Clarifying the British Palaeolithic: Unsystematic Traditions

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Introduction

Archaeological computing techniques have rarely been applied to the British Palaeolithic. This spatial model demonstrates one potential application of GIS, to the archaeology of that period. The model examines the post-depositional processes influencing the historical discovery of Lower and Middle Palaeolithic archaeology (c.500-40kyr bp), within southern Britain over the last 150 years. This was achieved through a quantification of the regional, spatial variation, in research opportunities and traditions.

The spatial model deviates, in two aspects, from 'traditional' predictive models of archaeological site location (Kvamme, 1995, p.3). First, it is concerned with the quality of the archaeological data set (with respect to spatially biased site visibility), rather than the correlation of site patterning, with environmental variables (Wheatley, 1998, p.4). This approach was demanded by the nature of the Palaeolithic material, of which the majority is deeply buried within fluviatile Middle Pleistocene gravel and sand deposits (Wymer, 1968, p.19). The goals of the spatial model were also set, by the temporal aspect of lithic assemblages, which have accumulated, over a period of at least 500,000 years (Roebroeks & van Kolfschoten, 1994). Given the extensive landscape alterations, which have occurred during that time, attempting to predict site locations, on the basis of modern environmental data (e.g. Kvamme, et al., 1989; Carmichael, 1990; Warren, 1990a; Brandt, et al., 1992), would serve as an uninformative and fruitless exercise.

Second, the model incorporates human agency variables, alongwith physical environmental data. These variables include the spatial patterns, generated by the fieldwork and lithic collections, of the 19th and early 20th centuries' amateur antiquarians, responsible for the discovery and recording of the majority of Britain's Lower and Middle Palaeolithic data (e.g., Roe, 1981, p.23-26). The methods, employed to model the variables, are by no means ground-breaking, or technically innovative (Gaffney & Van Leusen, 1995, p.370-371). What they are intended to represent is a small aspect of the shift, away from constrained outlooks, towards the types of data, which can be modelled in a spatio-temporal framework, the explanatory frameworks (often functionally deterministic) of GIS models (*ibid.*, p.378), and the range of archaeological applications, to which GIS approaches can be orientated (Wheatley, 1998, p.6). It is suggested, that until archaeologists learn to incorporate a wider range of variables into their spatio-temporal models, GIS applications will remain of limited value, whatever their individual goals may be.

The spatial model supported applications in two separate spheres: cultural resource management, of the British Palaeolithic heritage, in light of increasing threats from the aggregates industry and commercial developments (Wymer, et al., 1993, p.2), and the modelling of Middle Pleistocene hominid behaviour, with particular respect to demographic trends and colonisation capabilities, at high latitudes.

Limitations of British Palaeolithic Research

Approximately 95%, of Britain's Lower and Middle Palaeolithic data, occurs in the form of derived artefact assemblages, deposited within river terrace sand and gravel (Wymer, 1968, p.19). The lithic material has typically been transported and abraded (figure 1), by fluvial agents, which removed it from its original land surfaces, before subsequent secondary deposition (figure 2). As a result of erosion, transportation and depositional processes, assemblages lack accurate chronological information (associated faunal remains and organic sediments are rare), while their spatial component has been blurred and distorted. Assemblages of this type occur across the extent of southern Britain, with particular concentrations in East Anglia, the Lower and Middle Thames Valley, and the Solent region (Roe, 1996, p.2 & fig. 1.1).

The data offers a coarse, temporal representation of one aspect of accumulated hominid behaviour: the discard of lithic artefacts. Bridgland (1994, 1996) has indicated that climatic fluctuation acts as the driving force behind terrace generation. The oceanic, oxygen isotope record, of glacials and interglacials, therefore, enables an estimation of the duration of deposit formation. Gamble (1996, p.65) suggests 70,000 year long temporal units, over which time lithic artefacts have been sporadically deposited in terrace sand and gravel.

The structure of the data, therefore, provides a framework, supporting long-term, regional models of hominid behaviour, during the Middle Pleistocene. It offers a starkly contrasted perspective, to the *in situ* site data, at both spatial and temporal scales. Gamble (1996, p.66) notes that this enables the contrast of scales of hominid behaviour, preserved in the archaeological record: e.g., fifteen minute flint scatters and 70 kyr, time-averaged assemblages. Yet much Palaeolithic research in Britain (and Europe in general) remains focused on the spatially discrete, short-term sites which have produced bone and stone and/or human remains, from primary or minimally disturbed contexts, such as Boxgrove, England (Roberts, et al., 1987) and Atapuerca, Spain (Carbonell, et al., 1995). In contrast, interpretation of derived artefact assemblages, at the regional scale, has not frequently stepped beyond notions of presence and absence (e.g., Roe, 1981). Two of the main reasons behind this skewed treatment, of available data, concern the characteristics of the secondary context evidence:

1. The difficulties of dating lithic material. In the best case scenario, artefacts can only be assigned to c.70 kyr units. In many circumstances, however, artefacts have been re-worked, from higher and older terrace deposits, stretching their temporal origins over hundreds of thousands of years (Wymer, 1968, p.32).
2. The circumstances of assemblage discovery, over the last 150 years. Assemblages were commonly found through industrial excavation activities and the fieldwork of amateur antiquarians. Industrial excavations included the extraction of commercially valuable sand and gravel from river terraces, building projects (e.g., the digging of drains and cellars), and the expansion of infrastructure (road and railway) networks (Roebroeks, 1996, p.58).

The second of these factors has generated regional distributions, of recorded Lower and Middle Palaeolithic archaeology, which are spatially associated with the locations of modern industrial activity. In the Hampshire Basin (on the south coast of England), those distributions are biased towards the major urban centres (figure 3). The apparent relationship, between industry and archaeology, prompts the central question, addressed by the spatial model: what does the distribution of the archaeology represent? Does it represent spatial landscape preferences of Middle Pleistocene hominids, or the locations of 19th and 20th century excavation works ? This question must be answered, before the data can be meaningfully interpreted. A spatial model of the industrial landscape was developed, to quantify the distributions and totals of archaeological material, at the regional scale, in the Hampshire Basin.

The Spatial Model

British Palaeolithic review literature (e.g., Evans, 1897; Roe, 1981; Wymer, 1968, 1996; Roebroeks, 1996; Read, 1885; Chandler & Leach, 1912; Leach, 1913; Dale, 1896, 1912; Hosfield, 1996) identifies six variables, believed to influence the discovery of Palaeolithic archaeology (figure 4);

- Pleistocene geology. While fluviatile sand and gravel form the majority of derived contexts, recorded deposits also include clay-with-flints, raised beaches, and brickearths (Wymer, et al., 1993, p.16-17). The inclusion of lithic artefacts, within these deposits, occurred through primary hominid discard and secondary geological processes, including downslope movement, by solifluxion and fluvial transportation (Wymer, 1996, p.12-22).
- Antiquarian research. The impact of antiquarians, upon the formation of the archaeological record, includes selective recovery (of particular artefact types), the collection or purchase of especially striking artefacts, the distortion of spatial integrity, and the introduction of forgeries, to the commercial trade of implements (Roe, 1981, p.23-26). The activities of the antiquarians were frequently, poorly documented, as were the spatial dimensions of their research and fieldwork.
- Aggregates extraction industry. The 19th century social and economic developments, in southern Britain, resulted in the large scale development of natural resources (Roebroeks, 1996). The demand for gravel, sand, and clay required an expansion in the aggregates industry. The hand-digging and screening of the pits facilitated the recovery of artefacts, by both labourers and visiting antiquarians.
- Infrastructure development. The expansion of road and railway networks, over the last 150 years, has been significant in two areas: the demand for aggregates, particularly gravel, and the direct exposure of Pleistocene sediments, during the excavation of road and railway construction.
- Urbanisation. The growth of towns and cities, around the turn of the century, led to a demand for aggregate resources, for the purposes of road and house construction. Wymer, et al., (1993, p.144) notes that in the case of Southampton, that demand was met locally on the fringes of the town. Along with the provision of services, these activities could lead to the exposure of Pleistocene sediments.
- Erosion. The exposure of Pleistocene sediments through erosion, in the Hampshire Basin, is concentrated around gravel-capped sea cliffs, on the Solent and Isle of Wight coastlines (e.g., Evans, 1897; Wymer, 1993). Since erosion occurs at different rates over time (undergoing periods of stabilisation), cliff and water slope features were identified as potential erosion sites.

The Pleistocene geology and erosion variables were recorded as two dimensional surface coverages (as were the aggregates, infrastructure and urbanisation variables). While this method only provided a partial representation, of three dimensional deposits and eroding landscapes, the necessary volumetric data was frequently fragmentary, or entirely unknown. The variables were documented from a series of cartographic sources (Southern Rivers Palaeolithic Project, British Geological Survey, and Ordnance Survey). The geological deposits were split into a series of categories, according to a ratio of observed; expected findspots. While this approach ignored variations in industrial excavation (e.g. differential working of high and low-level terrace gravel), it did identify broad trends in the 'implementiferous' nature of the deposits. The remaining variables presented two separate problems.

The Impact of Mechanisation

The onset of mechanisation in industrial excavation works reduced the opportunities, for viewing Pleistocene gravel sections and collecting Palaeolithic material (Wymer, 1968, p.8; Roe, 1981, p.26). The mechanisation process included both the introduction of steam-powered and mechanical diggers (figure 5) in excavation projects, and the shift to mechanised washing and crushing plants, in the aggregates industries (Poole, 1932).

Lithic collection data, from the adjacent sites of Dunbridge (Dale, 1912) and Kimbridge Farm (Harding, *pers. comm.*), provided comparative quantitative information, concerning the effects of mechanisation on artefact collection opportunities. A continuous gravel deposit excavation took place on the sites, between c.1900-1925 at Dunbridge, and during the early 1990's at Kimbridge Farm. The Dunbridge collection was acquired over c.25 years, by pit labourers (Dale, 1912), at an approximate rate of 40 bifaces $year^{-1}$. The Kimbridge Farm artefacts were collected in the early 1990's as part of an English Heritage watching brief, in which waste materials were examined for lithic material. The contrasting rate (c.4 bifaces $year^{-1}$) indicates the general effect of reduced manual labour, the increased speed of excavation, and the rapid removal of aggregates, from pit sections to the processing plants.

It was, therefore, important to date the shift from manual to mechanical techniques in the three industries (aggregates extraction, infrastructure, and urbanisation). Photographic (e.g., Robertson, 1989; Norwood, 1973; Popplewell, 1973) and literary evidence (e.g., Dale, 1912; Poole, 1932) supported this work, suggesting the following dates:

- Aggregates extraction industry (1930-1950)
- Infrastructure development (1890-1910)
- Urbanisation (1930-1950).

The industrial excavation sites were recorded as two, 'time sliced' surface coverages, from maps dating to the periods listed above, and from the most recent cartographic sources. Such a binary division is a simplified representation of a presumably gradual development, with mechanisation, no doubt, being adopted earlier in localised areas, as larger companies and projects pioneered the transition. Nonetheless, the logistic regression analysis (Warren, 1990b) indicated the importance of the transition, with the pre-mechanised surface coverages, for all three industrial variables (cut10, grv35 and urb40 - see section 4), generating a higher partial contribution (R statistic) to the spatial model, than did the post-mechanisation variables (cut80, grv80, urb80). This approach to recording data enables the impact of changing industrial practices, upon Palaeolithic research, to be incorporated within the model.

Spatial Patterning in Antiquarian Research

The second obstacle concerned the transformation of amateur antiquarian research into a spatio-temporal variable. This aspect of the modelling process was hindered, both by the partial documentation available (Roe, 1981, p.26) and the difficulties of representing 'mobile' human agents, within a spatial model.

The antiquarian fieldwork and primary documentation, of Ernest Westlake (figure 4), provided the basis for a solution to these problems. The activities of this Hampshire antiquarian and naturalist were documented by Delair (1981, 1985), after the discovery of Westlake's field notebooks and memoranda, in 1980. After education at the University College in London, Westlake devoted much of his life to field studies, after his father released him from 'the need to earn a living'. From the 1870's onwards, he visited geological sites, across southern Britain, and began to examine river valley gravel, in search of flint implements. The notes and section drawings, resulting from his studies, are recorded in 17 notebooks, and provide strong support for the assumption, that Westlake physically visited the geological and archaeological sites. 41 Palaeolithic findspots were identified, from the Westlake documentation. Dating evidence and additional references suggested that 9 of these findspots were identified 'first', by Westlake, and brought to public attention (e.g., as was the case for the findspots at Wood Green and Breamore). Of the remaining sites, it appears that he visited, recorded and acquired lithic artefacts, from findspots, which had already been discovered.

The geological and archaeological sites were plotted, and their spatial distribution was analysed from a central point (Westlake's home at Oakland's House, Fordingbridge, Hampshire). It was immediately apparent, that the geological sites were distributed over a wider expanse than the Palaeolithic findspots (table 1).

Distance from central point (km)	Geological Sites		Palaeolithic Findspots	
	%	No.	%	No.
0-10	1343	231	1505	14
10-20	337	175	286	8
20-30	119	91	365	15
30-40	89	81	61	3
40-50	109	119	17	1
50-60	22	27	0	0
60+	13	37	0	0

Table 1. Distribution of E.Westlake's Geological and Archaeological Sites from Oakland's House

The number of observed and expected sites, per 10km distance band, were calculated (according to the distance band surface areas). From these values, a differential % was generated (observed sites / expected sites x 100) and a 'watershed' identified (where the differential % was less than 100 - i.e., fewer sites than expected were being observed). This analysis unrealistically assumes a uniform distribution of sites, and this assumption is discussed below. The watershed of geological sites was approximately 45-50km, compared to an archaeological watershed of 30-35km. There are two possible reasons for this discrepancy; first, a localised distribution of Palaeolithic findspots, possibly due to the structure of the local river systems and terrace gravel, and second, the local limits of Westlake's specialist field knowledge, with respect to suitable Pleistocene deposits and potential archaeological sites (the actions of other antiquarians, in monopolising 'private' sites, may also have played a part).

To test the first reason (and the assumption of a uniform distribution), the Westlake findspots were compared to the complete sample of the Hampshire Basin findspots (table 2), collated by the Southern Rivers Palaeolithic Project (Wymer, et al., 1993). This secondary analysis indicated that the distribution was not uniform, with the concentration of findspots, in the 10-30km distance bands, reflecting the material from Bournemouth, Southampton and Salisbury (figure 3). However two notable elements of the Westlake site distribution remain unexplained by this distribution;

1. The concentration of findspots, within 10km of Oakland's House, suggested a local orientation to Westlake's fieldwork.
2. There was a total absence of findspots, at greater than 45km from Oakland's House, despite the presence of SRPP sites and Westlake's own geological sites.

The analysis of the findspot data suggested a spatial limit, for the extent of Westlake's Palaeolithic fieldwork and lithic collecting activities. It is proposed that the major factor, influencing these spatial limits, was Westlake's locally-orientated field knowledge.

Distance from central point (km)	Southern Rivers Palaeolithic Project Findspots		E. Westlake Findspots	
	%	No.	%	No.
0-10	93	20	1505	14
10-20	145	94	286	8
20-30	282	269	365	15
30-40	65	74	61	3
40-50	33	44	17	1
50-60	51	48	0	0
60+	29	10	0	0

Table 2. Distribution of E.Westlake's Archaeological Sites and the SRPP Findspots from Oakland's House

A 'collection territory' template was generated, to model antiquarian research, from Westlake's activities (figure 7). The left-hand weightings were generated from the complete Westlake findspot sample; the right-hand set was generated from only those findspots, first identified by him. In effect, the two versions of the template, model 'local' and 'regional' fieldwork. The template assumes:

1. A range 'limit' of 40km, for Westlake's "flint hunting" activities (Roebroeks, 1996, p.58).
2. The frequency of visits and collections decreased, from a central place (his family home).

The Westlake 'collection territory' template was applied to the Hampshire basin, to model regional variations in amateur antiquarian fieldwork and research. The antiquarians were identified in three county journals (the Proceedings of the Hampshire Field Club and Archaeological Society, the Proceedings of the Dorset Natural History and Archaeological Society, and the Wiltshire Archaeological and Natural History Magazine), through Palaeolithic-related entries (e.g., discovery notes, site 'reports', and donations of palaeoliths to local museums). Membership dates and addresses, in the journals' ('Lists of Members') provided an estimation of their 'working life' (y_n, in equation 1.2) and the central place, upon which the template was plotted, generating the cell values (w_n, in equation 1.1), in the raster image:

$$t = (t_1 + t_2 \dots t_n)$$

(Equation 1.1)

where t=the total raster cell value; t_n=the collection value for each antiquarian, whose 'collection territory' encompassed that raster cell.

$$t_n = w_n * y_n$$

(Equation 1.2)

where t_n=the antiquarian collection value; w_n=the template weighting value, assigned to that raster cell; y_n=the number of years, over which the antiquarian was active in the field.

The regional plot of antiquarian traditions, for the Hampshire Basin, was generated from equations 1.1-1.2 (figure 8). There is a notable spatial association, between the regional population centres and areas of strong antiquarian traditions (as would be expected, since the templates were plotted around the antiquarians' homes). Logistic regression analysis indicated that this variable makes a positive, partial contribution to the spatial model (R=0.2928). The methodology makes three assumptions:

1. While not every antiquarian was identified, the approach offered a relative measure of fieldwork and research, across the region.
2. The historical period of an antiquarian's 'working life' was not significant. This was supported by the relatively late mechanisation of the aggregates industry (section 3.1). However, it does ignore the impact of contemporary changes in public and private transport, upon the range of the 'collection territory'.
3. Information flow, between contemporary antiquarians and over time, was represented at a basic level. The impact of two or more antiquarians, operating in the same area, was measured as an incremental, rather than an exponential increase. This area of the model would clearly benefit from simulation studies, as the documentation currently available doesn't support further modelling.

The methodology does, however, offer a preliminary and practical approach to the spatial modelling of a significant variable, within the process of archaeological discovery: the activities of amateur antiquarians in the field.

Applying the Spatial Model

The technique of logistic regression analysis was employed in the building of the spatial model (see Warren, 1990b, for a fuller discussion). The technique was adopted specifically, because:

- It operates with a mixture of ordinal (e.g. the presence / absence data representations of the aggregate industry variable) and ratio-scale (the antiquarian traditions variable) data.
- The output format enables predictions of site presence and site absence probability.

The Hampshire Basin study region (co-ordinates 360000-468000, 63000-155000) was represented as a raster image, in the GRASS4.1 software package. Cell resolution was 500m^2, generating 39,744 cells (184 rows x 216 columns). Of these, 369 cells were classified as sites. To remove the inherent bias towards non-site prediction, 369 non-sites were sampled, producing a total of 738 cells, from which model variable values were sampled (table 3). These data were exported to the SPSS statistical software package. The forward stepwise selection procedure (entry probability 0.05, removal probability 0.10, maximum iterations 20) generated the spatial model (the regression formula is included in figure 9).

$$
\begin{aligned}
\text{forward\_model} = -1.9984 &+ 0.0014\ (grv35) \\
&+ 0.0255\ (grv80) \\
&+ 0.0006\ (urb40) \\
&+ 0.0092\ (urb80) \\
&+ 7.9175\ (urbunx) \\
&+ 2.0667\ (slope) \\
&+ 0.0000857\ (antiq) \\
&+ 0.3909\ (gol6) \\
&+ 0.2754\ (geol7) \\
&+ 0.1880\ (geol8) \\
&+ 0.7470\ (geol9) \\
&+ 0.1994\ (geol10) \\
&+ 0.2259\ (geol11) \\
&+ 0.1652\ (geol12) \\
&+ 0.2359\ (geol13) \\
&+ 0.1444\ (geol14) \\
&+ 0.1510\ (geol16) \\
&+ 0.0887\ (geol27)
\end{aligned}
$$

$$p(opps) = \frac{1}{1+\exp(-(forward\_model))}$$

86.99% of the sampled site locations were predicted by the model (321 out of 369). This compares with 78.05% of sampled non-sites (288 out of 369) and 82.52% of all sampled locations. In other words: 87% of the sampled sites were associated with favourable, modern industrial conditions (for discovering Palaeolithic sites), as predicted by the spatial model. The model did not predict site locations. It predicted the conditions, associated with site discovery. In this respect, the less successful prediction of non-sites is not of immediate concern, since in some cases, the model has associated favourable conditions (e.g., gravel pit sites) with land parcels, in which no buried archaeology exists (hence, the mis-classified prediction). The logistic regression formula was then applied to the Hampshire Basin raster images, to predict conditions for Palaeolithic research in the non-sampled areas of the study region (figure 10).

Variable	Code	Scale	No. Of Values
Antiquarian traditions	antiq	Ratio	1594
Urban sites (pre-1940)	urb40	Nominal	2
Urban sites (1980)	urb80	Nominal	2
Urban sites (undated)	urbunx	Nominal	2
Aggregate pits (pre-1935)	grv35	Nominal	2
Aggregate pits (1990)	grv80	Nominal	2
Aggregate pits (undated)	grvunx	Nominal	2
Cuttings (pre-1910)	cut10	Nominal	2
Cuttings (1980)	cut80	Nominal	2
Sea slope features	slope	Nominal	2
Sea cliff features	cliff	Nominal	2
Gravels (category 1)	geol1	Nominal	2
Gravels (category 4)	geol4	Nominal	2
Gravels (category 5)	geol5	Nominal	2
Gravels (category 6)	geol6	Nominal	2
Gravels (category 7)	geol7	Nominal	2
Gravels (category 8)	geol8	Nominal	2
Gravels (category 9)	geol9	Nominal	2
Gravels (category 10)	geol10	Nominal	2
Gravels (category 11)	geol11	Nominal	2
Gravels (category 12)	geol12	Nominal	2
Gravels (category 13)	geol13	Nominal	2
Gravels (category 14)	geol14	Nominal	2
Gravels (category 16)	geol16	Nominal	2
Gravels (category 26)	geol26	Nominal	2
Gravels (category 27)	geol27	Nominal	2

Table 3. Environmental and non-Environmental Variables

In general, the spatial model was most successful, when predicting favourable research opportunities (potential findspot locations), associated with river gravel and sand deposits and the industrial exploitation of those resources. It was less successful, with respect to surface discoveries (e.g., individual handaxe finds from the chalk downlands), and future modifications of the model will seek to incorporate the recent research of Scott-Jackson (1992, and *pers. comm.*), in this area.

Archaeological Applications

The archaeological applications of the spatial model are two-fold.

Cultural Resource Management

Identifying a landscape's archaeological potential, before the disturbance and destruction of its Pleistocene deposits, is a pressing need in the curation of Britain's Palaeolithic heritage. By correlating Palaeolithic research conditions in the recent past, against known archaeological distributions, it is possible to model the potential of currently 'blank' areas, through a simple premise: where modelled Palaeolithic research conditions are favourable (i.e., greater than 0.5), yet no archaeology has been recorded, the probability of buried materials is relatively low. The ratio-scale output predictions, of the logistic regression model, allow statistical guidelines to be generated: in essence, the higher the probability, the lower the archaeological potential.

Where predicted research conditions are unfavourable (i.e., less than 0.5), predicting the potential of those 'blank' areas becomes more problematical. Two interpretative methods are proposed:

1. Subjective (external data). The first approach employs external data to assist in the interpretation. These data include: geology (e.g., have deposits of a comparable age yielded greater or fewer findspots than expected, from statistical testing, across the study region ?) existing archaeological distributions (e.g. the abundance or paucity of Palaeolithic findspots, in the immediate proximity of the land parcel, under investigation), and formation processes (ongoing research suggests that concentrations of derived artefacts, commonly occur at the confluence of Middle Pleistocene rivers, and immediately below the transition, between upper Cretaceous (chalk) and tertiary bedrock, in the Hampshire Basin). The application of these data is subjective (although the initial identification, of poorly researched locales, was generated from a statistical model), so any CRM guidelines would be presented as a relative scale of

archaeological likelihood. In contrast to the second approach (below), this subjective approach assumes that the distribution of buried archaeology (like the known materials) is not uniform, in Middle Pleistocene deposits. Figure 11 demonstrates an interpretation of the future archaeological potential of the Lower Avon. 'Low' potential areas include both Bournemouth (where there has already been extensive exposure of gravel deposits and lithic collecting) and the higher ground, where terrace gravel and other suitable deposits, are scarce. 'Strong' potential areas are mainly restricted to sections of the Avon Valley, where modelled research conditions have been poor (e.g., sporadic or absent gravel works).

2. Objective (logistic regression predictions). The logistic regression model, ratio-scale predictions are incorporated into the interpretation, in the form of a quantifiable scale (i.e., a prediction of 0.6 is twice that of 0.3). Where research conditions were favourable, potential for archaeology was relatively poor (as discussed above), and where conditions were unfavourable, the archaeological potential was good. Since the spatial model incorporated geology, as one of the variables, it was necessary to map out areas of the landscape, in which there were no Pleistocene sediments. Otherwise, the scale would mistakenly predict those locales (for which the model's measure of research conditions was relatively poor, given the absence of terrace gravel), as areas of high archaeological potential. This form of objective interpretation assumes a broadly, uniform distribution of buried archaeology, within Middle Pleistocene deposits, as demonstrated by figure 12, where the majority of locations, north of Bournemouth, are predicted as high potential areas.

By observing brief data, fieldwork and future developments should provide a measure of the respective accuracy, of these two approaches, while also supplying further control data with which to modify predictions. At present, however, the spatial model offers a quantifiable resource, to assist in protecting Palaeolithic archaeology, in the face of increasing development and the demand for aggregates.

Modelling Hominid Demography

The model of Middle Pleistocene hominid demography has its origins in Foley's (1981a, 1981b) model of regional archaeological structure. Foley estimated expected artefact densities, which would result from material accumulation, caused by repetitive human behaviour. While the aim was, primarily, to identify the relevant order of magnitude, this type of modelled data couldn't be compared to Palaeolithic lithic evidence (especially that from northern Europe), because the artefact sample is a partial one: the total quantities of buried archaeology were unknown, as was the % figure, represented by the recovered sample.

Archaeological models, of hominid demography and adaptation, have traditionally assumed that occupation was effectively continuous, and that populations were larger at low latitudes (e.g., East Africa), where there were no extremes of climate (Gamble, 1996, p.65). This is believed to be in stark contrast to northern Europe, with its cyclical, glacial-interglacial climatic regime. These assumptions have never been demonstrated, however, primarily because the archaeological records are not comparable. Europe's records have been selectively collected across regions, by collectors following 'bus routes and good pubs' (*ibid.*, 1996, p.65), while East Africa's were systematically sampled and excavated at individual sites.

The spatial model, of research conditions, offers a means of adjusting European data, according to its history of collection, and supporting a high-low latitude comparison. It was assumed that a logistic regression model prediction value, of 0.01, represented ideal (British) conditions, for the collection of Palaeolithic archaeology, while a value of 0.99, represented the poorest conditions. Biface totals, from the Hampshire Basin's archaeological record, were adjusted according to the logistic regression model values and river terrace gravel deposit data, to estimate 'real' totals (equation 1.3). Bifaces were employed as the unit of analysis, because of their status as a recognisable class of lithic artefact, which were commonly and selectively collected, by amateur collectors (Roe, 1981).

$$at = t*((\frac{l_n}{l_{\max}})*((\frac{g}{sa})*100))$$

(Equation 1.3)

where at=adjusted biface totals; t=recorded biface totals; l_n= average spatial model prediction; l_{max}=maximum spatial model prediction; g=Middle Pleistocene deposits surface area; sa=study region surface area.

Following Foley (1981a), expected biface totals were predicted assuming a 30-person hominid group (Steele, 1996; Gamble and Steele, 1998); 1 butchery event, requiring a single biface, per week (after Foley 1981b, p.9-10) and assuming sporadic scavenging, from natural mortalities and carnivore kills (after Gamble, 1987), and the re-use of a biface, over 10 butchery events, before being discarded. The home range of the hominid group was estimated at 1088km^2, from lithic raw material transfer data (Féblot-Augustins, 1997; Gamble and Steele, 1998). Figure 13 includes biface estimates for the Hampshire Basin, during the Middle Pleistocene (500-128kyr bp): recorded data, adjusted totals, and two predicted totals. The first predicted total assumes constant occupation, while the second argues that hominids were unable to adapt to interglacial forests and were limited to open landscapes (Gamble, 1986; 1996, p. 69; Stringer and Gamble, 1993, p.45).

Comparison of the biface totals suggests that occupation was not continuous, close to 50% of the open landscape phase (c.100 kyr from the period 500-128kyr bp). Moreover, the prediction totals are generated for a hominid home range of 1088km^2. The adjusted totals, by contrast, incorporate the entire Hampshire Basin (4963km^2). Therefore, not only is occupation suggested to have been sporadic, but at any point, only c.20% of the Basin landscape was incorporated, within the (presumably mobile) hominid home range (figure 14). This type of modelling approach is tentative (and inevitably dependent upon it's starting assumptions), but it does suggest that Middle Pleistocene hominid occupations at high latitudes, were characterised by low population densities (0.006 people per km^2, according to the listed data) and an under-populated landscape.

Comparison of the adjusted Hampshire Basin data, to East African evidence, from the sites of Olorgesailie (Isaac, 1977) and Kilombe (Gowlett, 1978, 1991), was supportive of a low-high latitude contrast in hominid demography. Figure 15 indicates the massive differential, between European and African biface data. This is true for the Olorgesailie data, as well as the Kilombe (which is an exceptionally-rich Acheulean biface site, both by European and African standards) and suggests higher density populations, continuously occupying the East African landscape (despite the fact that the analysis is inherently biased towards Europe, with the low latitude data, based on single sites, rather than on regional data).

In general, the data from Europe and East Africa support an interpretation, of hominid occupations in Northern Europe, as being discontinuous and characterised by low population densities, reflecting the ebb and flow of hominid groups from Mediterranean refuges, into higher latitude environments. Such movement probably occurred, in response to climatic fluctuation, perhaps on an annual summer / winter basis, and supports a model of generic (transferable) skills, with limitations that restricted the hominids' ability, to maintain occupation at high latitudes (Gamble, 1997, p.410).

Conclusions

This paper has sought to demonstrate the application of GIS spatial modelling, to a 'difficult data set' (Gamble, 1996, p.64) from the British Palaeolithic. It is not an attempt to 'clean up' the data, but rather to address the formation processes, which have influenced the structure of the archaeological record. The existing problems and assumptions, incorporated within the model, and archaeological interpretations, indicate the need for further work. However, it has been demonstrated that, first, a fuller range of variables can and must be introduced into the process, if archaeological models are to yield meaningful results, and second, spatial modelling shouldn't be restricted to proving that hunter-gatherers preferred south-eastern facing slopes, near water.

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