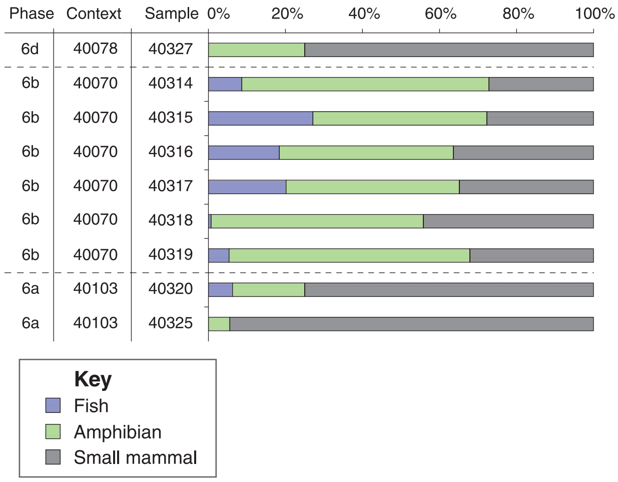


Figure 7.14 Column 2 small-vertebrate diagram

Column 1 (Fig. 7.15)
Four samples (from 3 to 20L) were taken at 100mm intervals through shelly tufaceous sediments in Column 1. The sampling included a less tufaceous, sandy/clayey deposit (assigned to context 40144) near the top of the sequence. The percentage of fish in the basal samples is low but rises through the sequence to maximum of about 35%. The representation of amphibians is constant throughout the sequence (*c* 35%), but small mammals show a regular fall in successive samples from 50% at the base to 30% at the top of the profile.

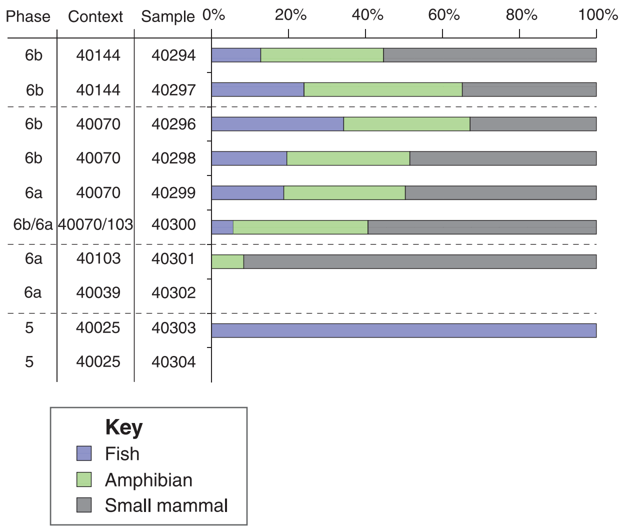


Figure 7.15 Column 1 small-vertebrate diagram. Sampling of the tufa respected the sedimentary boundaries; however contortion and inclusion of discontinuous lenses of clay made some mixing unavoidable

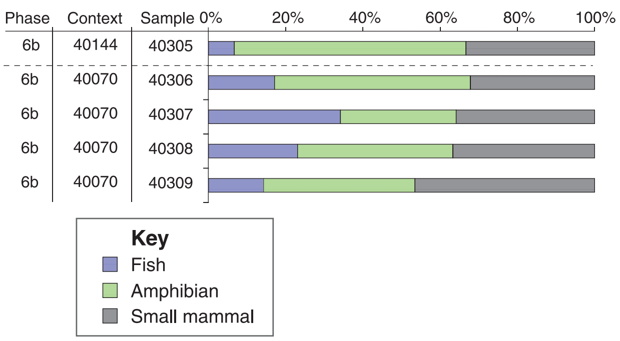


Figure 7.16 Column 3 small-vertebrate diagram

Column 3 (Fig. 7.16)
Four samples (11 to 29L) were collected from successive tufa units. These minor facies differences were identified in the field from differences in particle size (coarser at base) and colour. The faunal succession is similar to that of Column 2, with the top sample being characterised by higher numbers of amphibian remains and a relatively low representation of fish remains.

Column 4 (Fig. 7.17)
The tufa samples that make up Column 4 come from a much shallower (marginal) succession than those from the other columns and they are consequently limited to a two units: a clay-rich tufa (sample <40313>, 10L) and an overlying deposit of fine sandy tufa (sample <40310>, 7L). The spectrum of fish, amphibians and small mammals in sample <40313> resembles that of sample <40308> in Column 3, but <40310> differs from the preceding level in the unusually high representation of fish remains, which now account for over 60% of the small vertebrate assemblage.

It is clear from comparison of the columns that they illustrate approximately the same faunal trends. As has been suggested above, there are two main phases; in the first there is a convincing increase in the frequency of fish at the same time as a decrease in the frequency of small mammal remains. The second phase is characterised by low numbers of fish and small mammals and shift to a dominance of amphibians in Columns 2 and 3. The environment during the first phase is clearly one of a small stream, which was followed by a shallowing phase and the development of marshy conditions.

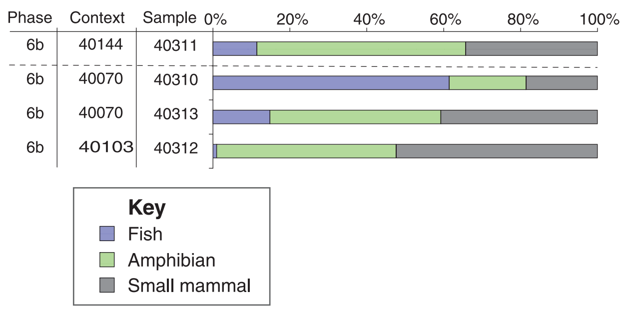


Figure 7.17 Column 4 small-vertebrate diagram

The diversity and abundance of amphibians, which includes newts, toads and frogs, indicates the prevalence of aquatic habitats bordered by marsh. A notable record is tree frog (*Hyla* sp.), which is represented by an ilium from sample <40332>. Two species of tree frog (common tree frog *H. arborea* and stripeless tree frog *H. meridionalis*) occur in Europe; both species have been recorded from the British Pleistocene (Parfitt 2008). European tree frogs favour well-vegetated habitats, preferring areas with trees and bushes or reed-beds. A waterbody with still or slow-flowing water and shallows with good weed growth would have provided a suitable breeding site for the newts, toads and frogs. The predominance of small fishes, together with the presence of minnow *Phoxinus phoxinus*, indicates a smaller and better-oxygenated water body than that represented by context 40025. No estuarine fishes were identified and the abundance of amphibians indicates freshwater conditions.

While the fish and amphibian remains are from animals that lived and died in the immediate vicinity of the site, the small mammal remains were mostly accumulated by avian and mammalian predators and were probably captured from a wider area around the channel. A clear indication of mammalian predator involvement in the accumulation of the assemblage is provided by gastric etching, small tooth punctures and gnawing marks on several of the amphibian and small mammal bones. These traces show that the bones had passed through the gut of a carnivore and were deposited in scats (droppings) close to the depositional site. Indeed, small mustelids are present in the faunal assemblage from context 40070, with polecat *Mustela* cf. *putorius* represented by a mandible and by isolated teeth from other channel samples. The habitat envisaged for the Phase 6b would have been ideally suited for polecat. Today, polecats favour woodland, particularly in damp areas where they can find the frogs that form a large part of their diet. Small rodents, rabbits and birds also form an important part of their diet. Like most carnivores, mustelids mark their territory with faeces (scats) left in prominent places (known as latrines). The scats contain the indigestible prey remains and considerable quantities of bone can accumulate at latrine sites. The bones were probably washed into the channel from both scats and owl pellets that were deposited near the margins of the waterbody.

The small mammal fauna is the most diverse from the site, with at least 18 taxa represented. The insectivore assemblage is remarkable for the high diversity of shrews. This includes at least four species of *Sorex* from the tufa alone. In addition to pygmy shrew *Sorex minutus* and water shrew *Neomys* sp., there is at least one more (and possibly two) medium-sized species, as well as a much larger shrew that is indistinguishable from the Early-Middle Pleistocene *Sorex* (*Drepanosorex*). Amongst the medium-sized forms, mandibles and isolated teeth of a relatively smaller species are common; this form resembles Laxmann's shrew *S. caecutiens*, the most common soricid found at many Middle Pleistocene sites in Britain. Remains of a somewhat larger species resemble common shrew *S. araneus*, but these are infrequent.

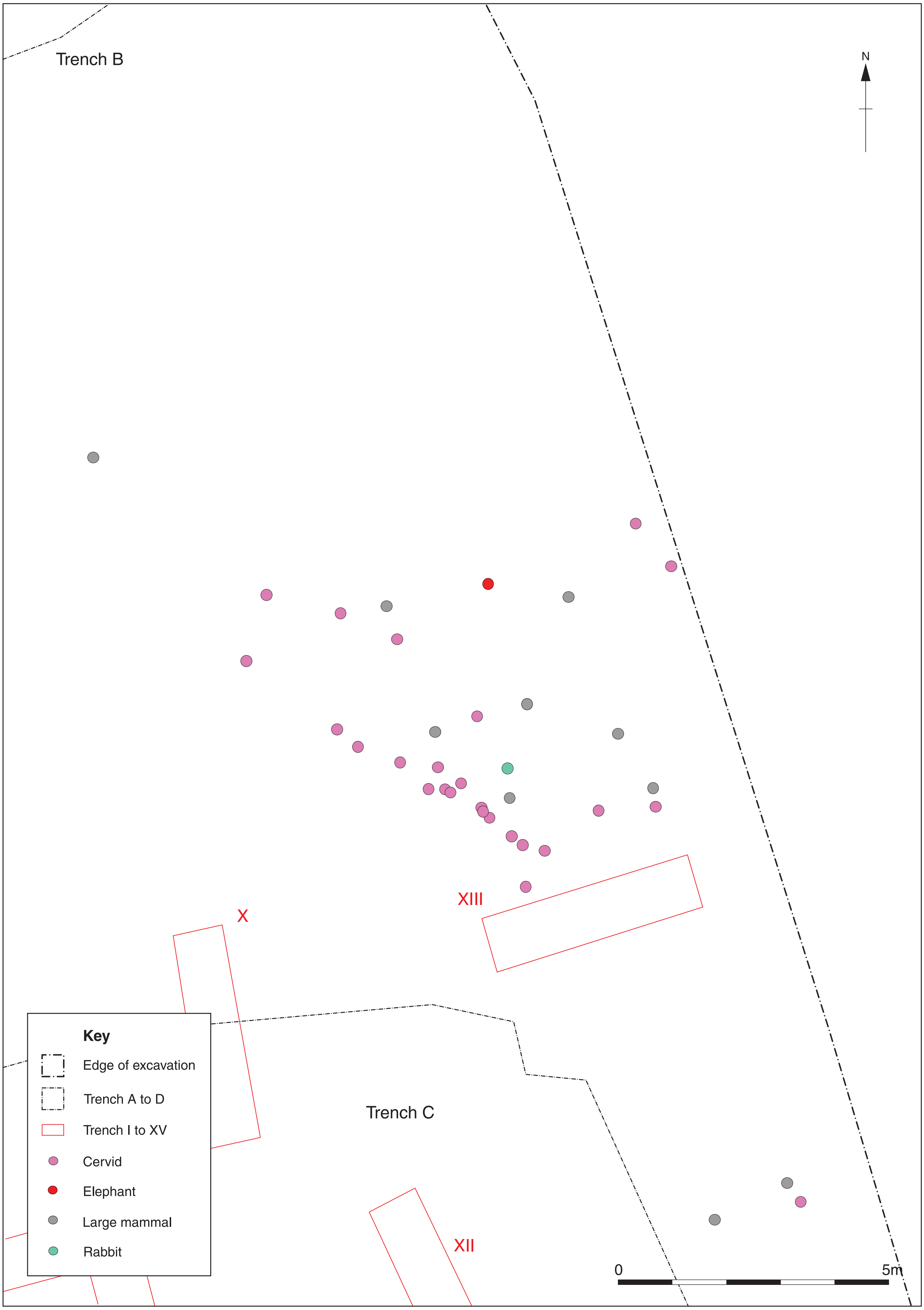


Figure 7.18 Distribution of bones from context 40144

In terms of ecology, the small mammal assemblage with abundant bank voles and wood mice is indicative of dense ground-level vegetation, shrubs and woodland, an interpretation which is corroborated by evidence from molluscs (see Chapter 12). There is also a significant open-ground component, indicated by grassland voles such a field vole *Microtus agrestis* and northern vole. Mammals of waterside habitats, including water vole and water shrew, are notably common. Of particular ecological significance is squirrel (*Sciurus* sp.). Squirrels are semi-arboreal rodents that prefer large expanses of mature woodland with continuous canopy. Coniferous woodland is favoured, but they are also found in deciduous woodland (especially beech) or more sparsely wooded areas when numerous (Corbet and Southern 1977). None of the squirrel teeth are waterworn, nor do they show signs of digestion, thereby suggesting that squirrels were living in trees close to the depositional site. The presence of Daubenton's bat *Myotis daubentonii* is also significant as it is closely associated with open water, where it hunts for insects. Daubenton's bat prefers open woodland and would have roosted in hollow trees, since there are no rocky outcrops near the site. The climate was probably as warm, if not warmer, than the present day.

Context 40144 and 40143

The large mammal remains from context 40144 are again dominated by antler fragments (Table 7.6), 16 (72.2%) of which are smaller than 50mm in length. Rhinoceros was identified from two pelvis fragments and straight-tusked elephant from a cuneiform (Fig.7.18). This foot bone is almost certainly part of the elephant carpus, represented by other carpal bones, metapodials and phalanx, found near the western edge of the channel (see Chapter 8). The presence of the cuneiform in (40144) implies that the tufaceous deposits were deposited contemporaneously with clay-silts (40078) that contained the dispersed bones of the straight-tusked elephant. No identifiable large mammal bones were found in the thin white silty layer (40143), but small vertebrates were common in the bulk samples from both contexts. Although all of the small mammal taxa found in contexts 40144 and 40143 were also present in context 40070, there is a greater representation of woodland small mammals in the upper part of the succession.

The small mammal faunas from Phase 6b differ from those of Phase 6a in the nearly equal numbers of woodland and humid grassland animals and the higher numbers of semi-aquatic small mammals (Fig. 7.3b). Overall, the vertebrate evidence is consistent with initial development of a small shallow body of slow-flowing freshwater bordered by open herbaceous vegetation (possibly reeds with grassland patches) in an otherwise forest-dominated landscape. At the top of the sequence, there are indications for drying up of the waterbody, and local development of more marshy conditions. Although the contribution of aquatic and semi-aquatic taxa is rather high, the local area must have included areas of well-drained soils to support both rabbit and mole. The vertebrate fauna does not provide any indication that the climate was significantly different to that of today.

The bird remains *by John R. Stewart*

The bird remains from the site are not very numerous and all come from tufaceous context 40070, Phase 6b (see Appendix 10). Specimens that have been identified to any significant taxonomic level include two bones of a thrush that conform in size with those of song thrush *Turdus philomelos* or redwing *T. iliacus* and the remains of mallard-sized and smaller ducks. As for the rest of the bird remains, they largely represent undetermined small species, most likely various passerines (songbirds) ranging from blackbird to smaller than house sparrow in size.

The presence of song thrush would indicate boreal to warm temperate woodland, whereas redwing lives in more open wooded environments during the breeding season. Areas of woodland or scrub may also be inferred from the relatively high number of passerine remains, as song birds are often abundant in fossil assemblages from such closed environments (Harrison and Stewart 1999). Another, albeit less numerous component of the assemblage are waterbirds, represented by at least two species of duck. The presence of ducks supports the sedimentology and associated molluscan evidence for deposition in slow-flowing freshwater.

The palaeoecological indications provided by the Southfleet Road bird assemblage are therefore consistent with a freshwater course running through temperate woodland. This assemblage is similar in many respects to that from Barnham (Stewart 1998), where bird bones were recovered from waterlain deposits, dating to the same (Hoxnian) interglacial.

Phase 6 (contexts 40099, 40160, 40162)

Three contexts from the lower part of the grey silty clay in the central part of the site yielded large vertebrate material. All of the material is fragmentary and none could be identified to species or genus (Table 7.7). The samples are so small it is not possible to draw any conclusions concerning taphonomy and environment.

Phase 6 (contexts 40078, 40100, 40158)

The main fossil horizon at Southfleet Road is located in the middle-upper part of the grey clay sequence. Stone tools are abundant in this horizon and include many refitting pieces associated with the scattered and poorly-preserved bones and teeth of a straight-tusked elephant. The sediment containing the elephant remains has a blocky ('brecciated') structure with prominent dark brown 'humic' horizons. The brecciation is indicative of cycles of desiccation and wetting, causing the sediment to expand and contract; this is the principal reason for the fractured condition of the elephant bones. In the field, bones were mostly assigned to two contexts: 40078 for those associated with the dense cluster of elephant remains (Fig. 7.19; Table 7.8), and 40100 for finds from the surrounding area of grey clay (Fig. 7.20; Table 7.9). Although distinguished by different context numbers,

Table 7.7 Phase 6 (context 40158, 4099, 40160, 40162). Taxonomic list of large mammals with body-part data and number of fragments (NISP)

Taxon	*NISP*	*Body parts*
Context 40158		
Cervidae gen. et sp. indet. (red-fallow deer sized)	2	Antler frag (beam & tine), metapodial shaft frag
Bovidae gen. et sp. indet.	1	R tibia (distal & shaft, dist. fused)
Indet. large mammal (red deer or larger)	1	Indet. bone frag
Indet. large mammal (smaller than fallow deer)	1	Long bone shaft frag
Indet. large mammal	1	Indet. bone frag
Context 40099		
Indet. large mammal (probably elephant)	1	Indet. bone frag
Indet. large mammal	1	Indet. bone frag
Context 40160		
Cervidae gen. et sp. indet. (red-fallow deer sized)	2	Antler base frag (shed), antler tine
Indet. large mammal (red-fallow deer size)	1	Carpal/tarsal frag
Context 40162		
Cervidae gen. et sp. indet. (red-fallow deer sized)	3	Antler tine, antler frag, long bone shaft frag
Indet. large mammal (rhino or larger)	1	Indet. bone frag
Indet. large mammal	1	Indet. bone frag

Table 7.8 Phase 6 (context 40078). Taxonomic list of large mammals with body-part data and number of fragments (NISP)

Taxon	*NISP*	*Body parts*
Palaeoloxodon antiquus	2	L & R M^3
Elephantidae gen. et sp. indet.	61	29 tusk frags (2 large pieces of L & R tusk), 4 cervical vertebra frag, lumbar vertebra centrum (cranial epiphysis unfused, caudal epiphysis fused), 4 thoracic vertebrae (1 with cranial and caudal epiphyses unfused), lumbar vertebra (cranial epiphysis unfused, caudal epiphysis fusing), 6 vertebra frags, 4 rib frags, 2 L scapula frags, R magnum, R trapezium, R unciform, R metacarpal II, R metacarpal IV, metacarpal frag, metapodial frag, 2nd phalanx IV
Stephanorhinus cf. *hemitoechus*	3	L scapula frag (dist. fused), L humerus (dist. & shaft, fused), L femur (prox. fused)
Stephanorhinus kirchbergensis	1	L ulna (dist.)
Cervus elaphus & cf. *Cervus elaphus*		Antler base. brow & bez tines, beam (shed), R antler base, brow & bez tines, beam (shed), L antler base, brow & bez tines, beam (shed), L antler (shed), L antler trez tine & beam, L tibia frag (dist & shaft, dist fused)
Cervidae gen. et sp. indet. (red/fallow deer sized)	6	R mandible frag with M_3 (mid wear), lower molar frag, molar frag, lower frag, cheek tooth frag, 6 antler base frags (shed), cheek tooth antler base & tine frags (shed), 41 antler frags, vertebral centrum frag, L radius (prox. & shaft, prox fused), R metacarpal (prox. & shaft), L metacarpal (dist, fused), L metacarpal (dist unfused), L metacarpal (prox & shaft), metacarpal shaft frag, metacarpal shaft frag (juvenile), L innominate (unfused), L femur (dist. & shaft), R tibia (prox & dist fused), R tibia frag (dist & shaft, fused), L tibia frag, metatarsal frag, L calcaneus frag (*tuber calcis* unfused)
Cervidae gen. et sp. indet.	2	2 antler frags
Bos primigenius	1	R metatarsal (prox.)
Bovidae gen. et sp. indet.	2	Metacarpal (dist. fused), metapodial condyle
Indet. large mammal (elephant size)	169	4 ?skull frags, 2 vertebra frags, 7 rib frags, 156 indet. bone frags
Indet. large mammal (rhinoceros or larger)	1	Indet. bone frag
Indet. large mammal (*Bos* or larger)	45	Skull & tooth frag, ? vertebra, carpal/tarsal frag, 42 indet. bone frag
Indet. large mammal (red deer or larger)	11	Rib frag, long bone shaft frag, 9 indet. bone frags
Indet. large mammal (red/fallow deer size)	13	Vertebra frag, rib frag, L femur frag (dist. & shaft, dist. fused), 10 long bone shaft frags
Indet. large mammal (smaller than fallow deer)	2	Rib frag, long bone shaft frag
Indet. large mammal	107	103 indet. bone frags. ? skull frag, ? rib frag, 2 long bone shaft frags
Indet. vertebrate	1	Indet. bone frag

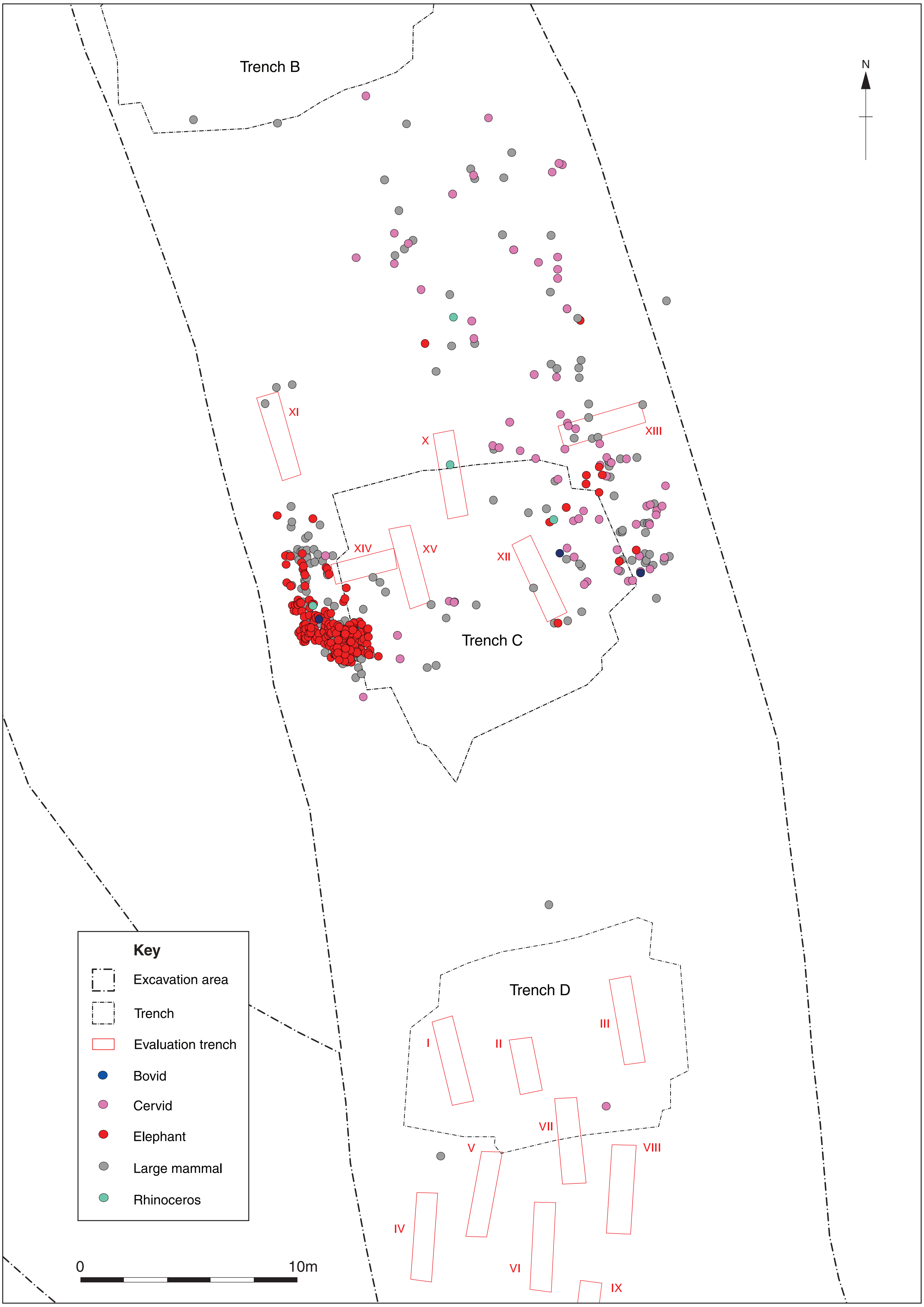


Figure 7.19 Distribution of bones from context 40078

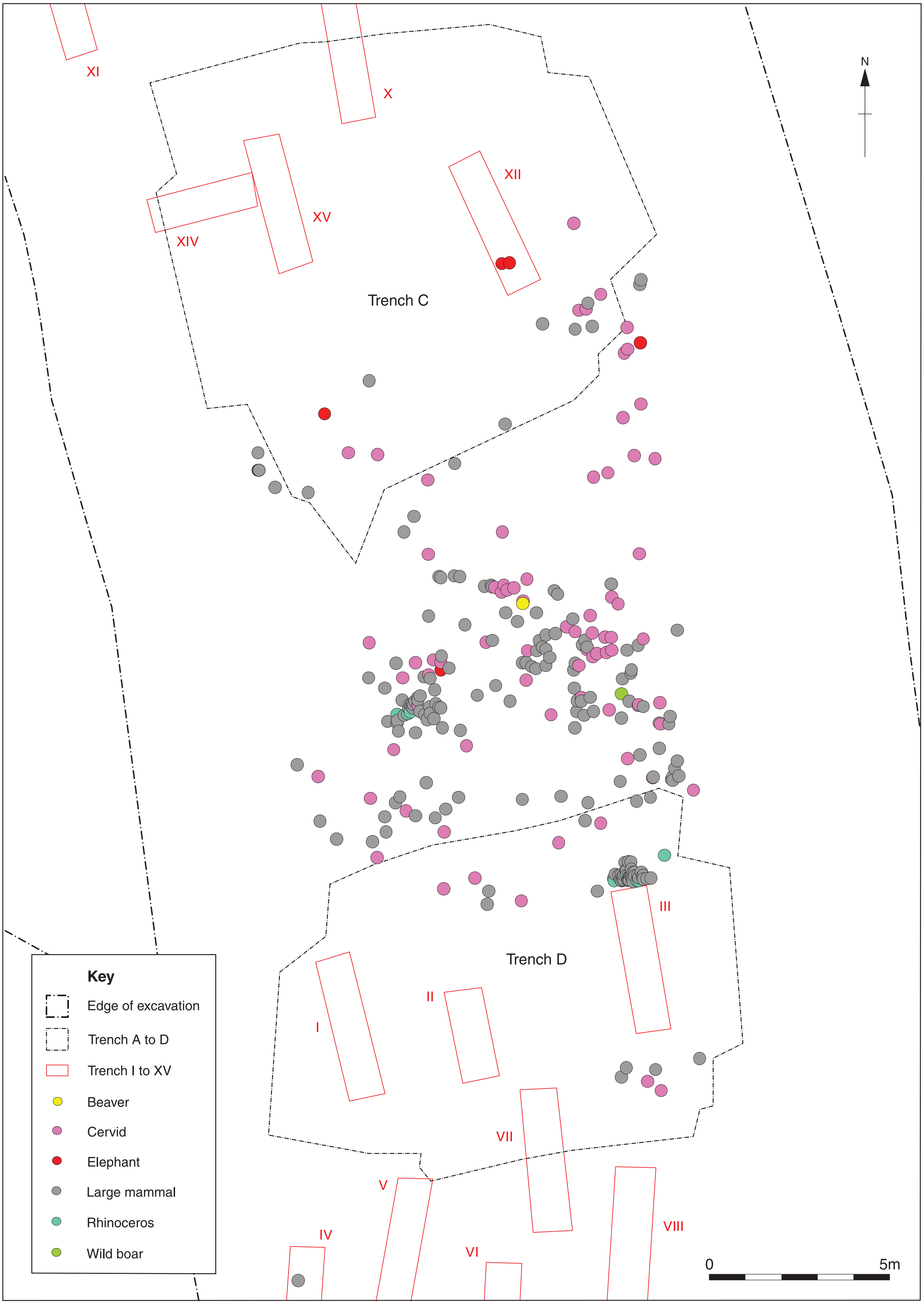


Figure 7.20 Distribution of bones from context 40100

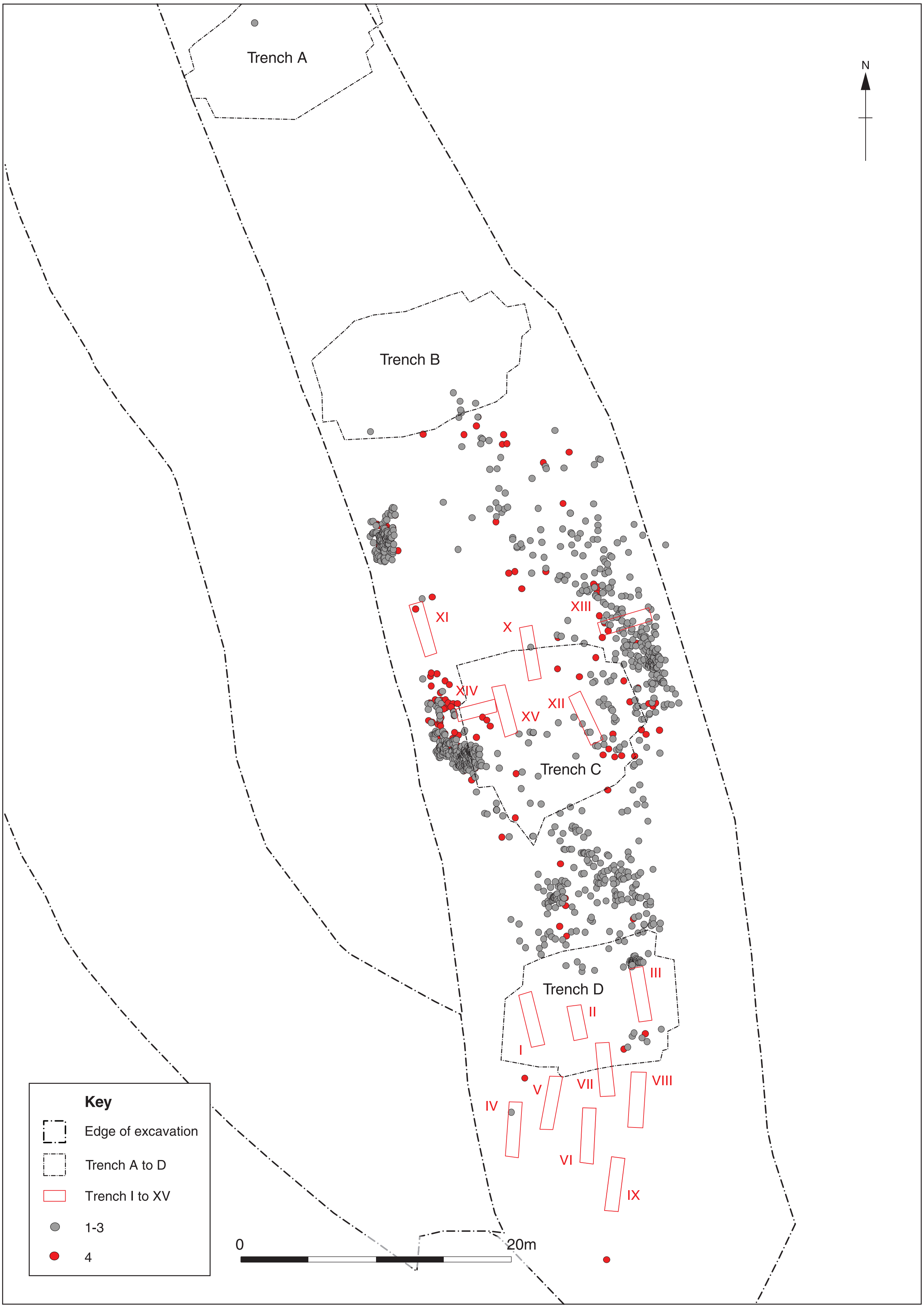


Figure 7.21 Distribution of bones from contexts 40100 and 40078 according to condition. Condition ranges from excellent (1) to extremely poor (4)

40078 and 40100 were not stratigraphically distinct and the two assemblages have been combined in some analyses. There are, however, important differences between the two assemblages, not only in species composition but also in taphonomy, which appear to reflect contrasting depositional conditions. Bulk samples were processed for small vertebrates, but these yielded virtually no bones. Some identifiable small mammal material was recovered by hand excavation, but the sample is scanty and it is not possible to draw any conclusions concerning taphonomy and environment from these remains.

Clear differences between the two large mammal assemblages are in fragment size. The bones from 4100 are mostly smaller than 50mm in length, whereas those from 40078 include 17 bones that are larger than 300mm; only 29% are smaller than 50mm. These differences reflect the predominance of elephant bones in 40078, whereas smaller herbivores form the greater part of the assemblage from 40100. The bones in 40078 are mid- to dark-brown in colour. About twice as many are manganese (5%) stained than are iron stained (10.3%). In contrast more of the bones from 4100 are stained (16.8 % iron stained, 5.9% manganese stained), but this does not account for the lighter colour (fawn to white) of the bones from this context. Overall, surfaces of the bones are better preserved in 40078, with 68% bones having more than three quarters of the original cortical surface preserved, compared with only 35.5% in 40100 (Fig. 7.21). Only four specimens from both contexts are weathered, indicating that most of the bones were either buried quickly or protected from weathering by dense vegetation. Fewer than 2% of the bones from 40078 are root-marked compared with 27% of the bones from 40100 (Fig. 7.22). The high proportion of root-marked bones from the latter context indicates burial in a soil; the distribution of root-etched pieces across the site is likely to reflect the distribution of vegetation shortly after the bones were buried. The low number of root-etched elephant bones may indicate that they were buried in an aquatic environment, whereas those from 40100 were buried in a vegetated terrestrial setting.

The most notable component of the large mammal assemblage from this phase is the dispersed skeletal remains of a large straight-tusked elephant from context 40078 (see Chapter 8). This individual is represented by as many as 237 bones, only 78 of which could be identified to skeletal element. There is a substantial concentration of fragmentary and crushed elephant bones located near the truncated western edge of the site. This cluster is associated with a spatially discrete scatter of flint artefacts; the association of the bones and artefacts in the same horizon, together with limited vertical dispersal, suggests contemporaneity. Almost all of the bones in the cluster are from the axial skeleton and include fragments of the cranium (skull, third upper molar, two large tusks and many tusk fragments), vertebrae (cervical, thoracic and lumbar) and ribs. The spatial disposition of these elements suggests the elephant carcass was lying on its left-hand side, with its head to the south. Many of the smaller bones were probably buried rather rapidly, but weathering and the poor condition of the larger bones and tusks suggest that they had been exposed to prolonged subaerial weathering. An indication of burial processes is provided by the preferred orientation of the smaller bone fragments, which have a strong east-west alignment. The fact that easily transported bones, such as vertebrae, are present suggests that slow-flowing water, possibly slopewash was responsible for depositing the silt in which the bones were buried. The bones were probably subjected several times to flowing water that orientated the bones to the direction of flow without transporting them away from the carcass site. The only appendicular element identified in the main scatter is the left scapula represented by two refitting pieces. Parts of the appendicular elements may have been destroyed during the road construction work, which truncated the western part of the scatter, while other elements may have been transported away from this cluster. This is indicated by the diffuse scatter of elephant remains that extends to the north and east of the main cluster of elephant bones. This scatter includes parts of the left forefoot located some 20–30m to the north-east of the cluster and at the same horizon. Some of these elements can be articulated and their spatial distribution shows that they have been dispersed for short distances in a north-south direction. The elements include carpals, metapodials and a phalanx, which are all light cancellous bones that are easily transported by flowing water. These bones must have been transported to the edge of the tufa-channel before the foot had decayed. This may be explained by the natural sequence of decay in mammalian carcasses, in which the major forelimb elements detach from the body early in the decay sequence. The foot bones, which are held together by strong ligaments and tendons, could have been transported as a unit by a large carnivore or by an inquisitive elephant. As none of the bones are gnawed, it seems more likely that elephants were responsible for displacing some of the bones. African elephants react strongly to the carcasses of other elephants and will carry or kick the bones, sometimes smashing them in the process. Pleistocene elephants probably displayed similar behaviour. Although this is a supposition, the presence of trampling marks on several of the elephant bones in the main cluster suggest that the carcass may have been visited by elephants.

Although the elephant bones and tusks are the most conspicuous element of the large mammal fauna, the deposit has yielded a relatively high diversity of other large mammal species, each represented by a small number of identifiable bones. Ungulates are dominant in the assemblage and point to a rich and varied environment. Some of the taxa are important indicators of the existence of very specific habitats. For example Merck's rhinoceros *Stephanorhinus kirchbergensis* implies a wooded environment, whereas the narrow-nosed rhinoceros would have inhabited more open habitats with rich herbaceous vegetation. Wild boar is generally associated with denser woodland or shrubs and marshy environments. A mixture of woodland and grassland would have favoured red deer,

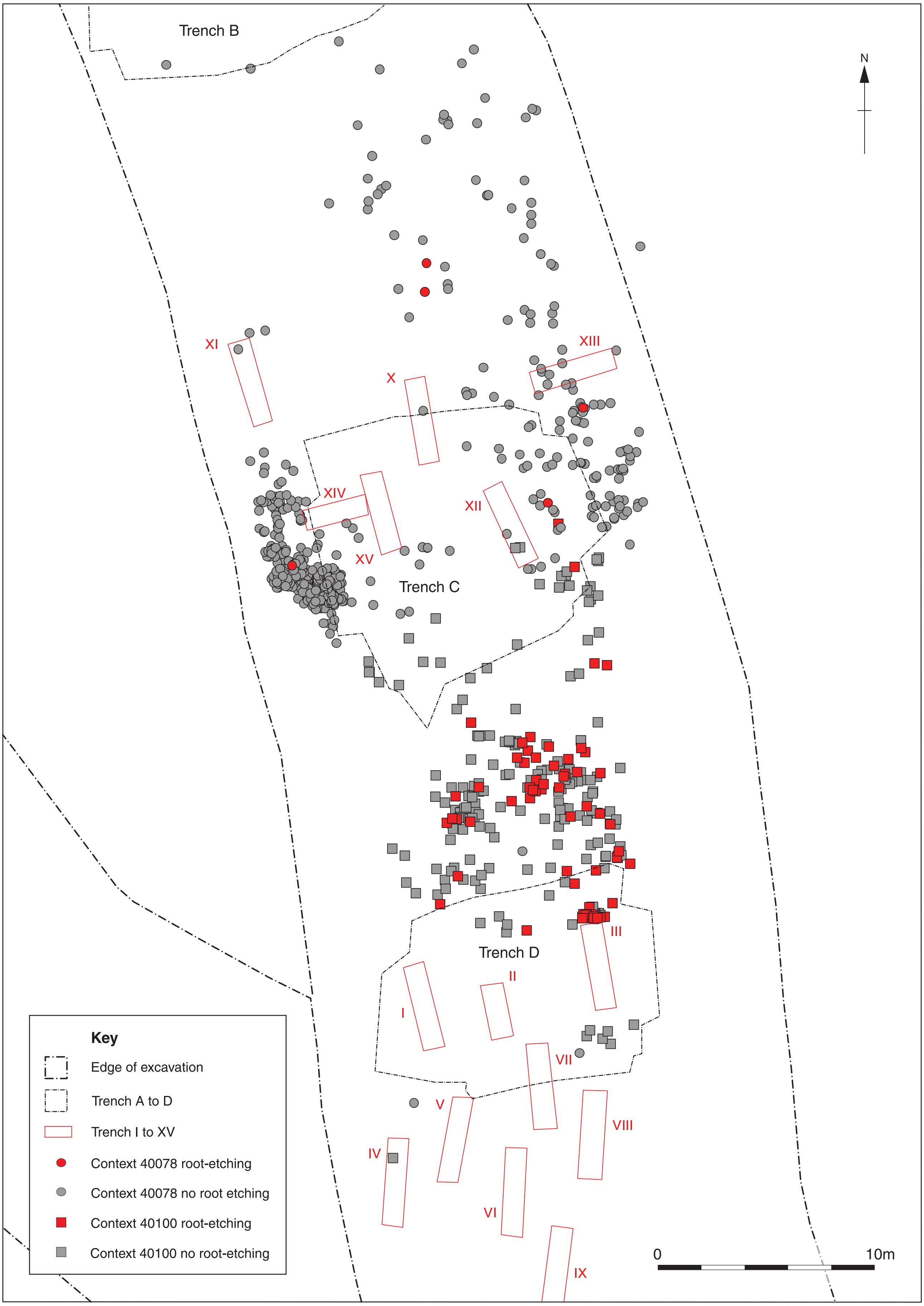


Figure 7.22 Distribution of root-etched bones from contexts 40100 and 40078

Table 7.9 Phase 6 (context 40100). Taxonomic list of large mammals with body-part data and number of fragments (NISP)

Taxon	*NISP*	*Body parts*
Castor fiber	1	R P^4
Stephanorhinus hemitoechus & *S.* cf. *hemitoechus*	3	3 L radius frags (2 distal, 1 prox. & shaft)
Stephanorhinus kirchbergensis & *S.* cf. *kirchbergensis*	6	2 mandible frags, M_3 (mid-late wear), R lower cheek tooth & mandible frags, cheek tooth frag, tooth frag
Sus scrofa	1	R I^2 (mid wear)
Dama dama & cf. *Dama dama*	3	R mandible with M_{1-3} (late-mid wear), L P_3 (late wear), R astragalus
Cervus elaphus & cf. *Cervus elaphus*	11	L antler (shed), L antler base frag (shed), L P_3, R M_3 (early mid-wear), L scapula frag (dist. fused), L scapula (dist. fused), L radius (prox. & shaft, prox. fused), L tibia (distal & shaft, dist. fused), R distal fibula, R astragalus, 1st phalanx (prox. fused)
*Capreolus capreolu*s	1	Metapodial shaft frag (juvenile)
Cervidae gen. et sp. indet. (red/fallow deer sized)	58	28 antler frags, L $M^{1 \text{ or } 2}$, L $M_{1 \text{or} 2}$, 3 upper molar frags, upper cheek tooth frag, 3 cheek tooth frags, molar frag, tooth frag, axis frag, ? lumbar vertebral centrum (cranial epiphysis fused), R dist. humerus frag, L radius (prox. & shaft, prox. fused), prox. radius frag, L ulna (prox.), L lunate, L unciform, R metacarpal frag (prox.), L metacarpal frag (prox.), metacarpal frag (dist. & shaft, dist. fused), R innominate frag, 2 astragalus frags, R navicular-cuboid frag, metatarsal shaft frag (juvenile), 2 metapodial distal condyles, metapodial (badly crushed)
Cervidae gen. et sp. indet.	4	4 antler frags
Artiodactyl?	1	Tooth frag
Indet. large mammal (elephant size)	5	Rib frag, 4 indet. bone frags
Indet. large mammal (rhinoceros or larger)	1	L & R occipital condyles
Indet. large mammal (*Bos* or larger)	40	4 long bone shaft frags, 36 indet. bone frags
Indet. large mammal (red deer or larger)	38	? mandible frag, tooth root frag, 3 long bone shaft frags, 33 indet. bone frags
Indet. large mammal (red/fallow deer size)	18	2 petrosal frags, 3 vertebral centrum frags, 10 long bone shaft frags, 3 indet. bone frags
Indet. large mammal (smaller than fallow deer)	5	5 long bone shaft frag
Indet. large mammal (fox size)	1	? thoracic vertebra frag
Indet. large mammal	85	84 indet. bone frags, tooth frag

fallow deer and aurochs. Nearby freshwater environments are indicated by European beaver *Castor fiber*, which is represented by single tooth from context 40100. The beaver is a valuable environmental indicator species as it is closely tied to large streams or lakes with adjacent deciduous woodland. Beavers feed mostly on herbaceous plants, such as stems and rhizomes of rushes and the leaves and twiggy branches of trees and shrubs. They may have a significant impact on their immediate surroundings by felling trees, which opens-up the forest and creates patches of dense shrubby cover, and by building dams to create ponds (Coles 2010).

The large mammals provide a clear indication for a locally wooded landscape with dry areas and some open herbaceous vegetation close to a large body of freshwater. Overall, the large mammal fauna is entirely consistent with a fully temperate climate.

Phase 7 (context 40167)

A bovid cheek tooth is the only identifiable specimen from this phase (40167). The remnants of the cementum and dentine are heavily corroded, showing that extreme processes must have been operating at some stage during burial and that post-depositional loss is severe.

Phase 8b (context 40048, 40049)

This extensive deposit of bedded clast-supported gravel appears to be largely unfossiliferous. Contexts 40048 and 40049 yielded indeterminate large mammal remains dispersed through the deposit. Two of these pieces are heavily rounded and abraded, with edge-rounding consistent with fluvial transport.

DISCUSSION

Environmental context of the Clactonian occupation

The vertebrate faunas yield a consistent and detailed picture of the contemporary environmental and climatic conditions associated with the Clactonian occupation at the site (Table 7.10). Understanding the taphonomy of the faunal remains is, however, central to attempts at reconstructing site formation processes and the ecological succession at the site. The taphonomic analysis also provides a basis for making broader faunal comparisons that allow the Clactonian archaeology at Southfleet Road to be placed in the wider context of the Lower Palaeolithic occupation in Britain. The following section

Table 7.10 Summary of the Hoxnian environmental history of Southfleet Road, based on evidence from the vertebrate fauna

Phase	*Context (Large mammal NISP)*	*Vertebrates*	*Depositional context*
9		None	?
8b	40048 (3) 40049 (1)	Rare large mammals	Fluvial
7	40167 (1)	Rare large mammals (decalcified)	?
6d	40158 (6)	Rare large mammals	?
	40100 (282)	High-diversity ungulate fauna	Vegetated landsurface
	40078 (491)	Straight-tusked elephant skeleton	Landsurface with episodic slopewash
6c	40099 (2) 40160 (3) 40162 (3)	Rare large mammals	?
6b	40143 (0)	Amphibians & fish dominant	Shallow, slow-flowing stream
	40144 (42)	Fish, amphibian & small mammals present in equal abundance	
	40070 (165)	Fish increase up-sequence. Amphibians dominant in upper part	Shallow, slow-flowing stream. Temporary drying-out of waterbody at top of tufa sequence
6a	40103 (13)	Large mammals & fish (4%) rare, amphibians common (40%)	Landsurface & marsh
	40039 (234)	Mammals common, amphibians & fish rare (1%)	Landsurface (weathering, rootlet corrosion & post-depositional decalcification indicative of burial in a soil)
5	40025 (14) 40072 (1)	Rare large mammals, abundant fish (46%); amphibians & small mammals common	Fluvial, deep water
4		None	?
3	40028 (1) 40061 (1) 40062 (2) 40159 (1)	Rare large mammals	?
2		None	?
1		None	?

summarises the taphonomy of the Southfleet Road vertebrates as a prelude to discussions on broader issues concerning the environmental context of the Clactonian.

The sediments at Southfleet Road were deposited within and on the lateral margins of a fluvial channel. In this depositional setting, accumulation and burial of the bones took place on the floodplain, in fluvial channels, near springs and seeps and in colluvium. There is little indication of human involvement in the accumulation of any of the assemblages. Only two possible cut marks were identified, in spite of the presence of artefacts throughout the fossiliferous sequence. Although none of the elephant bones were cut-marked, their intimate association with a cluster of mint-condition refitting artefacts is, however, suggestive of human involvement (see Chapters 17 and 22). Most of the large mammal bones probably accumulated from natural deaths or as carnivore kills. Determining the carnivore or carnivores responsible for accumulating these bones relies on the identification of their skeletal remains and chewing damage. At Southfleet Road, lion is the only large mammalian carnivore represented. The much larger mammal assemblage from contemporaneous deposits at Swanscombe includes, in addition to lion, a smaller jaguar-sized cat, cave bear *Ursus spelaeus*, wolf *Canis lupus*, wild cat *Felis sylvestris* and pine marten *Martes* cf. *martes*. At Swanscombe, further evidence for carnivore activity is provided by characteristic chewing marks on some of the bones. Carnivores are therefore implicated in taphonomic modification of the large mammal remains and the destruction of bones through chewing at both Swanscombe and at Southfleet Road. This is highlighted by the skeletal element analysis which shows that preservation is strongly correlated with structural density of the bone, with the more dense bones being preferentially preserved. The feeding and scavenging activities of predators was also probably partly responsible for the disarticulated and dispersed distribution of the bones. Bones from most of the contexts were deposited on a land surface and were exposed to such destructive forces as desiccation, frost and damaged by plant growth. Other bones were subsequently modified by transport and weathering, resulting in further breakage or loss of material.

The small vertebrate bones also accumulated on the same landsurfaces and fluvial deposits over a similar period of time. Many of the small vertebrates probably lived and died close to the depositional site, but the remains of other animals show signs of predation by birds of prey and mammalian carnivores. The remains of these hunted small vertebrates were transported to the site,

Environmental interpretation	*Climate*	*Archaeology*	*Correlation with Swanscomb*
?	?	Acheulian	Stage II?
?	?		
?	?	Clactonian (dervived?)	?
?	?		
Mosaic of woodland, grassland and wetland	Fully temperate		
	Fully temperate		
?	?		
Dense woodland with some wetland & grassland areas bordering a stream			
Mosaic of woodland, wetland & grassland habitats bordering a stream			
Wetland habitats, areas of herbaceous vegetation (reed-beds) & closed woodland bordering a stream	Fully temperate	Clactonian	Stage I
Marsh or damp habitats with a mix of woodland & grassland			
Woodland with grassland & distant water-edge habitats			
Large stream or river bordered by marsh and extensive grassland. Drier areas with light soils supporting scrub or woodland			
?	?		
?	Temperate		
?	?		?
?	?		?

most likely from within the confines of the valley itself and probably within a radius of less than 1km from where they were deposited. The incorporation of allochthonous elements (ie transported to the site from various habitats) combined with autochthonous elements from natural deaths at the site needs to be borne in mind in their interpretation. This mixture of elements from different sources accounts for the wide faunal spectrum indicating varied local environments represented, ranging from aquatic to dry grassland and woodland, as well as the presence of fish remains in the colluvial and landsurface deposits.

The taphonomy of the large mammal bones records a dynamic local environment characterised by high fragmentation, dispersal and destruction of individual large mammal bones, with burial of mainly scattered and isolated elements. Some of the bones clearly derive from partial skeletons of animals that died at the site, whereas other bones could have been transported from elsewhere by mammalian carnivores. Few of the bones had been exposed to prolonged weathering, indicating burial was relatively rapid in each of the phases of fluvial, alluvial and colluvial deposition. Studies of modern analogues for fossil assemblages preserved in open sites shows that they can provide sensitive records of population shifts in the dominant herbivore species (Behrensmeyer 1993). There is no reason to suggest that the large mammals from Southfleet Road do not reflect the composition and abundance of the various large mammal species in the living community.

Summary of faunal change through the sequence

The basal sediments were largely devoid of vertebrate material, with sieved samples from Phases 1, 2 and 3 being totally barren. The presence of aurochs in sediments assigned to Phase 3 provides the only mammalian indication of the prevailing conditions at the time. Locally, the landscape would have supported rich grazing and probably also deciduous trees. In terms of climate, aurochs is known only from interglacial and interstadial periods in Britain, implying that the prevailing climate was not unduly severe. The Phase 3 ostracod fauna (Chapter 11) indicates a fully interglacial climate.

The extensive deposit of bedded fluvial sands of Phase 5 yielded a vertebrate fauna composed of rather few taxa but with a mixture of dry ground, marsh and aquatic species. The water-body, which was of sufficient depth to support relatively large fishes, was probably slow flowing, although gravel lenses suggest occasional episodes of higher energy. Amphibians inhabited marshland or damp terrestrial habitats on the floodplain and the associated mammals are consistent with extensive open grassland that included drier areas. Areas of open woodland supported herds of aurochs and fallow deer, which were predated by lions and other large carnivores. A fully temperate climate is indicated by the presence of thermophilous fish species (eg tench) and mammals, such as rabbit, aurochs and fallow deer. Other elements of the vertebrate fauna (northern vole and ground squirrel) are generally thought of as more typical of cold climates in the British Pleistocene. However, both the ground squirrel and the northern vole have been found in temperate contexts during the Middle Pleistocene in Britain, possibly occurring as survivors from a preceding cold stage.

The vertebrates confirm the sedimentological interpretation that the deposits assigned to Phase 5 are clearly fluvial in origin and deposited by a large stream or river. The sediments were characterised predominantly by sands with some gravel bands and finer sediments. There was a change, with the transition into Phase 6, to predominantly finer-grained silts and clays. This coincided with a change to drier conditions and implies a major change in the character of the depositional environment. The basal sediments of this alluvial sequence were weathered and decalcified. Intense iron-staining reflects chemical alteration during formation of a soil, with drab clays accumulated during periods of flooding, when burial was rapid enough to prevent development of mature palaeosols (Chapter 5). Micromorphological evidence from the iron-stained layers indicates that the soils formed in a woodland setting. The condition of the large mammal bones is also consistent with accumulation on a ground surface and burial in a biologically active soil. Common alterations include corrosion and pitting as a result of chemical leaching and root-etching during burial. These destructive processes have removed the outer layer of cortical bone on many specimens, but several of the better-preserved pieces show carnivore chew marks and splitting from weathering. In combination, these processes account for the fragmentary and disarticulated nature of the remains recovered from these deposits. This transition from predominantly sandy to silty sediments also coincides with abrupt changes in the composition of the small vertebrate fauna. A near absence of fish and amphibians implies a relatively dry terrestrial local environment, which supported abundant woodland mammals. Locally, the landscape appears to have been a drier and more wooded habitat than during Phase 5, although the climate was also fully temperate at the time.

The mammalian assemblage from the tufa-filled channel (Phase 6b) is consistent with deposition near spring-seeps and in shallow, flowing water. Freshwater fish bones, which are particularly common in some of the sampled levels, are mainly from relatively small fishes, indicating a more restricted waterbody than that of Phase 5. The water-body appears to have been relatively shallow but well-oxygenated. Several columns were sampled for small vertebrates and these all show a dominance of amphibians and a steady increase in fish remains with a complementary decrease in small mammal. In localised areas, the upper part of the tufaceous sequence is characterised by low numbers of fish and small mammals with abundant amphibians. This appears to reflect a change in the local environment from that of a small stream, which was steadily encroached by marsh. The terrestrial vertebrate fauna from the tufaceous deposit indicates a mixture of grassland, marsh and aquatic habitats in a generally wooded environment. The most striking aspect of the fauna is the presence of squirrel, which provides a clear indication of local closed-canopy woodland. Aquatic conditions diminish in the upper part of the sequence, with an even greater representation of woodland species in the small mammal fauna, and with a decline in fish and an increase in amphibians. Other elements of the vertebrate assemblage point to a local mosaic of habitats that included woodland, grassland and wetland habitats bordering a stream.

The sediments immediately overlying the tufaceous channel are grey brecciated silty clays with localised darker brown ('humic') horizons; the grey clays extended across most of the site, but the darker brown organic-rich horizons were restricted to the central part of the site to the west of the tufaceous channel. Small vertebrate remains are scarce, but large mammals are relatively common and include the dispersed remains of a straight-tusked elephant. The elephant carcass seems to have been situated in a landscape with significant woodland, possibly of alder-carr type. Open herbaceous vegetation occurred nearby. There is no indication for significant climatic difference, with the vertebrates indicating fully temperate conditions; the presence of a foot bone from the elephant in the tufaceous channel fill establishes its contemporaneity with context 40078, and suggests that much of the vertebrate material from context 40100 could likewise be contemporary.

Landscape setting of the site

Ashton *et al.* (2006) have argued that human occupation in Britain during the Hoxnian was focussed in river valleys. They point out that the valleys were areas of greater biodiversity, with extensive tracts of grassland supporting a higher biomass of grazing herbivores than the more heavily wooded interfluves. The rivers would also have provided drinking water for large mammals, as well easy access to raw materials for making stone tools in the form of gravel bars. The location of the Southfleet Road site in a relatively small tributary valley was somewhat different to most of the sites studied by Ashton *et al.* (ibid.) which were mostly associated with much larger river valleys. Differences in the ecology and taphonomy of the mammal remains in these different landscape settings appears to be reflected in the composition of the mammal faunas at the site. The Southfleet Road site was also situated close to the edge of a shallow valley which opened out into the Thames Valley near Swanscombe. Clast lithological evidence (Chapter 6) indicates sediments were deposited by a small south-bank Thames tributary with a limited catchment that did not extend beyond the chalk high-ground to the south of the site. Sedimentological analysis shows that there were

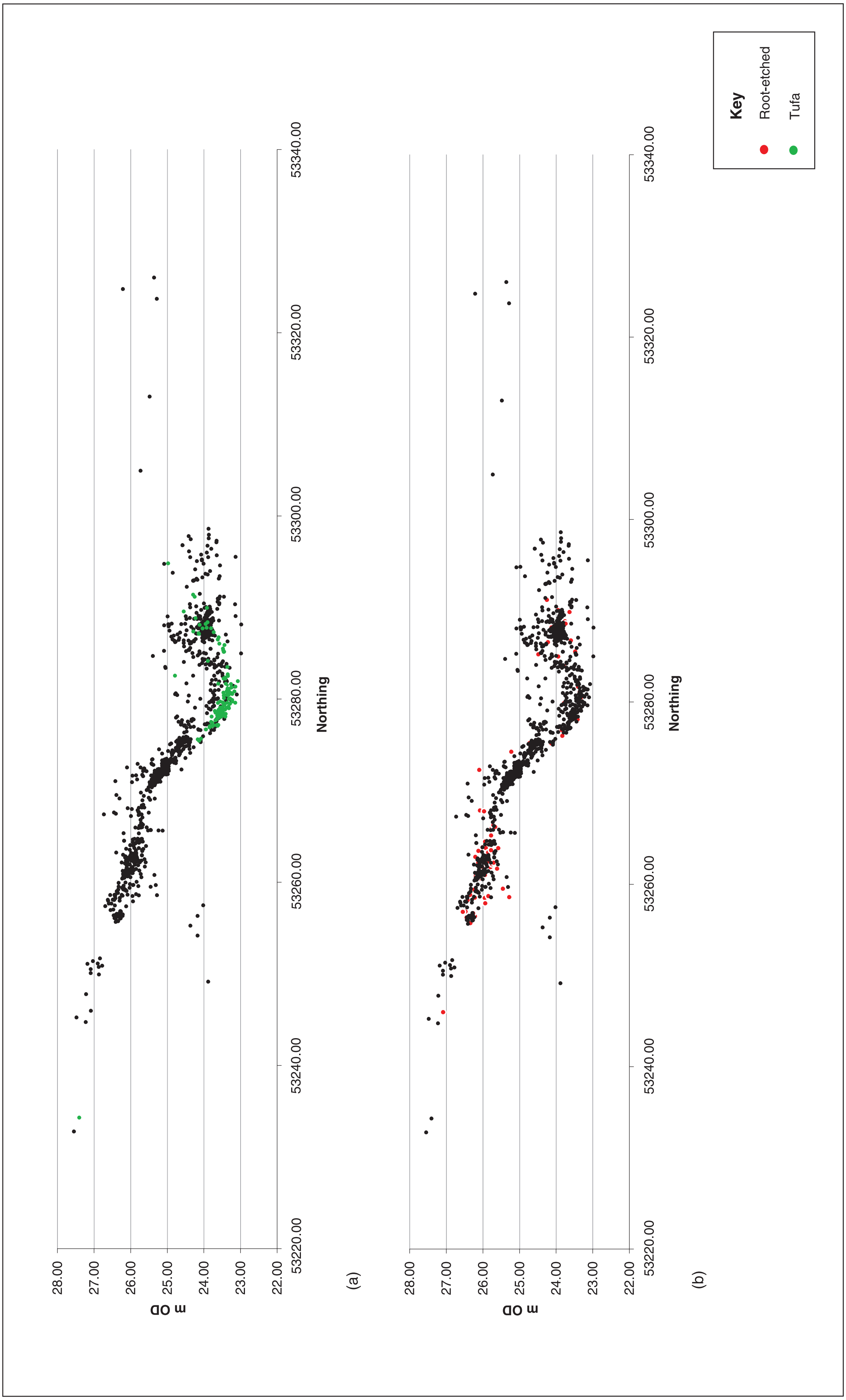


Figure 7.23 Sections of plotted bones from the tufaceous channel (a) compared with root-etched bones (b), the latter suggestive of drier conditions associated with areas of higher topography

changes in hydrological conditions and water-level that gave rise to varying conditions from fluvial channels, wetlands, spring seeps, and dry land.

Interpreting the relationship of the archaeology and faunal remains to these environments is complicated by post-depositional displacement, slumping and deformation of the sediments, which has distorted the original topography (Chapter 4). Nevertheless, the distribution of the bones in Phase 6 gives an indication of a sloping channel-edge with waterlain tufaceous sediments in a shallow stream at the foot of the slope (Fig. 7.23a). These tufaceous deposits have yielded a rich fish assemblage indicative of slow-flowing water. Most of the artefacts, however, are from the area of highest topography at the southern end of the site. In contrast, the major concentration of bones is to the north of the main artefact concentration, on the sloping surface and in the area of lower topography associated with the tufa channel. An outlying concentration of artefacts is associated with the elephant skeleton, but elsewhere artefact density is relatively low. Similarly, root-marked bone is not distributed randomly across the site. In Phase 6, for example, there is a high degree of clustering of bones with root marks coinciding with the area of higher topography (Fig. 7.23b). The concentration of root-marked bones may suggest that this was a dry land surface with well-developed cover of vegetation, abutting the wetter and topographically lower ground to the south. The human occupation therefore took place in a valley setting at the transition between dry land and wetland habitats. This would have offered a variety of environments for early humans, but whether any one of these environments was the preferred habitat is difficult to determine from the evidence at Southfleet Road alone. The vertebrate evidence does however indicate that the local environment was not static and that there was a succession of small-scale changes that appear to relate to local conditions rather than regional climate change (Table 7.10).

The role of herbivores in maintaining the habitat patchwork

Records of Hoxnian vegetational change are preserved in lake sequences, such as those at Hoxne, Suffolk and Marks Tey, Essex (Turner 1970). These reveal a progressive invasion of forest that covered most of the landscape of southern England after the retreat of the Anglian ice sheet. By the early temperate substage an abundance of tree pollen is taken to indicate closed-canopy deciduous forest. Low counts of non-arboreal pollen indicate local herb communities associated with lakes and bogs or glades in the forest. However, the palynological evidence for closed forest at these sites is contradicted by the mammalian evidence, which suggests more open conditions with areas of extensive grassland. This apparent contradiction may be explained by invoking spatial differences in woodland cover, with more open conditions of grassland or open parkland associated with the mammalian evidence from floodplain situations and denser woodland on the interfluves associated with the lake sites (Ashton *et al.* 2006). At Southfleet Road there can be little doubt that there were trees nearby when these deposits accumulated (see Chapter 12), but the location and density of the woodland is more difficult to assess. Similarly there are indications for fluctuations in tree density which require explanation.

The mammalian evidence from Southfleet Road suggests that the local vegetation was a patchwork of dense woodland with grassy glades, interspersed with more extensive open grassland, marsh and other water-edge habitats. Changes in faunal composition show the vegetation structure of the immediate area was not static and that there were periods when open grassland was dominant (Phase 5) and other times when dense woodland covered the site (contexts 40070, 40144). Several factors, such as: geomorphic change, fire, fluctuating water levels, floods, edaphic factors and climate change may be implicated in modifying the vegetation. However, climate change is unlikely to have been one of them, given that there are no strong indications that there were major changes in the climate associated with the main faunal horizons (see below). The availability of freshwater at the site evidently attracted large herds of herbivorous mammals and provided a home for European beaver. Large herbivores are an important natural agent in shaping habitats and the activities of these animals are likely to have played an important role in woodland dynamics. For example, the European beaver is an important agent in altering landscapes and ecosystems as a result of their tree-cutting and dam-building behaviour (Coles 2010). They crop small deciduous trees along the edge of water bodies, creating breaks in the canopy that encourage herbaceous vegetation. Large grazing mammals also maintain clearings that are maintained in that condition by intensive grazing and browsing. The feeding activities of elephants are critical in opening-up wooded environments as both African and Asian elephants browse mainly on leaves, twigs and branches and roots. In the process they can cause considerable damage to woodland. It is likely that the straight-tusked elephant would have had a similar impact on the environment at Southfleet Road. Browsing and trampling by mega-herbivores inhibits scrub and woodland regeneration and would have helped to maintain the open grassland areas within the forest. These open areas would have attracted other grazing herbivores to feed (Turner 1975). Turner (ibid.) has shown that the expansion of grassland over what had been woodland can be a direct result of large herbivore activity. Conversely, any reduction in grazing pressure would lead to woodland regeneration; changes to woodland domination may be remarkably fast, due to the spread of already existing trees that had hitherto been confined by grazing.

Comparisons with large mammal assemblages from Clactonian levels at Swanscombe and Clacton-on-Sea

The foregoing discussion has outlined the environmental setting of the Clactonian occupation at Southfleet Road, interpreted from the vertebrate data. The vertebrate faunas from Southfleet Road can now be placed into a wider context of Early Palaeolithic Hoxnian environments by comparison with faunas associated with the Clactonian at Swanscombe and Clacton in the Thames Valley. These sites provide interesting comparisons between localities where Clactonian occupation occurred in different geomorphological settings. At Southfleet Road, the occupation took place in a small tributary valley that supported a patchwork of vegetation, including woodland, marsh and open areas with herbaceous vegetation. At Swanscombe, the sediments were deposited in the channel and on the floodplain of the Thames, which in this area had a wide floodplain flanked by chalk hills. At Clacton, some 45km downstream from Swanscombe, Clactonian artefacts are found in Thames river gravels and silts deposited in the lower reaches of the river, close to its estuary. The floodplain at Clacton was probably more extensive and beyond the floodplain the surrounding landscape was one of generally low-lying topography. The limited relief was formed of fluvial sands, gravels and clays deposited during the Anglian glacial stage. In contrast, Clactonian activity at Southfleet Road took place in a minor tributary valley of Thames. This narrow valley was cut into fine-grained Tertiary sediments and Chalk. Although both Clacton and Swanscombe have yielded substantial quantities of fossil vertebrate material, most of the material from earlier collections was not recovered during archaeological excavations but from searching foreshore exposures at Clacton and during quarrying at Swanscombe (Currant 1996). As well as producing a bias in favour of larger specimens and animals, many of the fossils collected in this way lack precise stratigraphical information. With the Clacton material there is an added complication as older museum collections incorporate specimens from several sites associated with different channels, one of which post-dates the Hoxnian (Bridgland *et al.* 1999).

More directly comparable with the Southfleet Road assemblages in terms of recovery techniques are the large mammal assemblages from controlled archaeological excavations undertaken by Wymer at Clacton (Singer *et al.* 1973) and by Waechter at Swanscombe (Conway *et al.* 1996). Although bulk wet-sieving was not undertaken at either site, the deposits were nevertheless excavated carefully and all of the retrieved bone fragments were kept. The Swanscombe assemblage even includes rodent teeth and other microfauna recovered during trowelling. The excavations at Swanscombe between 1968 and 1972 were focused on newly recognised Clactonian archaeology in the Lower Loam; the immediately underlying Lower Gravels were also sampled. The Lower Gravels and Lower Loam at Swanscombe represent a single depositional unit reflecting a change from fast flowing-water to quieter conditions of a meander channel to a dry landsurface at the top of the Lower Loam succession (Table 7.11). The excavation recovered refitting scatters of Clactonian knapping debris and abundant large mammal remains from several different horizons

Table 7.11 Swanscombe: correlation of sediments and summary of the environment from Waechter's 1968-72 excavations at Barnfield Pit, based on evidence from the vertebrates, molluscs and sediments (Conway *et al.* 1996)

Stage	*Horizons with mammals*	*Environment (Conway 1996)*
Lower Middle Gravel IIa	Lower Middle Gravel	High-energy fluvial conditions, appearance of Rhenish species
	Base of Lower Middle Gravel	
Lower Loam Ie	Lower Loam surface Weathered Lower Loam	Landsurface with soil formation in dry, open grassland conditions (large mammal footprints). Fully temperate
		Deeper quiet water bordered by dry grassland
Lower Loam Id	Lower Loam main body Lower Loam sandy horizon Base of Lower Loam	Meander channel. Low-energy regime, virtually still if not stagnant, interrupted by phases of channel cutting and infilling and temporary relatively dry landsurface with dessication. *In-situ* knapping scatters. Molluscs indicate reed swamp and fen with dry grassland in open woodland
	Lower Loam/Lower Gravel junction	Erosional surface, marking boundary between high-energy regime below and low-energy regime above
Midden Horizon Ic	Lower Gravel (midden)	Mollusc fauna comparable with that from upper part of Lower Gravel
Lower Gravel Ib	Lower Gravel unit 4 Lower Gravel unit 3 Lower Gravel unit 2 Lower Gravel unit 1	Fluvial, fully temperate. Molluscs dominated by aquatic species (90%), terrestrial molluscs indicate rather open (marsh) conditions, woodland/scrub species moderately common

Table 7.12 Numbers of identified larger mammal specimens (including lagomorphs) from Wymer's (1969–70) excavation at Clacton-on-Sea (Singer *et al.* 1973), Waechter's (1968–1972) excavation at Swanscombe (based on Schreve 1996, with corrections) and Southfleet Road.

	Clacton	*Swanscombe*				
	Sandy gravel	*Lower Gravel*		*Lower Loam*		
	Layer 4	*1*	*2*	*3*	*4*	*5*
Primates						
Macaca sylvanus, Barbary macaque						
Lagomorpha						
Oryctolagus cuniculus, rabbit			1	5		
Rodentia						
Trogontherium cuvieri, beaver-like rodent	1					
Castor fiber, beaver						
Carnivora						
Canis lupus, wolf			1			
Ursus spelaeus, cave bear		1				
Ursus sp., bear		2	1	1		
Felis sylvestris, wild cat			1			
Panthera leo, lion						
Proboscidae						
Palaeoloxodon antiquus, straight-tusked elephant			6			
Elephantidae gen. et sp. indet., indeterminate elephant	5	2	2			
Perissodactyla						
Equus ferus, horse	6	2				
Stephanorhinus kirchbergensis, Merck's rhinoceros		1	1			1
Stephanorhinus hemitoechus, narrow-nosed rhinoceros	2		2			
Stephanorhinus sp., rhinoceros	3		3	1		
Artiodactyla						
Sus scrofa, wild boar				1		
Megaloceros giganteus, giant deer						
Dama dama clactoniana or *D. dama* ssp. indet., fallow deer	2	10	31	3	2	4
Cervus elaphus, red deer	3	3	3	2		
Capreolus capreolus, roe deer						
Cervidae gen. et sp. indet, indeterminate deer	8	31	53	23		4
Bos primigenius, aurochs		5		1		
Bison priscus, bison		1				
Bos primigenius or *Bison priscus*, aurochs or bison	10	3	9	5		1
Total (NISP)	40	61	114	42	2	10

Clacton (Wymer excavation. Singer *et al.* 1973)
Swanscombe (Waechter excavation. Conway *et al.* 1996)

Swanscombe
1. Lower Gravel
2. Lower Gravel midden
3. Lower Loam - Lower Gravel junction
4. Base of Lower Loam
5. Lower Loam sandy horizon
6. Lower Loam main body
7. Weathered Lower Loam
8. Lower Loam surface / weathered surface

Southfleet Road
1. Phase 5
2. Phase 6a (Context 40039)
3. Phase 6a (Context 40103)
4. Phase 6b (Context 40070)
5. Phase 6b (Context 40144)
6. Phase 6 (Context 40078)
7. Phase 6 (Context 40100)

Note – spatially associated specimens that are likely to have come from the same individual are counted as one specimen.

Swanscombe *Lower Loam*			*Southfleet Road*						
6	*7*	*8*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1						1			
10	2	2	2	1					
									1
3									
3									
1	1		1						
			1				1	2	
3								61	
		2							
								1	6
				23			2	3	3
1	2								
1	4			1					1
	1								
28	5	5	1	4	1	2			3
6	2	1		4	1	8		6	11
						1	1		1
59	10	16	4	33	5	88	11	70	62
2			1					1	
3	1	3	2	3				2	
121	28	29	11	69	8	100	15	146	88

(Conway *et al.* 1996). A much smaller vertebrate assemblage was recovered from Wymer's trenches at Clacton (Singer *et al.* 1973). Most of the bones were recovered from a sandy gravel (layer 4) containing Clactonian artefacts. The deposits at Swanscombe and Clacton have been correlated using several lines of evidence, with palynology at Clacton showing that the Clactonian activity took place during the early part of the Hoxnian interglacial (Kerney 1971; Bridgland *et al.* 1999). The Clactonian at Southfleet Road is argued to date from the same period, based on vertebrate palaeontology (Chapter 9), the pollen record (Chapter 12) and amino acid dating (Chapter 13).

Comparisons of the larger mammal faunas from the three excavations are given in Table 7.12. Here, the relative and absolute abundance are assessed by a simple count of the number of identifiable specimens (NISP, excluding indeterminate fragments). The counts shows the expected relationship between the size of the assemblages and the number of taxa; the largest samples are from Southfleet Road (NISP = 437) and Swanscombe (NISP = 387), with 12 and 15 taxa respectively. The much smaller assemblage from Clacton (NISP = 40) has seven taxa represented. Deer, bovids, proboscidians and rhinos are present in all three assemblages, with red deer and fallow deer fossils by far the most common identifiable specimens represented at Swanscombe and Southfleet Road. At the latter two sites, cervids account for more than half of the identified larger mammal specimens. In keeping with trophic structure, carnivores

Table 7.13 The relative abundance of larger mammals at Clacton, Swanscombe and Southfleet Road based on counting a limited set of homologous (non-reproducible) elements: third lower molar, axis, distal humerus, proximal metacarpal, pelvic acetabulum, distal tibia, proximal metatarsal.

	Clacton	***Swanscombe***				
	Sandy gravel	*Lower Gravel*			*Lower Loam*	
	Layer 4	*1*	*2*	*3*	*4*	*5*
Primates						
Macaca sylvanus, Barbary macaque						
Lagomorpha						
Oryctolagus cuniculus, rabbit						
Rodentia						
Trogontherium cuvieri, beaver-like rodent	+					
Castor fiber, beaver						
Carnivora						
Canis lupus, wolf			+			
Ursus spelaeus, cave bear		+				
Ursus sp., bear		+	+	+		
Felis sylvestris, wild cat			1			
Panthera leo, lion						
Proboscidae						
Palaeoloxodon antiquus, straight-tusked elephant			+			
Elephantidae gen. et sp. indet., indeterminate elephant	+	+	1			
Perissodactyla						
Equus ferus, horse	2	1				
Stephanorhinus kirchbergensis, Merck's rhinoceros		1	1			+
Stephanorhinus hemitoechus, narrow-nosed rhinoceros	+		2			
Stephanorhinus sp., rhinoceros	1		+	+		
Artiodactyla						
Sus scrofa, wild boar				+		
Megaloceros giganteus, giant deer						
Dama dama clactoniana or *D. dama* ssp. indet., fallow deer	+	2	6	1	+	+
Cervus elaphus, red deer	+	2	2	1		
Capreolus capreolus, roe deer						
Cervidae gen. et sp. indet, indeterminate deer	1	2	7	2		+
Bos primigenius, aurochs		1		+		
Bison priscus, bison		1				
Bos primigenius or *Bison priscus*, aurochs or bison	4	2	+	+		+
Total	8	12	20	4		

Clacton (Wymer excavation. Singer *et al.*, 1973)
Swanscombe (Waechter excavation. Conway *et al.*, 1996)

Swanscombe
1. Lower Gravel
2. Lower Gravel midden
3. Lower Loam - Lower Gravel junction
4. Base of Lower Loam
5. Lower Loam sandy horizon
6. Lower Loam main body
7. Weathered Lower Loam
8. Lower Loam surface / weathered surface

Southfleet Road
1. Phase 5
2. Phase 6a (Context 40039)
3. Phase 6a (Context 40103)
4. Phase 6b (Context 40070)
5. Phase 6b (Context 40144)
6. Phase 6 (Context 40078)
7. Phase 6 (Context 40100)

+ indicates presence of taxa not otherwise represented by a 'countable' element.

	Swanscombe *Lower Loam*			***Southfleet Road***						
	6	*7*	*8*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
	+						+			
				1	+					
										+
	+									
	+									
	1	+		+						
				+				+	+	
	+								1	
			+							
									+	1
					+			1	2	+
	1	+								
	+	+			+					+
		+								
	4	3	1	+	1	+	+			1
	3	1	+		2	1	+		1	3
							+	+		+
	9	3	1	1	2	+	4	+	6	4
	+			+					1	
	1	+	+	+	+				+	
	19	7	2	2	5	1	4	1	11	9

are rare, although they are better represented at Swanscombe than at Southfleet Road, where lion is joined by wolf, wild cat and the omnivorous cave bear. These differences aside, the Swanscombe and Southfleet Road faunas share many species in common, but there are differences either in qualitative presence/absence or in relative frequency that require explanation. Taxa missing from Southfleet Road assemblages included giant deer, bison (both represented in the Waechter collection by one specimen each) and horse. These differences could result simply from chance, circumstances of preservation, small sample size or inability to identify fragmentary remains (for example the bovid bones from Southfleet Road may include bison but the specimens are generally too fragmentary to make a definitive identification). The absence of horse in the Southfleet Road assemblage is more intriguing as it occurs in the both the Lower Loam and Lower Gravels at Swanscombe and in the much smaller Clacton assemblage, where it is represented by more than one individual (Singer *et al.* 1973). A plausible explanation for the occurrence of horse at Swanscombe and Clacton is that the floodplain bordering the Thames had more extensive areas of open grassland suitable for herds of grazing horses, whereas Southfleet Road was more heavily wooded, especially during the deposition of Phase 6. The narrow wooded valley of the proto-Ebbsfleet may simply have been less suited to horses.

Turning now to the relative proportion of deer species, the NISP counts show that fallow deer specimens are much more common than red deer in both the Lower Gravel and Lower Loam assemblages, whereas the opposite relationship holds in the Southfleet Road assemblages. This could simply result from differences in taphonomy between the two sites, either from differential fragmentation of the bones and the incorporation of shed antlers of red and fallow deer skewing the counts. Both factors could act together to inflate the counts in favour of one species over the other. The problem of differential fragmentation was tackled by counting only a limited set of non-reproducible elements (cf. Davis 1992; O'Connor 2003) and by making separate counts for the antlers. It is clear, both from the NISP (Table 7.12), limited elements (Table 7.13) and the antler counts (Table 7.14), that red deer remains are about three times as common as those of fallow deer in the Southfleet Road assemblage and that fallow deer are consistently more abundant at Swanscombe. These differences would appear to reflect differences in the living population, implying that the local environment at Southfleet Road was better suited to red deer, whereas conditions at Swanscombe provided a more suitable habitat for fallow deer. An indication of the differences in ecology is provided by the molluscan fauna from Swanscombe, which contains a significant component of open ground and marsh taxa, as well as others that prefer woodland or scrub. This mixture of local habitats would have provided ideal conditions for fallow deer, which today are closely associated with parkland, sparse forests, marshland and grassland. Although red deer are found in a similar range of habitats, optimal conditions are provided by dense deciduous forest and forest margins. It may be significant that roe deer is present (although uncommon) in several horizons at Southfleet Road, compared with Swanscombe, where it is represented by only one specimen in the entire collection (Lister 1986). The ecology of roe deer would support other indications of dense woodland at Southfleet Road, which is the preferred habitat of this species, especially in the western part of its range.

More detailed comparisons of the ecology of the Clactonian levels at Swanscombe and Southfleet Road are hampered by the unevenness of the vertebrate records. At Southfleet Road, the vertebrate fauna includes a significant small vertebrate component, which is largely missing in the Swanscombe collections. Although some sieving was undertaken to recover molluscs at Swanscombe (Kerney 1971), the samples were too small to recover a useful sample of the smaller mammals, birds, reptiles, amphibians and fishes. This information gap is unfortunate, as at Southfleet Road the smaller vertebrates have enabled detailed bed-by-bed reconstructions of the local ecological conditions. At Swanscombe, such information is provided by the molluscan fauna, which is much more extensive than at Southfleet Road (Chapter 10). Although the larger vertebrate faunas from the Thames Clactonian sites are clearly very incomplete samples of the once-living populations that they represent, they nevertheless show interesting points of similarity as well as differences that are probably the result of local ecological conditions.

Table 7.14 A comparison of antler counts from Swanscombe (Waechter's excavation) and Southfleet Road.

	Unshed	*Shed*	*Frag*	*Total*
Swanscombe (Lower Gravel)				
Fallow deer	6	9	10	25
Red deer			1	1
Deer		1	26	27
Total	6	10	37	53
Swanscombe (Lower Loam)				
Fallow deer	3	9	7	19
Red deer	2	1	1	4
Deer		1	15	16
Total	5	11	23	39
Southfleet Road (Phase 6)				
Fallow deer		3		3
Red deer		8	1	9
Deer	2	15	178	195
Total	2	26	179	207

Climatic implications of the vertebrate fauna

The vertebrate fauna provides important information about the climatic conditions prevailing during the Clactonian occupation at the site. The climatic conditions can be reconstructed by analogy to the present-day ecology of extant taxa (or their nearest living relatives), combined with the analysis of the whole mammalian fauna using taxonomic habitat indices and the climatic preferences of fossil mammals inferred from associated biological proxies (Andrews 1990; Candy *et al.* 2010). A comparative framework is provided (Table 7.15), with extant taxa divided into climatological groups according to the northern boundary of their ranges: (1) species whose northern-most boundary extends above the Arctic Circle into the tundra zone; (2) species whose northern-most boundary just reaches the Arctic Circle; and (3) species who only range to southern Scandinavia. In relation to the Pleistocene record, most of the Southfleet Road taxa are known only from warm stages in Britain (Ig = interglacial; Is = interstadial), but a few had wider climatic ranges, and were present in both cold (C) and warm stages.

Mammals are strongly influenced by climatic variation, temperature and humidity. Many of the extant mammals represented in the Southfleet Road assemblage are tolerant of a wide range of conditions and occur widely from the Mediterranean coast and into northern Europe, with some having ranges extending into the tundra above the Arctic Circle (climatological group 3 in Table 7.15). The broad latitudinal distribution of mammals in this group implies that they have wide ecological and climatic tolerances (but see Candy *et al.* 2010 and Polly and Eronen 2011) for a discussion of the problems of inferring climate from warm-blooded animals). The remaining taxa can be divided into two further climatological groups according to the northern boundary of their ranges. The first group includes

Table 7.15 Ecology and climatic preferences of mammalian taxa from Southfleet Road. Extant taxa are divided into climatological groups according to the northern boundary of their ranges: 1 - Species whose northern-most boundary extends above the Arctic Circle into the tundra zone; 2 - species whose northern-most boundary just reaches the Arctic Circle; 3 - species who only range to southern Scandinavia. Most of the taxa are known only from warm stages in Britain (Ig = interglacial, Is = interstadial) but a few had wider climatic ranges and occur in both cold (C) and warm stages.

	Climatological zone			*Pleistocene occurrence*			*Phase*					
	1	*2*	*3*	*Ig*	*Is*	*C*	*3*	*5*	*6a*	*6b*	*6*	*7*
Extant in Europe												
Oryctolagus cuniculus, rabbit			✓	✓				+	+	+		
Microtus (Terricola) cf. *subterraneus*, common pine vole			✓	✓	✓			+		+		
Apodemus sylvaticus, wood mouse			✓	✓	✓			+	+	+		
Dama dama, fallow deer			✓	✓	✓			cf	+	+	+	
Myotis daubentonii, Daubenton's bat		✓		✓						+		
Mustela cf. *putorius*, polecat		✓		✓						+		
Sus scrofa, wild boar		✓		✓	✓				+		+	
Sciurus sp., squirrel	✓			✓						+		
Neomys sp., water shrew	✓			✓	✓			+	+	+	+	
Castor fiber, beaver	✓			✓	✓					+	+	
Clethrionomys glareolus, bank vole	✓			✓	✓			+	+	+		
Capreolus capreolus, roe deer	✓			✓	✓					+	+	
Sorex minutus, pygmy shrew	✓			✓	✓	✓		+		+		
Spermophilus sp., ground squirrel	✓			✓	✓	✓		+				
Microtus agrestis, field vole	✓			✓	✓	✓				+		
Microtus oeconomus, northern vole	✓			✓	✓	✓		+		+		
Cervus elaphus, red deer	✓			✓	✓	✓		+	+	+	+	
Extinct in Europe												
Macaca sylvanus, Barbary macaque				✓	✓					+		
Panthera leo, lion				✓	✓	✓		+				
Extinct												
Stephanorhinus kirchbergensis, Merck's rhinoceros				✓							+	
Apodemus maastrichtiensis, mouse				✓						+		
Bos primigenius, aurochs				✓	✓		+	+			+	
Talpa minor, mole				✓	✓				+	+	+	
Palaeoloxodon antiquus, straight-tusked elephant				✓	✓			+		+	+	
Arvicola cantianus, water vole				✓	✓	✓		+	+	+	+	
Stephanorhinus hemitoechus, narrow-nosed rhinoceros				✓	✓	✓			+	cf	+	

Daubenton's bat, polecat, and wild boar, whose northern-most boundaries just reach the Arctic Circle. The final group includes species intolerant of cold climate, with ranges extending no further than southern Scandinavia. Included in this group are rabbit, pine vole, wood mouse and fallow deer. Rabbit and fallow deer, in particular, are generally accepted as strong indicators of fully interglacial conditions in north European contexts (Stuart 1982). As a group the mammals from Phase 5 and 6 indicate deciduous woodland and by inference fully temperate conditions.

Of note is the presence of northern vole in the interglacial deposits. This small rodent has been extinct in Britain since the end of the last cold stage; today it has a largely northern Palaearctic distribution, favouring tundra and taiga habitats. There are, however, British Pleistocene records from temperate stages, including the warmest part of the interglacial (MIS 5e), when temperatures were 1 or 2°C warmer than the present day (Stuart 1982) and in fully temperate parts of MIS 7 in the Ebbsfleet Valley (Wenban-Smith *et al.* forthcoming). Similarly, the presence of ground squirrel in Phase 5 is intriguing as most British Pleistocene records are from cold stage contexts (Stuart 1982). As with northern vole, ground squirrels have also been found in more temperate contexts during the late Middle Pleistocene, at Crayford and Erith (Stuart 1982). Consequently, the presence of northern vole and ground squirrel do not necessarily indicate cooler conditions than present day. It seems likely that both species survived from the preceding cold stage in favourable microhabitats of marshland and dry grassland, respectively.

Temperature appears to be the main factor governing the present and past distributions of cold-blooded vertebrates (Stuart 1982). Although the amphibians and reptiles from Southfleet Road have not been identified in detail, the presence of tree frog is climatically informative. Today, *Hyla arborea* (common tree frog) is the most northerly tree frog. It has an extensive range throughout much of southern and central Europe, where it is found as far north as central Denmark and southern Scandinavia. In the east, its range does not extend far into European Russia, where the winters are too severe.

Other cold-blooded fauna are also strongly influenced by climate. For example, water temperature has been identified as a key factor controlling the distribution of cyprinid fishes (Cyprinidae: carp family) across different climatic zones (Wheeler 1977). Amongst the most theromophilic of these are tench *Tinca tinca* and rudd *Scardinius erythrophthalmus*, both of which are present in Phase 5 and 6 at Southfleet Road. Neither occurs farther north than central Fennoscandia and thus provide a further indicator of warm conditions.

Table 7.15 also summarises the inferred climatic preferences of the fossil mammalian taxa. Although some of these mammals had wide ecological tolerances, being found in both temperate and cold stages (for example pygmy shrew, field vole), the majority appear to have been restricted to temperate phases. The most significant of these is Merck's rhinoceros which, although frequently recorded in Middle Pleistocene interglacials, was absent from the intervening interstadials and cold stages in northern Europe (Pushkina 2007). The presence of Merck's rhinoceros therefore supports other indications for interglacial conditions.

Another approach to determining palaeoclimate by analysis of the whole mammalian fauna is the Taxonomic Habitat Index (THI) developed by Andrews (1990). The taxonomic habitat index approach adopted for the analysis of the Southfleet Road assemblage makes an assessment of the habitat preferences for all the micromammals in the fauna. The method uses presence or absence of taxa without any reference to their relative abundance, thereby reducing the bias arising from taphonomy (for example predator prey selection). It has the added advantage that it does not rely on single 'indicator species' but combines multiple species and makes allowance for fossil taxa. The habitats were divided into nine types: tundra, boreal forest, deciduous forest, Mediterranean, steppe, forest steppe, arid, tropical and montane. Each species was given a maximum possible score of 1.00 which was broken down according to the habitat preference of that species, so that if an animal occurs in more than one habitat type, it was scored proportionally according to its habitat preference (Andrews 1990). As an example, the hazel dormouse *Muscardinus avellanarius* that lives mainly in deciduous woodland, was scored 0.7 for 'Deciduous'. As it is also widespread in the Mediterranean bioclimatic zone, hazel dormouse was scored 0.3 for 'Mediterranean'. The scores for each habitat for all species are then added together and divided by the number of species to give an average weighed score for each habitat for that fauna. The spectrum produced is presented in the form of a histogram.

The THI spectra for different phases of the Southfleet Road sequence are plotted in Fig. 7.24, compared with the peak MIS 11 interglacial assemblage from Barnham (Parfitt 1998b). The fossil spectra have been compared with those of 71 modern small-mammal faunas from locations representing the key bio-climatic zones throughout western Eurasia (Parfitt, unpublished data). The THI spectrum of the species in Phase 5 is most similar to those from northern central Europe. Phase 6a is comparable with those of modern central-southern European deciduous woodlands,

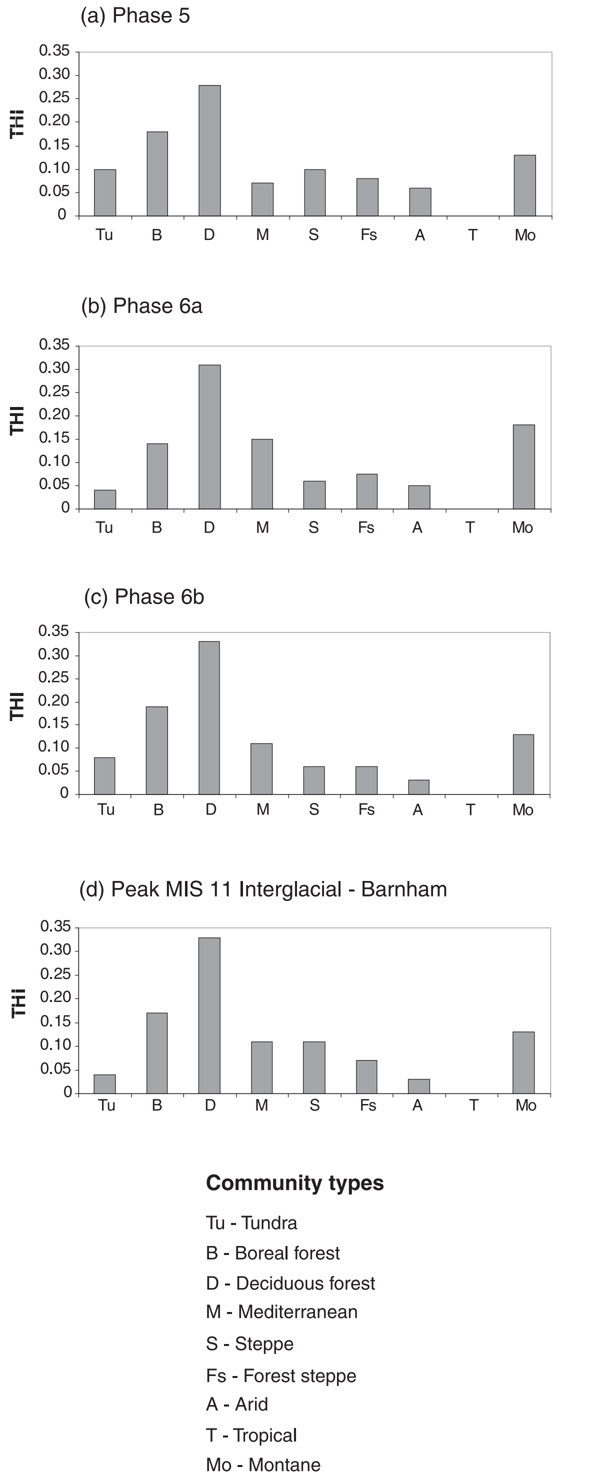


Figure 7.24 Taxonomic habitat indices for the micromammals from successive phases at Southfleet Road: (a) Phase 5; (b) Phase 6a; (c) Phase 6b, compared to the spectrum of a peak interglacial (MIS 11) assemblage from Barnham, Suffolk

whereas those calculated from the species present in Phase 6b are much more similar to those in the region encompassing southern England and the southern tip of Scandinavia. In Britain, such spectra are characteristic of the climatic optima of Pleistocene interglacials. This is illustrated by comparison with the THI spectrum from the Hoxnian fauna of Barnham (Suffolk). The Barnham fauna includes the thermophilous European pond terrapin *Emys orbicularis* and Aesculapian snake *Zamenis longissimus*. The former requires mean July temperature exceeding 17-18°C for hatching successfully; similar summer temperatures are indicated by Aesculapian snake.

The analysis shows that ecological differences between the spectra are slight, with high values for deciduous elements and somewhat lower scores for boreal elements in the three phases analysed. The spectrum from Phase 5 differs in having a slightly higher score for steppic categories and a somewhat lower Mediterranean component. Overall, the spectra are consistent with the deciduous woodland bioclimatic zone, encompassing central France to the southern tip of Scandinavia. Phase 5 appears to have a more continental aspect, whereas Phase 6a has a closer affinity with central France and 6b with more northerly localities. Overall, the spectra are entirely consistent with interglacial conditions (cf. Andrews 1990).

The vertebrate evidence provides a clear insight into the climatic conditions during the Clactonian occupation at Southfleet Road. A combination of community structure (using the Taxonomic Habitat Method) and climatic preferences of both the extinct and extant taxa yields a consistent picture, indicating that during Phases 5 and 6, the deposits accumulated during an interglacial period. Conditions during the deposition of Phase 3 were probably also temperate. The presence of warmth-loving vertebrates and the complete absence of any exclusively boreal species, suggests that the climate was as warm as that of southern England at the present day and may have been somewhat warmer.