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15

Sherd movement in the ploughzone—physical data base into computer simulation

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15.1 Introduction

During the last decade a major research programme has been carried out at the Butser Ancient Farm to explore the annual movement of simulated potsherds in the ploughsoil under a continuous arable regime (Reynolds 1986). The reasons for this programme lie in the fundamental question of whether the topsoil overlaying an archaeological site should be regarded as worthy of excavation in that the artefacts it may contain still bear a relationship to underlying features and therefore will have some interpretational value. The current view is that since the topsoil has been subjected to discontinuous agitation by plough action through time, it can be summarily dismissed. Hence the normal process prior to excavation is the stripping of the soil layer to the uppermost archaeological surface. There are, however, a number of arguments to be raised against this assumption. First, and most obviously, many sites are located by the surface scatter of pottery brought up by the plough. The greater the density of potsherds on the surface, the tighter is the isolation of the artefacts in the topsoil with underlying site. Some exploration of the relationship of artefacts in the topsoil with results has been carried out archaeologically, with results demonstrating clear association (Hinchcliffe 1979). Similarly sites are often located by soil marks. If ploughing disperses artefacts, it would be reasonable to expect that ploughing would similarly disperse soil marks soil marks. This too has been demonstrated not to be the case (Taylor 1987). Again, utilising enhanced magnetic susceptibility of magnetic oxides in the top soil, clear associations have been isolated with underlying features (Clark 1982). Ironically most archaeologists regard the soil heap from an excavation as their richest source of artefacts! One can further observe that both prehistoric and historic men were generally separated from the first archaeological layer by a cushion of soil especially in the rural zones.

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15.2 The experiment in spatial movement in the plough soil

To achieve some understanding of what actually occurs in the topsoil the following experiment was devised. Currently it is in its fourth phase, which is reported below, the previous phases having been published already (Reynolds 1982). The principle obstacle to verisimilitude lies in the nature of a sherd of pottery. In order to access spatial movement of a sherd as well as its individual changing attitudes, and its rolling and pitching within the soil, it proved necessary to make artificial numbered sherds so that they could be relocated by machine. Otherwise in order to recover the sherds each year total excavation would have been necessary, such a process denying the whole point of the trial. In earlier phases of the experiment diamond shaped 'sherds' were manufactured from plastic resin which encased both a number and a low powered bar magnet. The shape was chosen to mimic the general shape of actual sherds, and the magnet, sufficiently low powered as not to attract any metal object (including another magnet set at 25 mm distance), was inset to allow relocation with a fluxgate gradiometer. This machine is designed to detect extremely small magnet anomalies. In this current phase four different shapes of artificial sherd were simply to check whether shape had a significant bearing on movement. The shapes are as follows:– diamond, circle, shield and square. The weight of the artificial sherds correlates to that of commensurate sized sherds of prehistoric pottery. Within this experiment no account has been taken of sherd disintegration: nonetheless the *caveat* that the sherd began as a pot needs to be kept in mind.

The field area selected for the trials is within the confines of the Demonstration Area of the Butser Ancient Farm. Situated in a valley bottom the soil is a typical chalkland hillwash comprising friable black rendiza, clay with flints, and chalk granules to a soil horizon depth of 300 mm. It is cross ploughed with a cattle drawn ard three times a year. The cereal crop is subsequently planted in seed drills and hoed on average three times per season. The plough, while of simple type, creates a furrow 250–300 mm deep and 400–500 mm from crest to crest. The whole soil body of the field is subjected to movement as massive as a modern plough but less predictably. In overall terms the field is virtually flat. In fact, there is a slight fall of less than 1 in 30 to the south.

Initially the artificial sherds were laid out on the intersections of a five metre square grid. Shapes were randomised and each one of the thirty-six sherds were laid horizontally at a depth of 50 mm from the surface of the soil with the magnet set longitudinally on a north-south axis. The sherds are relocated annually each spring, their new spatial position plotted in relation to the original grid and their position *vis a vis* the magnet axis recorded.

Table 15.1

This table presents the field data as collected and forms the basis for the figures in the text. The grid of six sherds by six sherds reads from the south east corner, across to the west. Thus Sherd No. 156 is at the north west corner. Measurements are taken from the eastern and southern grid lines respectively and recorded in centimetres. When a figure is preceded by a sign the measurement tracks in the opposite direction. For example, under the heading SOUTH, +15 means the measurement is 15 centimetres to the south of the southern grid line. The depth recorded in centimetres is taken from the surface of the plough soil to the centre of the artificial sherd. The capital letter S indicates the sherd is on the surface of the soil. The Spatial Attitude column designates the lie of the sherds in the soil. H=Horizontal; V=Vertical; (= Angled; N.S.E.W. represent the points of the compass and are used to designate the line of the bar magnet in each sherd; U indicates shred is face up; O indicates sherd is face down. If a sherd is set vertically in the soil these symbols are not used.

Sherd No.	*East*	*South*	*Depth*	*Spatial Attitude*			*Year*
156	000	000	5	H	N-S	U	1981
	012	042	15	H	N-S	U	1982
	010	042	12	H	N-S	O	1983
	+005	060	5	H	E-W	O	1984
	111	+36	7	H	E-W	O	1985
	+092	000	5	V	E-W		1986
176	100	000	5	H	N-S	U	1981
	098	000	7	(E-W		0	1982
	089	003	8	V E-W			1983
	146	+102	S	(SW-NE	SE-NW	U	1984
	249	+022	10	(N-S		U	1985
	259	110	10	(NE-SW		U	1985
162	200	000	5	H	N-S	U	1981
	205	008	5	H	E-W	U	1982
	127	+038	5	H	SW-NE	O	1983
	356	+030	2	(W-E		O	1983
	420	+047	1	H	E-W	O	1985
	406	+042	S	(NW-SE		O	1985
135	300	000	5	H	N-S	U	1981
	300	+018	S	H	N-S	U	1982
	283	+010	S	H	N-S	O	1983
	532	+047	5	H	E-W	O	1984
	522	+065	15	H	NE-SW	O	1985
	432	000	13	(	NE-SW	U	1986
165	400	000	5	H	N-S	U	1981
	423	051	S	V	SE-NW		1982
	435	058	15	V	N-S		1983
	448	052	19	H	E-W	O	1984
Not located	—	—	—	—	—	—	1985
	445	045	28	(	N-S	U	1986
124	500	000	5	H	N-S	U	1981
	390	024	9	(E-W	N-S	O	1982
	393	027	7	V	NE-SW		1983
	440	+019	12	(E-W	N-S	U	1984
	545	045	12	V	SW-NE		1985
	502	100	10	H	N-S	U	1986
180	000	100	5	H	N-S	U	1981
	045	035	8	H	SW-NE	O	1982
	+090	043	10	V	N-S		1983
	+100	052	12	(E-W		U	1984
	030	+026	11	H		U	1985
	+132	017	S	(NE-SW		U	1986
153	100	100	5	H	N-S	U	1981
	105	100	15	H	SE-NW	O	1982
	+249	317	5	H	SW-NE	U	1983

Sherd No.	*East*	*South*	*Depth*	*Spatial Attitude*			*Year*
	+264	319	7	E-W	N-S	O	1984
	+270	290	9	N-S	N-S	O	1985
	+264	290	17	N-S		U	1986
171	200	100	5	H	N-S	U	1981
	115	120	5	H	E-W	U	1982
	110	096	12	H	N-S	O	1983
	085	184	S	H	NW-SE	U	1984
	145	185	S	W	E-W	U	1985
	+005	144	S	H	N-S	U	1986
130	300	100	5	H	N-S	U	1981
	210	125	10	V	NW-SE		1982
	291	093	1	H	E-W	U	1983
	275	127	10	H	NE-SW	O	1984
	265	120	25	H	NE-SW	O	1985
	271	135	20	H	N-S	U	1986
183	400	100	5	H	N-S	U	1981
	390	105	13	(E-W	N-S	U	1982
	350	070	8	V	E-W		1983
Not located	—	—	—	—	—	—	1984
	590	+465	2	H	NE-SW	U	1985
	363	+430	S	H	N-S	U	1986
105	500	100	5	H	N-S	U	1981
	445	152	S	H	N-S	U	1982
	455	155	20	(NW-SE		O	1983
	452	140	10	H	E-W	O	1984
	450	132	4	(S-W	E-W	U	1985
	456	130	16	H	E-W	U	1986
132	000	200	5	H	N-S	U	1981
	+020	339	10	V	E-W		1982
	058	216	9	(	E-W	U	1983
Missing, presumed lost	—	—	—	—	—	—	1984
Missing, presumed lost	—	—	—	—	—	—	1985
Missing, presumed lost	—	—	—	—	—	—	1986
170	100	200	5	H	N-S	U	1981
	+085	425	4	(S-N	N-S	O	1982
	+025	422	18	H	N-S	U	1983
	+080	440	10	H	N-S	U	1984
	+090	490	15	H	SW-NE	U	1985
	+105	000	12	H	NE-SW	O	1986
177	200	200	5	N	N-S	U	1981
	205	254	8	(S-N	E-W	U	1982
	220	227	20	H	NW-SE	O	1983
	234	230	15	H	N-S	U	1984
	174	226	15	H	NE-SW	U	1985
	181	223	17	(	NE-SW	U	1986

Sherd No.	*East*	*South*	*Depth*	*Spatial Attitude*			*Year*
163	300	200	5	H	N-S	U	1981
	300	210	12	(SE-NW	E-W	U	1982
	340	191	15	S-N	E-W	U	1983
	308	198	16	N-S	E-W	O	1984
	330	170	S	H	E-W	O	1985
	340	140	7	(N-S		U	1986
151	400	200	5	H	N-S	U	1981
	410	195	15	H	SW-NE	U	1982
	403	196	5	H	SE-NW	O	1983
	435	173	5	V	N-S		1984
	420	160	6	H	N-S	)	1985
	421	210	3	(	N-S	)	1986
182	500	200	5	H	N-S	U	1981
	505	190	14	(E-W	N-S	U	1982
	494	153	5	H	N-S	U	1983
	518	092	3	H	N-S	O	1984
	570	085	9	V	E-W		1985
	543	051	10	H	N-S	U	1986
112	000	300	5	H	N-S	U	1981
	+050	138	15	H	SE-NW	U	1982
	+192	166	5	N-S	E-W	U	1983
	+167	167	10	W-E		U	1984
	+210	195	10	H	E-W	U	1985
	+247	200	20	(NW-SE		U	1986
172	100	300	5	H	N-S	U	1981
	040	226	9	(S-N	NE-SW	U	1982
	+074	274	10	V	N-S		1983
	+088	390	3	(W-E	N-S	)	1984
	120	330	S	H	N-S	O	1985
	156	379	11	(NE-SW		U	1986
120	200	300	5	H	N-S	U	1981
	205	315	7	H	S-N	U	1982
	188	430	S	H	E-W	U	1983
	222	465	5	V	N-S		1984
	222	500	21	(E-W	E-W	O	1985
	225	500	16	(E-W		U	1986
178	300	300	5	H	N-S	U	1981
	265	285	12	(E-W	SW-NE	U	1982
	270	268	12	H	E-W	)	1983
	251	458	15	V	N-S	U	1984
	1790	585	10	H	N-S	U	1985
	1549	170	S	(	N-S	U	1986
127	400	300	5	H	N-S	U	1981
	395	392	10	(S-N	E-W	U	1982

Sherd No.	*East*	*South*	*Depth*	*Spatial*	*Attitude*		*Year*
	397	294	16	(NE-SW	NW-SE	O	1983
	370	322	5	(N-S	E-W	U	1984
	500	290	12	H	SW-NE	O	1985
	500	295	8	H	NE-SW	O	1986
169	500	300	5	H	N-S	U	1981
	496	292	*	H	SW-NE	O	1982
	450	275	5	(N-S	NE-SW	O	1983
Missing, presumed lost	—	—	—	—	—	—	1984
Missing, presumed lost	—	—	—	—	—	—	1985
Missing, presumed lost	—	—	—	—	—	—	1986
115	000	400	5	H	N-S	U	1981
	002	286	10	V	E-W		1982
	010	367	13	V	E-W		1983
	+005	390	3	(W-E	NW-SE	U	1984
	085	350	S	H	E-W	O	1985
	091	359	5	H	E-W	U	1986
179	100	400	5	H	N-S	U	1981
	092	427	6	(S-N	N-S	U	1982
	120	602	2	H	N-S	O	1983
	062	673	3	H	NE-SW	O	1984
	+040	772	3	H	N-S	)	1985
	+040	778	14	H	NE-SW	U	1986
133	200	400	5	H	N-S	U	1981
	+005	485	8	S-N	SE-NW	O	1982
	+020	480	13	N-S	SE-NW	U	1983
	+004	489	14	H	SW-NE	O	1984
	000	530	30	(E-W	N-S	O	1985
	010	525	20	H	N-S	U	1986
119	300	400	5	H	N-S	U	1981
	235	372	*	(W-E	N-S	U	1982
	200	324	9	H	N-S	U	1983
	105	336	S	H	E-W	O	1984
	235	560	5	H	N-S	U	1985
	220	562	10	H	N-S	O	1986
160	400	400	5	H	N-S	U	1981
	362	426	15	V	N-S		1982
	350	464	10	(E-W		U	1983
	323	384	S	H	SW-NE	U	1984
	320	200	8	V	N-S		1985
	026	210	5	(	NE-SW	U	1986
181	500	400	5	H	N-S	U	1981
	499	395	15	(SE-NW		U	1982
	400	453	S	H	N-S	O	1983
	585	589	4	H	N-S	O	1984
	615	500	5	(N-S	SE-NW	U	1985

Sherd No.	*East*	*South*	*Depth*	*Spatial Attitude*			*Year*
	114	491	8	(NE-SW		O	1986
129	000	500	5	H	N-S	U	1081
	010	554	9	(E-W	N-S	O	1982
	+045	485	7	H	N-S	O	1983
	+045	559	5	(W-E	SE-NW	O	1984
Not located	—	—	—	—	—	—	1985
	+034	489	11	V	N-S	1986	
125	100	500	5	H	N-S	U	1981
	115	536	S	H	N-S	O	1982
	107	507	3	V	SW-NE		1983
	088	667	1	H	NE-SW	U	1984
	050	653	19	H	E-W	O	1985
154	200	500	5	h	N-S	U	1981
	163	490	7	V	SE-NW		1982
	160	515	S	H	NW-SE	U	1983
	115	519	10	H	N-S	O	1984
Not located	—	—	—	—	—	—	1985
	+004	490	7	(	NW-SE	U	1986
128	300	500	5	H	N-S	U	1981
	218	453	S	(E-W	SW-NE	U	1982
	375	475	10	H	N-S	U	1983
	386	502	3	V	SW-NE		1984
	402	510	3	H	SE-NW	U	1985
	170	636	S	H	E-W	U	1986
173	400	500	%	H	N-S	U	1981
	383	451	5	H	SW-NE	U	1982
	413	508	10	V	N-S		1983
	370	441	2	H	SW-NE	U	1982
	483	222	S	H	SW-NE	O	1985
	476	310	15	(	NE-SW	O	1986
126	500	500	5	H	N-S	U	1981
	505	510	14	(N-S	SW-NE	U	1982
	513	474	20	V	NE-SW		1982
	485	504	18	H	E-W	O	1984
	520	500	20	(S-N	E-W	U	1985
	530	520	24	V	N-S		1986

The movement of all the sherds is recorded in Table 1 and plotted in Fig. 15.1. The initial random nature of the lines in Fig. 15.1 is somewhat misleading since there is a clear trend each year demonstrating the nature of the cross ploughing. This effect is best seen in the vector diagrams in Fig. 15.2 where all the sherd positions have been centralised to a single point with their lines of travel or vectors properly oriented and scaled to distance. The vector diagrams also suggest what might occur to a single pot broken and then spread by plough action.

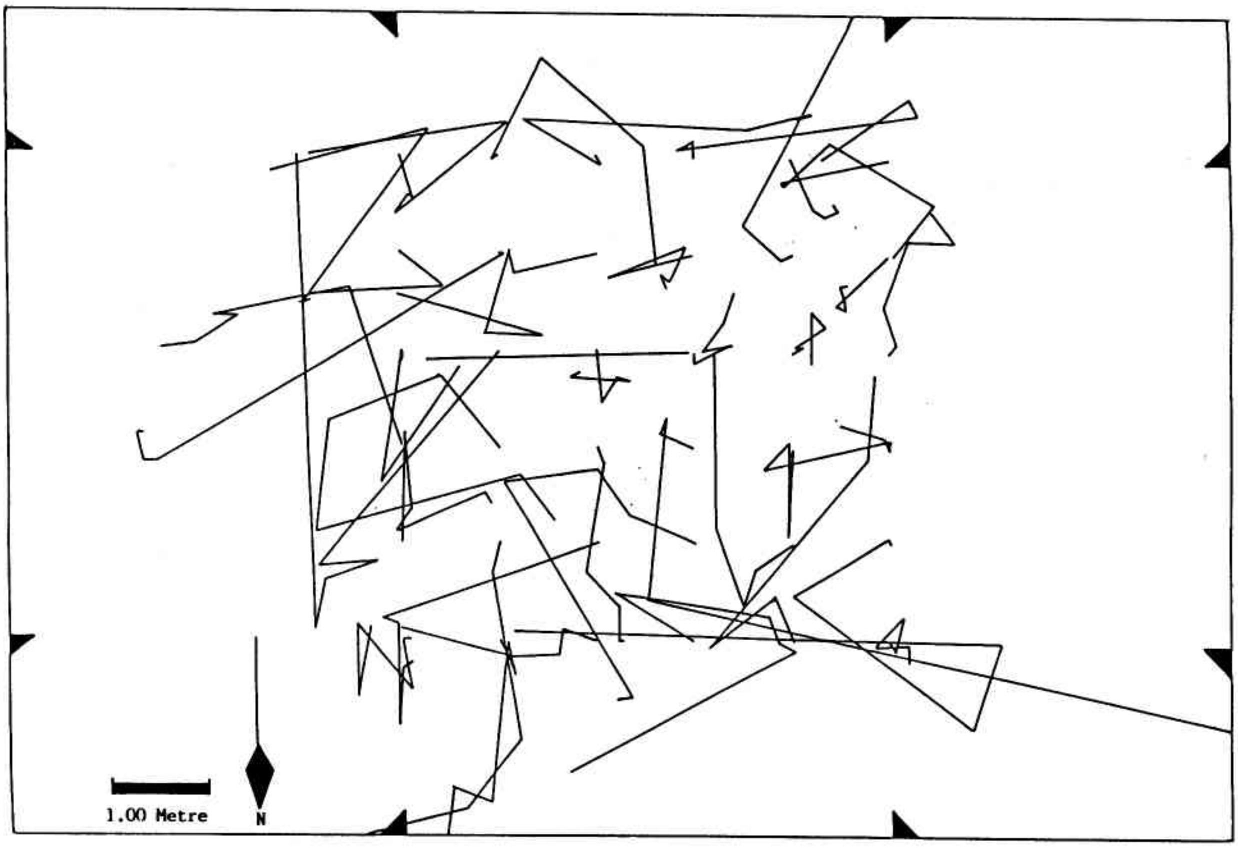

Figure 15.1: Artificial sherd movements 1981–1986

Distance	*No. of sherds*
0.00–0.50m	5
0.50–1.00m	8
1.01–1.50m	1
1.51–2.00m	7
2.01–2.50m	3
3.01m+	5

Table 15.2: Frequency of sherd to distance

15.3 Results of the experiment

The purpose of the present analysis is to draw some simple, if not simplistic, conclusions from this experiment at its half-way point. There is no doubt whatsoever that there are a myriad of different ways of treating these data which is, of course, one of the fundamental reasons for presenting the figures in detail. An initial simulation programme, discussed below, has been carried out by Yorston & Gaffney. However, these results and the following observations are not at all finite at this stage.

There have been relatively few problems experienced in the running of this experiment. The critical original grid is exactly fixed in the field area with permanent metal markers. Thus the grid can be repositioned each year with precision. Inevitably there is an error but it is likely to be insignificant and could be rated at ± 0.01 m. The search is carried out with the fluxgate gradiometer after the spring ploughing. As each sherd is electronically located it is carefully excavated. Its location, depth, orientation of bar magnet and its spatial attitude are carefully recorded. Once that location is clear of other artificial sherds it is replaced in its find position.

Over the five year period two sherds, Nos. 132 and 169, have been lost since 1984 in that while found and recorded in 1983 they have not been seen since. It is unwise to presume these to be completely lost since one sherd, No. 183, disappeared for one season in 1984 and a further three, Nos. 165, 129 and 154, disappeared in 1985 only to be found again subsequently. Similarly the life history of sherd No. 178 came to light when a volunteer hoer remarked that she had 'chucked' an odd plastic toward the edge of the field. Perhaps the missing sherds have suffered a similar or more ignominous fate. In the calculations below, the losses, absences and aberrations have been taken into account.

The most obvious question posed by whole experiment is the distance travelled by the sherds. Fig. 15.1 clearly shows the original gridded area still to be clearly defined by the sherds with remarkably few escapes. Nonetheless there is considerable confusion of original position within that area.

The average distance from the original position of each sherd to its location after five years of agricultural cultivation is 2.04 m (maximum 12.56 m, minimum 0.22 m), a figure which includes both lost sherds and the ill-fated No. 178 which provides the maximum. More realistically with these removed from the calculation the average is reduced if the five sherds which travelled a distance greater than 3.00 m are removed from the matrix. The frequency of sherd to distance is shown in Table 15.2. The average distance from deposition point to location after five years becomes 1.42 m utilising a significant 85.3% of the sherds.

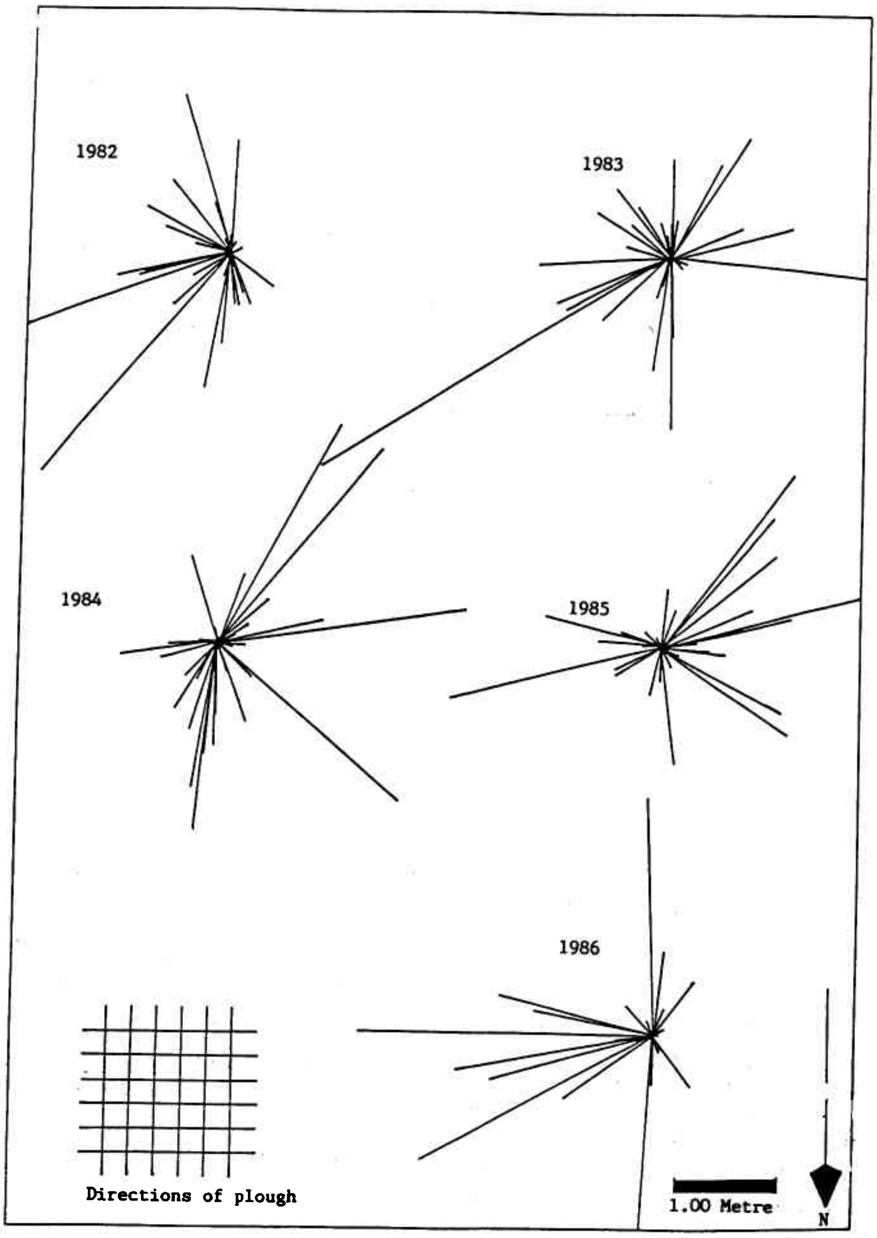

Figure 15.2: Vector diagrams 1982–1986

Year	*Number*	*Total*	*% Frequency*
1982	5	36	13.9
1983	4	36	11.1
1984	4	34	11.8
1985	5	34	14.7
1986	5	34	14.7

Table 15.3: Sherd frequency of surface of plough soil

The average distance moved by each sherd annually is a mere 0.83 m. It is interesting to observe that all sherds every year were actually moved by the cultivation practice. That the soil bulk is thoroughly stirred with a degree of inversion with the stirring process is demonstrated by two specific aspects. First the sherds are moved up and down within the soil structure. The simple result is a statement of the average vertical movement both up and down of the sherds of 54.7 mm (maximum 106 mm, minimum 26 mm). It is clear that this vertical movement is, in fact, a concept rather than the actuality since the sherds move three-dimensionally and are angled to different depths in the soil. Secondly, and more importantly, the spatial attitude of each sherd is recorded in the sense of its angle within the soil body. Initially set face upwards and horizontal, sherds have been regularly recovered face down and horizontal. Within the experiment to date there have been one hundred and seventy recorded movements of which on sixty-four occasions sherds were found completely inverted, a 38% frequency.

In the context of vertical movement, the frequency of sherds appearing on the surface of the plough soil does seem to have some significance. Above, the point is made that many archaeological sites are located by finding surface scatters of pottery on the plough soil and the hypothesis made that there is a distinct relationship between such scatters and the underlying features. A further hypothesis can be raised that there is within the soil matrix a finite number of sherds, a proportion of which are raised to the surface after each cultivation. Conversely a proportion of the surface scatter is buried at the same time. The question is therefore asked whether the surface proportion can be indicative of total material in the soil. Within a different programme at the Ancient Farm, Iron Age pottery has been carefully collected annually from a field area resulting in a mathematical hypothesis that 16% $\pm$ 5% of the material evidence is raised to the surface after each cultivation (Reynolds 1982). In Table 15.3 the frequency of the artificial sherds appearing on the surface of the plough soil is recorded. These figures significantly support this hypothesis. It would be of considerable value to test this actual site. If it were found to be sustainable, it would be of great value in estimating not only the potential of the site itself but also in evaluating the soil as an archaeological resource.

The element of shape has proved to be non-significant at this scale. There seems to be no observable behaviourable difference between the four shapes but this may well be a function of the sample being too small.

The preliminary conclusions to be drawn from this experiment argue that pottery sherds on the surface of the plough soil may well be considerably more important than mere indicators of an underlying archaeological site. The minimal movement of sherds demonstrated above in this Phase IV programme, albeit utilising a very simple plough type as the cultivation tool, argues strongly that the plough soil is not necessarily to be abandoned on the supposition that it has been totally disturbed. Indeed, it is likely that this plough type actually stirs the soil more randomly than a modern or historic turn-over plough. With these tools the movement of soil is much more predictable. So much is this so that ploughing disciplines are the norm to avoid actually moving a field. Fields are ploughed and cross ploughed in opposite directions sequentially. The logical result of which through time is that a particular patch of soil is moved back and forth over the same place. The probability is that modern agriculture, given the normal plough rather than the deep plough or mole plough, moves the soil body about far less than in the mediaeval period when the objective was the creation of ridges.

In fact, it is not unreasonable to suggest that prehistoric ploughing is the most disruptive if only from the point of view of lynchet aggradation on sloping land (Bowen) and a dishing effect on flat land (Brongers). These are the physical data currently at hand including the caveat concerning fragmentation by the agencies of ploughing and frost and the location being a preferred flat zone. The observable results, however, may be a delusion because logically the material must spread outwards through time. The end product ultimately must present the characteristics of a normal distribution centred upon the original source. As long as ploughing continues the spread will expand, currently at an unknown rate, within the total zone of disturbance. Given the fact that sites are located by pottery on the plough surface and that correlations have been observed between distribution and feature there is still a point in attempting to quantify movement even if the simulations have limited applications to selected sites where disturbance is not continuous through the millennia. In practice this would still embrace considerable tracts of landscape especially on chalklands. Modern ploughing in these zones can be timed within decades rather than hundereds of years. In this case the inevitable normal distribution may not yet have spread sufficiently to be of no practical value.

These data are presently being enhanced with a new sherd movement trial under a modern cultivation regime. This, Phase V, is committed for 1988, the results of which will be published in due course. Once modern ploughing effects are produced a combination of the data bases may provide some justification for ploughsoil excavation despite the gloomy prognosis.

15.4 Computer simulation

The data presented above have been subjected to a preliminary analysis with a view to computer simulation by R. M. Yorston and V. L. Gaffney (Yorston & Gaffney 1987). Necessarily a series of assumptions had to be made because the data, although rigorously achieved, are relatively few in number. Critically only the lateral movements have been considered and are presented in Fig. 15.3 as 164 single year displacements. The dense cluster still focuses around the original location. The simple *caveat* is that the 164 movements are the end product of five years of ploughing. Fig. 15.4a presents a three-dimensional plot of this density. The density function for the purposes of the simulation is regarded as symmetric. Similarly because of the limited nature of the data the normal distribution referred to above was found not to fit the frequency distributions along the axes North–South and East–West. Consequently a distribution was tentatively employed of the sum of two normal curves. The final distribution contains equal measures of bivariate normal distributions of standard deviation 0.205

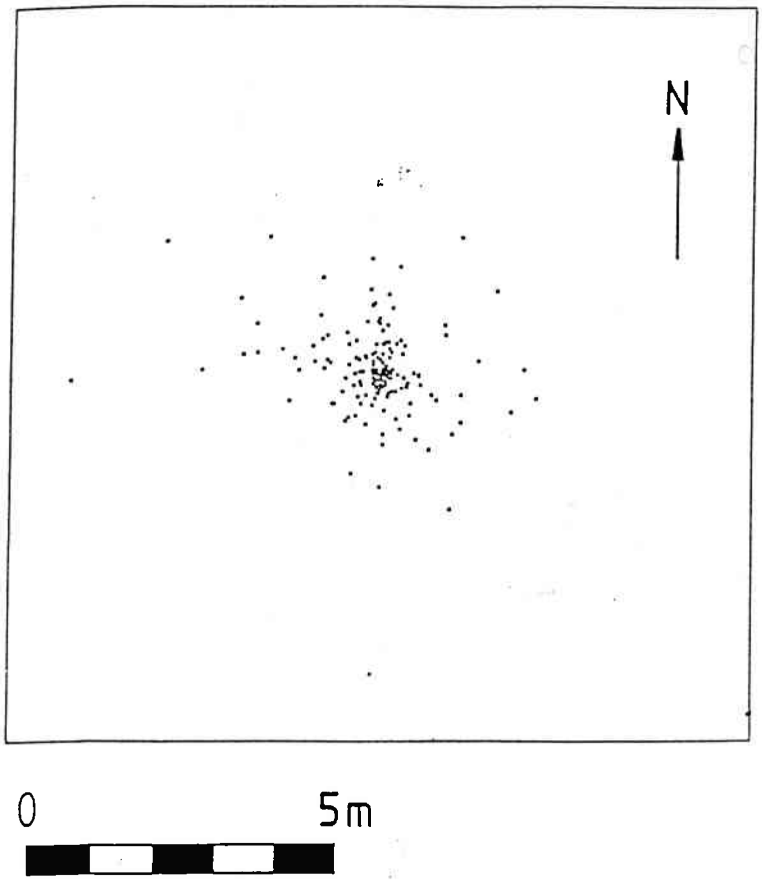

Figure 15.3: (after Yorston and Gaffney)

m and 1.02 m (Fig. 15.4b). In order to simplify analysis and simulation the possibility of sherd depth within the ploughsoil affecting movement was denied and the whole was regarded as a two-dimensional closed system.

Two treatments have thus far been explored by Yorston and Gaffney, convolution and particle simulation. The results of these systems are here displayed graphically, the mathematical formulae having been already published. In simple terms how the annual cultivation process affects the spatial distribution of the sherds is obtained as the convolution of the density function with the spatial distribution at the start of the year. By repeating the convolution annual distributions can be obtained.

In this case the simplest analysis takes the initial distribution as a single point, the two-dimensional delta function. Archaeologically this could be hoard or even a single pot. After one convolution the resulting distribution is the density function itself (Fig. 15.4b). Subsequent convolutions indicate the further spread of the initial distribution (Fig. 15.5). However, with arbitrary distributions convolutions can be calculated relatively easily by employing the Fourier transform techniques developed for computers. Unfortunately although deconvolution is no more difficult to execute than convolution, it is considered to be unlikely to give the original disposition of the material because of the variables of probability density functions since these are location specific, and the inevitable amount of noise in the data.

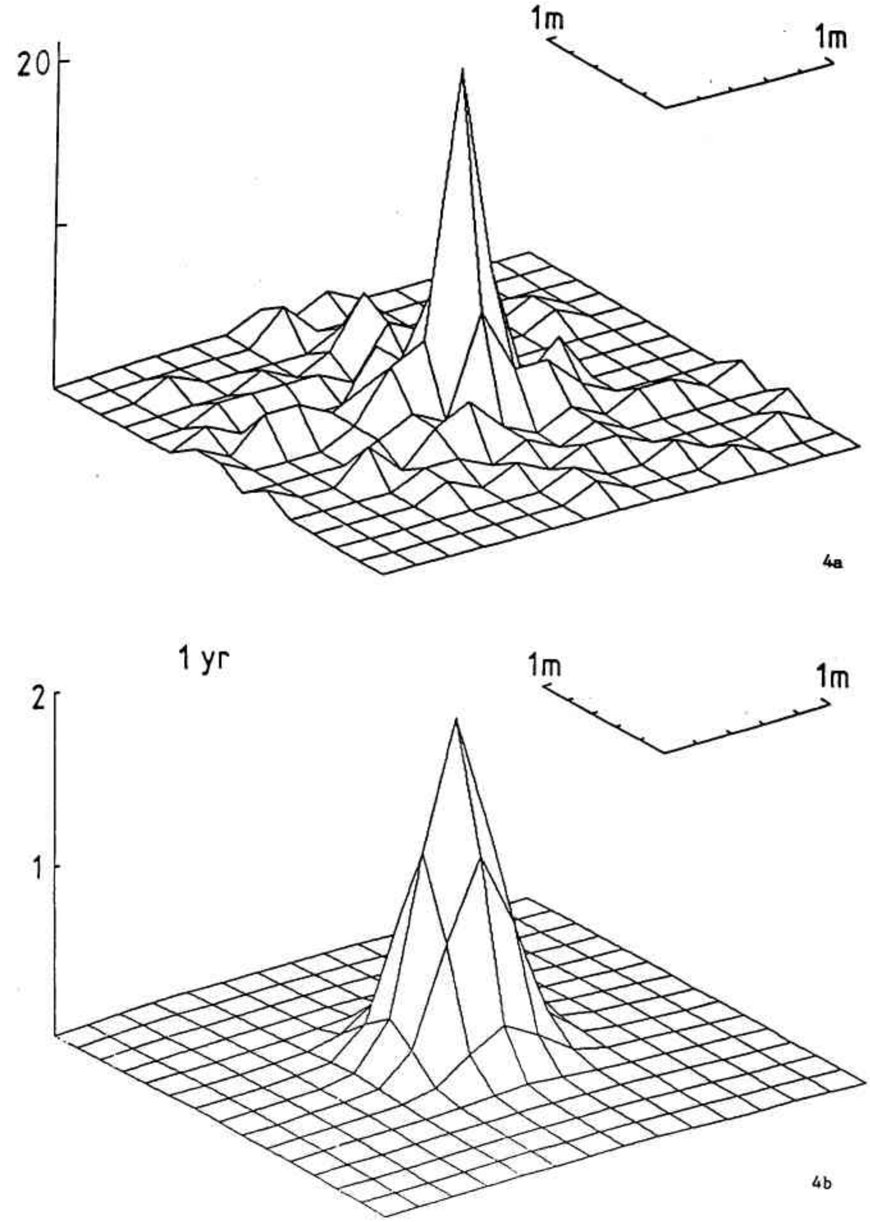

Figure 15.4: (after Yorston and Gaffney)

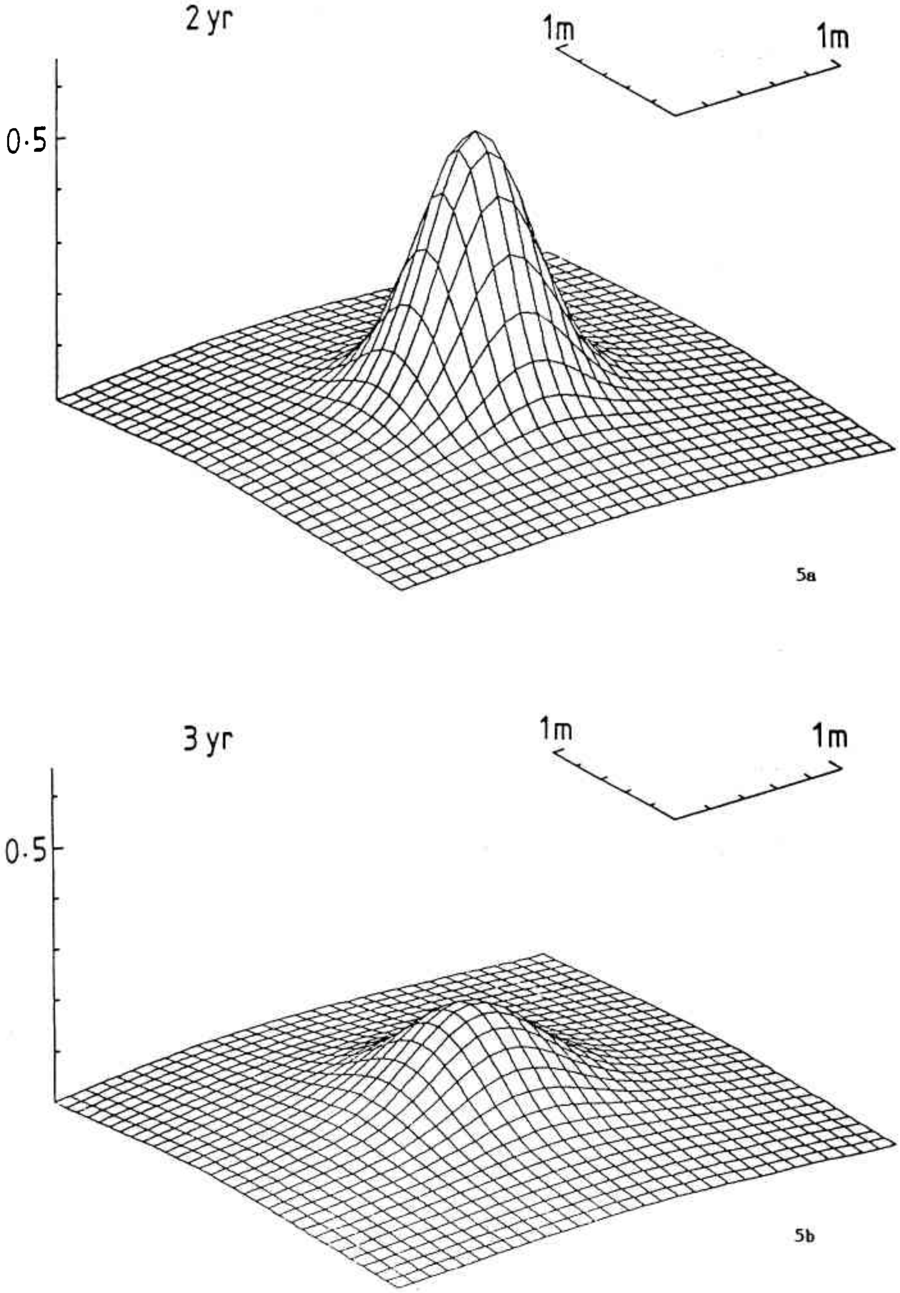

Figure 15.5: (after Yorston and Gaffney)

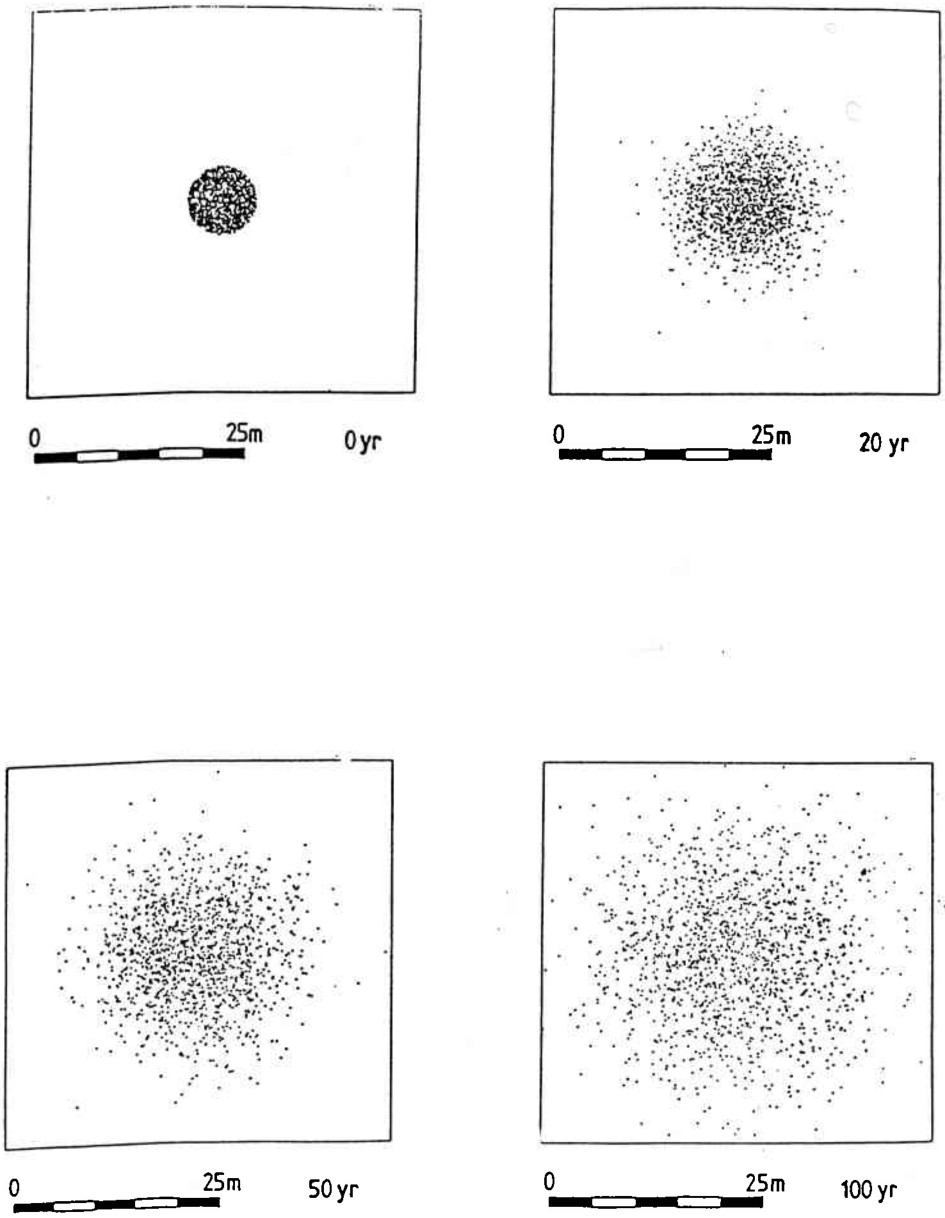

Figure 15.6: (after Yorston and Gaffney)

The second and more attractive technique applied to the data from the experiment is particle simulation (Hockney & Eastwood 1981). Apart from the relative ease of understanding the mechanics of the simulation, because of the simulations, the particle model is more amenable to future enhancement with the introduction of variables presently omitted. In Fig. 15.6, utilising the probability density of the sherd movement experiment, the result of ploughing a circular concentration of artefacts of 8 m diameter is presented. Initially fifteen hundred artefacts are randomly distributed within the circle, after twenty years the spread reaches thirty metres in diameter, after fifty years forty metres in diameter. Necessarily, given the assumptions made at the start, the simulated displacements are circularly symmetric.

15.5 Conclusions

For these descriptions and graphic results the author has drawn heavily and exclusively upon the work of Yorston and Gaffney to both of whom considerable gratitude is expressed. Because of the limited nature and quantity of the data the applications employed are circumscribed by restrictions and *caveats*. The initial aim of providing rigorously obtained data remains, with the added incentive of increasing the data base. Nonetheless, despite the professionalism of the approach there still appears to be a gulf between the perceived reality and the discouraging simulation prognosis. From the non-specialist point of view the dismissed variables, dismissed for perfectly acceptable mathematical reasons, seem to be potentially more significant. In this particular context one is concerned about the nature of the soil and the depth of the artefact within it. Depth would logically offer a braking effect. Similarly although ever increasing distribution is most probable, is there a case to be made for denying the effect of the minority on the majority as in Table 15.2. Further, the adoption of a circularly symmetric displacement is likely to offer a distortion of the physical disturbance process which is primarily linear in the sense that cross ploughing is the norm, but even that is complicated by directional variation. The plough approach to a distribution of artefacts in a ploughsoil can be more complex than presently allowed. Similarly the simulation, in the absence of more empirical data, is perhaps moving too quickly to a dismissable state. Similarly the simulation is set at a too high a dispersal rate and could be halved so that the difference in Fig. 15.6 between zero and twenty years could between zero and forty years, then the relationship is observably close. Thus archaeological sites in considerable tracts of countryside could be justifiably subjected to intensive examination including the soil surface. Huge areas of land, given over to pastoral use, perhaps as early as the beginning of the Roman period, have only been taken back into intensive arable cultivation in the last twenty years under the not inconsiderable blandishments of the Common Agricultural Policy of the European Economic Community. If, as is expected from Phase Five, movement is less than than recorded in Phase Four, both the physical results and the archaeologist's subjective observation would rather then dismissed even by this early development of computer manipulation.

In consequence, the data presented above and the computer applications already explored and presently being developed further, underline the considerable complexity both of the movements recorded and the programming allowing the potential to be exploited. One is seeking an answer to two directly inter-related questions. Firstly, is it possible to use the physical data base provided to build a predictive sequence simulating movement of the sherds in the ploughsoil through time? Secondly, and determined by a positive response to the first question, is it possible to take a distribution of sherds from an archaeological excavation of the plough zone and applying either the programme in reverse or modification of it as in deconvolution, to postulate the original disposition of the material? The main objective is to establish if there is a relationship between the material in the ploughsoil to underlying archaeological features as there at present seems to the archaeologist to be. Also in the case of where all the archaeology is actually within the matrix of the soil itself and therefore virtually featureless, can the distribution of the remaining hard artefact material be used to postulate the nature of the site using comparative evidence from other better preserved sites in association with a re-programmed distribution?

Currently the data base is being enhanced by the addition of trials examining sherd movement under a modern agricultural regime (see above). It is anticipated that the movement will be less random and less severe because of the nature of the machinery and its employment. The farmer's design is to maintain the soil in the same location. There is no doubt but that ploughing does the real damage to sites. Earthworks, especially ancient field boundaries or lynchets, can be levelled within a very few seasons. But, given the basic tenet of the enquiry, can the inevitable damage be quantified and some semblance of order be restored?

The writer is not a computer specialist and, in fact, respects only its speed of execution of complex mathematical problems. In the context of this proposition the physical data are offered as a set of actual references which require other expert examination. If archaeological inference is to have any substance, this type of data-base needs to be explored fully and either validated or rejected. It is perfectly true that archaeologists seek to employ more complex and sophisticated analytical techniques, many provided by the incredibly swift development of computer science. Of critical importance is the ability of the archaeological data withstand the scrutiny of such techniques. There is little point in applying or developing specialised computer programmes unless the data are sufficient reliability to provide meaningful results. In this experiment the data are, in fact, real and thus allow computer manipulation against actuality. As the data-base expands, so manipulation may be extended. The end product may provide a comparative basis against which quality judgments can be made of archaeological data. The polarisation of archaeology and computer science must be avoided but in order to do so interaction and common understanding must be fostered.

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