Population movements into Europe during the Pleistocene: a comparative approach

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Population movements into Europe during the Pleistocene: a comparative approach.

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This thesis concerns the movement of hominid groups into Europe during the Pleistocene. Four key issues are addressed by this project: the determination of whether it is possible to detect periods of movement in the archaeological record; the examination of whether archaeological treatments of movement have been justified; the establishment of a framework of interpretation of the archaeological record of movement in order to allow movement processes to be investigated; and the exploration of possible changes in the nature of population movements during the Pleistocene. In order to fulfil these aims, and to overcome the lack of a comparative ethnographic record of hunter-gatherer population expansion, a review of population movement processes described by academic disciplines that observe dispersals and migrations of human groups and non-human species, such as ecology, sociology and geography is presented. The processes highlighted by this review are used to build an interpretive framework of the behaviours associated with movement. The current state of archaeological knowledge of movement processes is discussed, in the form of a narrative analysis of the work of four archaeologists that have extensively worked on hominid dispersals. A methodology for the study of population movement processes in the Pleistocene is forwarded, and applied to the initial occupation of Europe during the Early and Middle Pleistocene, and the spread of *Homo sapiens* groups and the Upper Palaeolithic during the Late Pleistocene. The strength of the interpretive framework, and the usefulness of the concepts taken from contemporary observations of movements are considered, and the value of the archaeological approaches to the episodes of movement is evaluated. The interpretive framework is also used to assess whether social or biological models are more applicable to Pleistocene hominid movements. Recommendations for future studies of past population movements through the archaeological record conclude the thesis.

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The contents of this thesis are entirely based on the author's individual research, and have not previously been submitted for a degree at any university, nor submitted for publication.

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Chapter 1 : Introduction.

This project concerns the episodes of movement of hominid groups into Europe during the Pleistocene. In this introductory chapter, the aims of this project will be discussed in the context of past research into the initial occupation of Europe and the arrival of *Homo sapiens* and the Upper Palaeolithic, highlighting the need for an investigation into the processes of population movement. These aims are:

- to determine whether it is possible to detect periods of movement in the archaeological record;
- to examine whether archaeological treatments of movement have been justified;
- to establish a framework of interpretation of the archaeological traces of population movements allowing the processes rather than simply the chronology of dispersal to be investigated;
- to investigate whether the nature of population movements changed during the course of the Pleistocene.

The approach taken to the resolution of these problems and fulfilment of these aims will then be examined.

The problem of population movements in Pleistocene Europe.

Archaeological treatments of population movements.

Population movements have been neglected in archaeological research since the New Archaeology of the 1960s overturned the former culture-history approach to interpretation, which had used invasions and migrations as a major explanation of cultural change in the archaeological record (Chapman and Hamerow 1997). Migration has subsequently been considered either to have never taken place, or to be non-explanatory because archaeologists have not thought of migration as a process. The New Archaeology dismissed culture-historical explanation because it lacked nomothetic principles of interpretation. Thus, migration was considered to be a post-hoc explanation of changes in the archaeological record, that did not deal with social processes, could not be tested, and hence could not be included in the generalised laws of interpretation favoured by the proponents of this school of archaeological thought. Although the Post-Processual critique of the focus on laws of behaviour and economic systems in Processual archaeology has led to a resurgence of contextual interpretation, migrations continue to be dismissed as a potential factor in the later prehistoric archaeological record by the majority of researchers. Indigenous developments are argued to explain cultural changes, and the past is portrayed as being peopled by sedentary groups without any movement beyond the local area. The appearance of seemingly foreign objects in assemblages is attributed to exchange or trade, not migrations of people. However, movement of individuals and groups has occurred throughout recorded history (Skeldon 1990), and is therefore likely to have taken place in prehistory. This lack of concern over migration in archaeology has resulted in a failure to develop an understanding of the processes of movement.

The absence of awareness of movement can perhaps be attributed to the interest in the development of agriculture and settled societies in later prehistory, and a lack of knowledge of the ethnographic record of mobile peoples. Furthermore, Medieval texts describe the European population as constrained to their villages, with prohibitions on migration, which has created a picture of individuals being tied to their natal location in agrarian societies, despite high numbers of people overcoming the constraints on movement in Medieval Europe (Skeldon 1990). The European perception of an entire absence of mobility in agricultural societies is liable to have bolstered the anti-migration stance in archaeology.

Palaeolithic approaches to colonisation and dispersal.

In contrast, Palaeolithic research has retained a focus on movement and migration despite the demise of culture-historical interpretation. The initial dispersal of hominids from Africa to Asia and Europe has been a major topic of research, and can only be explained by the dispersal of hominid groups. Moreover, population movement has remained the explanation of the appearance of the Upper Palaeolithic and *Homo sapiens* in Europe at around 40 Kyr BP, as an intrinsic element of the "single origin hypothesis" of modern human evolution in Africa and subsequent dispersal with replacement of the indigenous hominid groups in all regions beyond Africa (Stringer 2002), which is currently the favoured model of modern human origins. The "multiregional" model of modern human origins, which received significant support until the 1990s, removed the dispersal associated with the Upper Palaeolithic by suggesting an *in situ* origin of *Homo sapiens* regionally throughout the Old World (Thorne and Wolpoff 1992), but the earlier colonisation of Europe has never been seriously challenged. Thus, the Palaeolithic is the only archaeological period that has maintained population movements as a major mode of explanation of the patterning of the archaeological record throughout the twentieth century.

Colonisation or dispersal has been used as an explanation of changes in lithic assemblages during the Palaeolithic. The appearance of prepared core technology and the Middle Palaeolithic has recently been suggested to mark a spread of population from Africa (Foley and Lahr 1997). Explanations of change by the arrival of technologically more advanced groups can be considered as a relict of the culture-history approach to archaeological explanation abandoned in the 1960s in later periods of prehistory, which has remained tacitly present in the Palaeolithic (Clark 2001). There has been a tendency to externalise change in the European Palaeolithic, with a focus on behavioural stasis, requiring a revolution at moments of change, often attributed to the arrival of new populations. Thus, periods designated as representing dispersal are those showing behavioural innovations, or changes in environmental tolerances, subsistence and inferred cognitive abilities. Within the Upper Palaeolithic, the appearance of new industries or techno-complexes, such as the Gravettian (Otte and Keeley 1990), have been explained by population movement from the east, with associated behavioural changes but no cognitive element. Thus, migrations are used to explain moments of change with or without an associated evolutionary change and accompanying population replacement.

The appearance of the Upper Palaeolithic has been considered as an episode that has required an explanation by incoming behaviourally and cognitively advanced groups, due to the inability of Palaeolithic research in Europe to address change (Clark 1989). Nevertheless, the biological and genetic evidence of replacement strongly supports the inference of the arrival of a new population in this episode (Stringer 2002). However, in the case of the Middle Palaeolithic and the Gravettian, such supporting biological evidence is lacking, and an indigenous origin of the behavioural innovations and ecological changes, such as occupation of new environments and landscapes, is viable. There is a need to establish a means of determining whether movement explains patterns in the archaeological record, particularly in the Palaeolithic, as genetic evidence is of limited value due to poor preservation of ancient DNA, and the replacement of archaic hominids resulting in the lack of genetic traces of the populations pre-dating *Homo sapiens* in the present European population. Thus, this study aims to ascertain whether the traces of episodes of movement in the archaeological record can be distinguished from indigenous developments of novel behaviours.

Despite the interest in dispersals during the Palaeolithic, little research has focused on the nature of these movements. The major debate during the 1990s over the initial occupation of Europe concentrated on the issues of the date of the first arrival of hominids (Roebroeks 1994; Dennell and Roebroeks 1996; Turner 1999; Aguirre and Carbonell 2001), and the means of validating the archaeological nature of the proposed earliest assemblages (White 1995; Palmqvist 1997). The ecological context in which movement took place has been addressed (Roebroeks *et al.* 1992; Rolland 1992; Gamble 1995c) but questions concerning the behaviours surrounding movements and the consequences of migration on the groups involved have been largely ignored. Likewise, recent debates over the appearance of the Upper Palaeolithic have focused on the dating of the earliest Aurignacian sites and the interactions between Neanderthal and *Homo sapiens* groups (d'Errico *et al.* 1998; Zilhão and d'Errico 1999; Mellars 1999), but have not considered the implications of colonisation itself on the social groups and technologies of the people undertaking the movement into Europe.

Therefore, despite colonisation being promoted to a "hot topic" in Palaeolithic research in the 1990s (Gamble 1998b), chronology remains the central issue of concern in the study of episodes of movement. Furthermore, there is a lack of concern among archaeologists regarding the processes of movement. This can be linked to the absence of interest and understanding of movement in archaeology as a whole, which has resulted in a lack of research into migration processes and the analogues in contemporary behaviours that could reveal patterns in the archaeological record associated with movement. In the Palaeolithic, interpretive frameworks are often developed in the light of hunter-gatherer ethnography concerning the processes under examination. It has not been possible to build ethnographic analogies of hunter-gatherer groups expanding their territories and colonising new landscapes because all contemporary hunter-gatherer groups are currently living in marginalized conditions surrounded by sedentary communities, and thus are geographically contained within their existing territories (Kelly 2003). This absence of comparative ethnographic studies of spatially expanding hunter-gatherer groups has resulted in the Palaeolithic studies of colonisation being based on a set of assumptions concerning the processes that were likely to have driven movement. This project aims to establish whether these assumptions concerning the nature of movement are justified.

Assumptions underlying Palaeolithic colonisations.

Palaeolithic treatments of colonisation of Europe have assumed that movement proceeds as a wave-front motion, and thus that a cline of dates radiating from the point of entry should be detected (Bocquet-Appel and Demars 2000), as modelled by Skellam (1951) for the movement of non-human species from a point of release in new territory. This assumption does not take account of the topography and environments through which movement had to occur, as the poor dating resolution of the Palaeolithic is taken to cause sufficient time averaging to obscure any localised impediments to movement. Models have been developed that consider the effects of environmental variations on the rate of spread, but these still treat movement as occurring at a constant rate unless forced to slow by environmental factors without considering non-environmental factors (Steele *et al.* 1998; Mithen and Reed 2002). Furthermore, continuous radiation from a point of entry, at a constant speed, does not allow the discussion of issues of social network maintenance as groups become physically more isolated, which could have implications for the viability of the demographic population involved in expansion, and could also have behavioural ramifications.

Behavioural change is taken to be unrelated to movement, and thus the origin of colonising groups can be traced by direct similarities in the material culture of groups entering Europe and those remaining at the origin (Bar-Yosef 1998; Saragusti and Goren-Inbar 2001; Straus 2001). The slow rate of change in the attributes of lithic assemblages during the Lower and Middle Palaeolithic may justify this approach; however, the lack of variation in the material culture of these periods also undermines the possibility of identifying an exclusive candidate for the parent population of the migrants. In the Upper Palaeolithic, the rate of technological and stylistic change seen in the assemblages may allow distinct cultural groups to be traced to a point of origin, but also creates the possibility that changes occurred between the origin and destination. Thus, the assumption that cultural similarities can be used to reconstruct population histories may not be justified. Therefore, this investigation will aim to examine the behaviours surrounding movement, and the likelihood of behavioural stasis during these events.

The causes of movement have been attributed to population increase and/or environmental deterioration at the origin acting as a "push factor" (Rolland 1998b; Carbonell *et al.* 1999c), in conjunction with the " pull factors" of availability of high quality resources without competition in the European destinations, despite the abandonment of the simple economic push-pull model of migration by human geography (Skeldon 1990) in favour of decision making and risk balancing models. Furthermore, in the absence of efficient long distance communications, the extent to which pull factors could drive movement is unclear, and thus these may be irrelevant to the events of the Pleistocene. Therefore, this study will aim to identify the potential processes that drove movement, without assuming that the push-pull model of migration is necessarily applicable.

Palaeolithic approaches to movement have considered the ecological circumstances of movement, using environmental constraints to explain the patterning of spread across Europe. However, little or no consideration has been given to other possible constraints, such as social network maintenance, and the need to explore and build knowledge of an area before large-scale occupation. Palaeolithic archaeology has traditionally focused on environmental adaptation, and has neglected the actions of individuals and groups in the construction of the world that they occupied (Gamble 1999). Furthermore, this lack of appreciation of the complex social worlds of hunter-gatherers has been a feature of anthropological research into contemporary foraging groups until recently (Conkey 2001). Thus, there is a need to consider whether ecological explanations do provide a complete picture of the nature of movements in the Pleistocene, or whether further social factors may have contributed. Moreover, the interaction between the physical environment and the groups moving through Europe may be more important than either set of processes alone.

Biological or social models?

Underlying the archaeological approaches to population movement in Pleistocene Europe is the assumption that biological models are applicable, particularly in the Lower Palaeolithic. Explanation of the timing and extent of colonisation has been focused on issues of environmental change and climatic cycles, inducing movements in the boundaries of biomes, which in turn influenced the distribution of faunal guilds and caused movements as resource distribution shifted (Foley 1987b). Gradual adaptation to environmental conditions within Europe and levels of competition in the faunal community have been taken to explain the later arrival of hominids in Europe compared to Asia (Turner 1982; Rolland 1992, 1995). The push factor of population increase is linked to the use of biological analogies for the behaviours of Pleistocene hunter-gatherers, as ecology proposes that animal populations will inevitably expand in numbers and territory until constrained by an external force (Elton 1958; Brown and Gibson 1983). This Malthusian approach to demography is controversial in the human sciences, and may not account for human population trends (Ehrlich and Lui 1997; Seidl and Tisdell 1999; Wood 1998). Moreover, ecological studies have also shown that population pressure may not be directly correlated to dispersal (Stenseth and Lidicker 1992b).

The ecological and biogeographical approach to movement is somewhat relaxed in the treatment of the Upper Palaeolithic, but environmental facilitation during a warm episode is often cited as a cause of the appearance of *Homo sapiens* in Europe (Mellars 1996; van Andel *et al.* 2003a). Models of the spread of the Upper Palaeolithic have considered that the groups of *Homo sapiens* involved were able to overcome environmental restrictions due to their more complex social lives, in comparison to archaic hominids (Gamble 1999). The cognitive advances that have been argued to be possessed by *Homo sapiens* have been used to justify the restriction of social issues in colonisation to the Upper Palaeolithic; for example, advanced communications through symbolism has been suggested to allow occupation of harsh environments that were uninhabitable to archaic hominids (Gamble 1980, 1986). Thus, there is an assumption that the Upper Palaeolithic movement into Europe, although environmentally constrained, was qualitatively different to that of the initial occupation of Europe.

Therefore, there is a need to examine whether the assumed applicability of biological dispersal models throughout the Palaeolithic, with elements of social colonisation models in the Upper Palaeolithic is valid. The differences between the two events require clarification, in order to establish whether the spread of *Homo sapiens* does require a more social explanation than the movement of archaic hominids, and whether the earliest occupation of Europe can be entirely explained by environmental constraints and adaptation. Moreover, the patterns expected to be left in the archaeological record of a biological dispersal or a cultural colonisation have never been explicitly researched, as the archaeological approach has assumed that the earlier events were biological and the later were social. Hence, this project aims to establish the nature of the differences and similarities between the movements into Europe during the Lower and Upper Palaeolithic. Furthermore, this research intends to explore the linkages between biological and social movements and the archaeological record, with the aim of determining which set of processes are applicable to which event.

The solutions to the problems of population movement in Pleistocene Europe offered by this study.

The interpretive framework.

In order to fulfil these aims it is necessary to review the existing biological and social models of movement from the disciplines that observe these processes. Therefore, this study will begin with an extensive examination of the ecological models of movement of non-human species in the present day, and historical biogeographical models of the past movements of fauna, to provide an overview of the biological processes of movement. Human geographical and sociological research into contemporary human migrations will also be researched and interrogated, with the aim of establishing the nature of human movements. These academic disciplines can potentially provide insights into the events of the Pleistocene, because they have intensively observed the processes of movement that take place in human and faunal populations. Therefore, it is possible that the findings of such research could provide a comparative framework of interpretation of the processes of movement. The lack of an ethnographic analogy for hunter-gatherer expansion into new territory may thus be overcome, by considering the nature of present day human migrations and faunal dispersals. The framework of interpretation of movement processes developed by this means will then be used to challenge and test the assumptions of the archaeological explanations of hominid movements into Europe. Furthermore, through the development of an interpretive framework, the identification of proxy data sources for the behaviours associated with movement is possible, allowing the archaeological record to be examined with respect to the processes of movement, rather than simply the timing and extent of dispersal.

Archaeology has assumed that movement has no impact on behaviours among the groups colonising Europe, with the possible exception of gradual behavioural adaptation to the conditions encountered. This assumption of behavioural continuity needs to be established before it can be used to trace the parent population of the colonisers by similarities in their material culture. Therefore, the investigation into the biological and social knowledge of movement will also aim to establish the impact of movement on the individuals and groups involved. Moreover, the nature of the individuals and groups that undertake migrations and dispersals will be examined, in order to reveal whether behavioural stasis or innovation is associated with movement.

Archaeological models have explained the patterning of hominid occupation of Europe in terms of environmental constraints. The examination of the biological and social models will consider whether environmental factors have been observed to affect the nature of dispersals and migrations. Furthermore, the ecological and geographical literature will be used to determine if there are other possible constraints and facilitators that have been overlooked in the archaeological treatment of movement.

Many archaeological models of the initial peopling of Europe have used aspects of historical biogeographical concepts of dispersal to support the chronology and extent of occupation favoured by the researcher. The biogeographical literature will be reviewed in the light of the predictions of such models, particularly the movement of hominids as a member of a guild of species, or during major faunal turnovers, in order to determine whether these conditions are valid. The findings of this review will then be applied to the archaeological models, to assess the extent that the assumptions underlying the approach are justifiable.

The archaeological models.

The archaeological approach to the population movements into Europe during the Pleistocene will be presented in Chapter 3 as a review of the work of four of the major researchers working on European colonisation: Clive Gamble, Nicholas Rolland. Eudald Carbonell and Robert Foley. These authors were chosen to represent a cross-section of views and theoretical approaches to the issues surrounding the Pleistocene movements, and thus to reveal the spectrum of current models of Palaeolithic colonisation. The archaeological models will be examined in the light of the interpretive framework of population movements developed in Chapter 2, in order to examine whether archaeological approaches conform to the expectations concerning movement developed by contemporary observations of dispersal and migration processes. The review of the archaeological approaches to movement also aims to reveal the aspects of the models that are worthy of further consideration, despite their lack of support from the biological and social models of movement, particularly the aspects that deal with the traces of movement in the archaeological record. Moreover, this review intends to identify the data sources connected to the processes involved in movement in each model, and thus allow the testing of the models by a review of the archaeological evidence for these processes. Narrative analysis of the four authors' work will be used to achieve these aims by breaking the models into the aims and agenda, theoretical perspective, data sources, and argumentation used to construct each model. Thus, this project aims to assess whether the current state of archaeological knowledge of the European Pleistocene is sufficient to support the models currently favoured by archaeologists, such as faunal turnover, competition, adaptation and social developments as explanations of the timing and patterning of movements.

The data collection and analysis.

The methodology developed to test the archaeological, social and biological models of movement will be discussed in Chapter 4. The testing of the interpretive framework is intended to assess whether the archaeological record contains sufficiently high-resolution data to be able to detect processes of movement observed in contemporary events. This methodology will then be applied to the archaeological record of the earliest occupation of Europe and the arrival of *Homo sapiens*, during oxygen isotope stage (OIS) 3. Throughout this study it is assumed that the differences between the Neanderthals and early modern humans were sufficiently large to justify a species level distinction, as suggested the the single origin hypothesis of human evolution (Stringer 2002); therefore, *Homo sapiens* is used to denote the early modern humans, rather than *Homo sapiens sapiens*, which would suggest a sub-species distinction as favoured by proponents of multiregional evolution. The suggested movements associated with the origins of prepared core technology and the techno-complexes of the Upper Palaeolithic have been excluded from this study due to the controversial nature of the movements. The testing of the data aims to develop a framework in which movement processes can be detected; hence, only the events that certainly involved movement will be considered. The application of the interpretive framework to further periods of the archaeological record that may have involved movement would then be possible, once the value of the framework has been established, and thus go beyond the scope of this project.

The results of the testing of the models, and the meaning of the patterns detected in the archaeological record of the Lower Palaeolithic will be presented in Chapters 5-7, and Chapters 8-10 will illustrate and discuss the Upper Palaeolithic results. The value of the interpretive framework developed in Chapter 2, and the archaeological models of the four authors reviewed in Chapter 3, will be assessed in Chapter 11, and the possibilities for future treatments of movement in the Pleistocene will be discussed in the concluding Chapter 12.

Chapter 2 : Biological and Geographical Models of Population Movement.

The causes and consequences of population movements have been studied by several academic disciplines, and models of the various forms of movement have been built. The categories of movement proposed provide a means of envisioning different forms and processes of movement. However, these categories divide a continuum of behaviours, and are themselves the subject of much debate (Tilly 1978; Pielou 1979). The geographical distances, numbers of individuals involved, duration and causes of population movements are all highly variable (Tilly 1978). Furthermore, the approaches taken towards population movements vary between disciplines, especially between social sciences studying the movements of humans, and biological sciences studying the movements of other species. The findings of the models developed by social and biological sciences can provide insights into the possible processes that occurred during the movements of the Pleistocene. This chapter will describe the models of population movement formulated by academic disciplines that observe movements, and their potential applications to hominid movements into Europe during the Palaeolithic, allowing the development of a framework of interpretation of these archaeological events. The findings of ecology and biogeography will be presented, followed by a discussion of their possible linkages to the archaeological record, and then the sociological and geographical models will be outlined, and the means of detecting their predictions in the record of the Pleistocene movements will be discussed. This chapter will conclude with an examination of the merits of these models with respect to the study of hominid dispersals.

Biogeography.

Biogeography is the study of the geographical distribution of species (Myers and Giller 1988b). Biogeography is divided into ecological biogeography, which concerns the present day distributions of species, and historical biogeography, which addresses the past distributions of species and their changes over time. The ecological approach allows the understanding of the limitations to species' ranges and population dynamics. The historical approach reveals long-term patterns and supra-species level trends in range distributions. The two approaches to biogeography provide complementary information, for example, changes in distributions at geological timescales can be accounted for by changing ecological conditions that affect local population dynamics (Rosen 1988).

Biogeography considers that the range of a species is constrained by the abiotic conditions that the species is able to tolerate, and by biotic interactions with other species (Hoffman and Blows 1994). The evolutionary history of a species also determines the range (Watts 1971). The fundamental niche of a species is the area in which the species could potentially survive, limited by physical conditions (Brown and Gibson 1983). The realised niche is the area within the fundamental niche in which the species actually exists (Brown and Gibson 1983), which is smaller than the fundamental niche because competition, mutualism and predation limit the population within the boundaries of the fundamental niche by reducing foraging efficiency and reproductive success at the edge of the range (Schoner 1988). Resource availability and distribution, as determined by climate have been found to be major factors limiting species distribution (Virgos and Casanovas 1999). Moreover, physical and habitat barriers can prevent a species from accessing parts of its fundamental niche (Bright 1999).

Ecological biogeography.

Ecological biogeography provides insights into the processes that limit species to a restricted distribution and how these are overcome during expansion. Ecological studies are able to use experimentation and direct observation in order to infer the effects of abiotic factors and biotic interactions on a species' range and the behavioural and physiological features of species with a wide distribution (Brown and Gibson 1983). These studies can be used to explain patterns of species distributions seen in the palaeontological record. Ecological studies have also been able to document the colonisation of new territories by expanding species, and have resulted in a list of predicted circumstances and biological traits that enable species to expand in geographical range (Williamson 1996). Elton (1958) termed the expansion of species range "biological invasion". The processes that prevent a species from becoming ubiquitous will be described, and the features of a species that allow a broad distribution will be discussed, as these must be understood before the circumstances surrounding expansion can be considered. The models of expansion processes derived by ecological studies will then be outlined.

Ecological biogeographical approaches to range constraints.

The distribution of species is limited by ecological processes (Brown and Gibson 1983). Individual members of a species must be able to forage efficiently, escape predation and reproduce successfully in order for the species to maintain its distribution (Rosen 1988). A species is not able to exist outside of its fundamental niche, but niches are dynamic, and change in geographical extent as a response to either abiotic or biotic conditions (Schoner 1988). The niche is unique to each species, and describes the habitat and resources required by the species. At the boundary of the range the species will have difficulties fulfilling these requirements, because either the habitat is unsuitable or there is a problem with access to resources (Brown and Gibson 1983).

A species will experience sub-optimal conditions at the edge of the range (Channell and Lomolino 2000), resulting in the sustainable population density decreasing to zero at the boundary. Among mammals the population is usually constrained by birth rate rather than death rate, since vagile organisms are able to escape limitation from mortality by moving to more hospitable conditions (Brown and Gibson 1983). The limitations to the birth rate may reflect either the lack of suitable resources for infants, or an overall shortage of resources (Myers 1986). Alternatively, competition from another species more suited to the local conditions may prevent access to resources (Brown and Gibson 1983). Predation can also act as a limit on population size and reproductive success, thus limiting the range (Jaksic and Fuentes 1991). At the periphery of an animal's range the population may be sustained by the influx of individuals from more optimal areas, who are forced to move by population crowding and high competition for territory (Grinnell 1922). This situation has been described as a source-sink (Hanski and Gilpin 1991). In the population sink surplus population from the source is absorbed but cannot reproduce. The presence of a population sink can significantly affect population dynamics, often damping large fluctuations and reducing instability (Lindenmayer and Lacy 1995; Dunning *et al.* 1995). An increase of population in the source may drive more individuals into the sink, and force a territorial expansion. Population density is often considered to drive dispersal; however, pre-saturation dispersal has been observed among rapidly expanding populations or populations recolonising areas (Stenseth and Lidicker 1992b) For example, the spread of brown bears in Norway after the introduction of hunting limitations (Swenson *et al.* 1998). Adaptation to conditions at the edge (Hoffman and Blows 1994), or a change in those conditions towards more favourable environments may allow the sink population to reproduce and expand (Mooney and Hofgaard 1999).

An additional constraint on reproductive success in the periphery of a species range is the problem of low-density population effects, or Allee (1938) effects (Crooks and Soule 1999). Reproductive success is reduced by the increased difficulties of finding a suitable mate in a low-density population, since search times are increased and small populations are more likely to lack a compatible mate through fluctuations in age and sex structure (Saltz and Rubenstein 1995). Small and isolated populations are subject to relatively large demographic fluctuations and are liable to local extinctions (Channell and Lomolino 2000). Connectivity between populations can overcome some of the problems of small population size (Hanski 1991). However, as dispersal between groups is dangerous, the risk of mortality while travelling may overcome the benefit of the exchange of individuals between local populations. Disperser mortality is especially high in poor environments and may act to destabilise the regional population (Boudjemadi *et al.* 1999). Sub-populations connected by dispersing individuals are termed a metapopulation (Hanski 1991). A metapopulation is stable despite localised extinctions if the successful colonisation of vacant habitat patches occurs at a greater rate than local extinction (Hanski and Gilpin 1991). Successful patch colonisation follows the same processes as the establishment of a biological invasion (see below). Metapopulation stability will depend on landscape physiognomy being suitable for the dispersal of individuals to other subpopulations, or vacant patches without high levels of mortality (Pulliam *et al.* 1992).

Features of wide ranging species.

The features of wide ranging species may have developed in archaic hominids or *Homo sapiens* and could have contributed to their expansion. Species that maintain a large range must have relatively broad tolerance limits for climatic conditions. These species are generalists and are able to survive on a range of resources. Large body size is associated with large range size. However, large body size is also a feature of generalism and broad tolerance limits. Large animals are able to withstand stresses through more efficient utilisation of energy than smaller species, as relative muscular effort and heat loss is reduced as size increases (Mace *et al.* 1983). Large body size is also associated with large individual ranges (Ayres and Clutton-Brock 1992), due to the need to traverse broad areas to find sufficient food. Large animals are able to travel more efficiently and are able to overcome small-scale environmental discontinuities more easily than small mammals. Carnivores have large ranges because as a group in a high trophic level, lower population densities than their prey have to be maintained whilst also finding sufficient food (Mace *et al.* 1983). Species that are abundant tend to inhabit a broad range (Brown and Gibson 1983), and abundance can also act as a proxy for generalism (Moulton and Pimm 1986). There is a correlation between range size and high latitude ranges, termed the Rapoport effect (Eeley and Lawes 1999). However, there is also a correlation between body size and high latitudes (Bergmann's rule). It seems that species in high latitudes have wider tolerance limits and greater flexibility of diet, which allows a wide range (Harcourt 2000). Species richness correlates with small range sizes and specialism, as niches are narrowed by competition, and declines as latitude increases (Eeley and Lawes 1999). Lesser competition in high latitudes may also account for broader ranges, or the lower primary productivity may produce lower density populations that are more widely spread (Eeley and Lawes 1999).

Establishment of new populations.

The processes of establishment may have affected groups moving into Europe during the Pleistocene, and thus can provide insights into the nature of the dispersal events. The majority of biological invasions fail to become established. Generally between 5-20% of recorded appearances of a species in a new territory result in a permanent population (Williamson 1996). The factors influencing establishment probability can be divided into extrinsic environmental qualities, and intrinsic characteristics of invasive species. Establishment is not guaranteed even when these conditions are met, since biotic resistance through competition, predation, parasitism and disease can limit the invading population (Simberloff 1986). Populations that fail to establish are unlikely to be detected in the palaeontological record.

Establishment is linked to the availability and accessibility of suitable resources in the new habitat. Therefore, the probability of establishment is greatly increased when a species expands into a similar habitat (Samways *et al.* 1999). Habitat similarity tends to decrease with distance, thus the majority of successful invasions are from a local source. Familiar habitats do not require changes in behaviour and diet. Furthermore, a matching of environments ensures that the species does not encounter conditions beyond its tolerance limits and remains within the fundamental niche. Establishment may fail if the environment fluctuates greatly during the initial stage of the invasion (Samways *et al.* 1999). Physical environmental resistance to an invasion is unlikely to be overcome, whereas biotic resistance can be adapted to, or overwhelmed by large numbers of invaders (Baltz and Moyle 1993). However, some species have been seen to rapidly adapt and shift their niche in response to the novel environment. Moreover, there are difficulties in determining a species' physical tolerance limits if it is constrained within its limits by biotic interactions.

Landscape structure may be more important than gross measures of environmental similarity, such as temperature and precipitation regimes. The majority of a range is uninhabited; species persist in suitable patches surrounded by a matrix of marginal-lethal conditions (Sax and Brown 2000). Most invasions fail because arrival will tend to be at an unsuitable location. Establishment depends on locating suitable habitat, and habitat patches being distributed in a suitable manner, in order for a viable metapopulation to become established. Patch sizes must be sufficiently large to support subpopulations. Small patches force most individuals to disperse and thus increase mortality, potentially to levels that cannot be sustained. The habitat must be of good enough quality to form at least one population source, with high reproductive success.

Biotic resistance to invasion will prevent establishment. However, some communities are more able to resist newcomers than others. Species-rich communities are likely to have a thorough utilisation of resources, leaving few opportunities for invaders (Fox and Fox 1986). "Saturated communities" utilise resources at the rate that they are produced, resulting in no vacant niches (Myers and Giller 1988b). Species-poor communities tend to have less competition, parasitism, disease and predation, and thus cannot constrain an invader as effectively as species-rich communities (Elton 1958). Species-poor communities may also have vacant niches, which facilitates establishment by reducing the biotic resistance to the invader; for example, the establishment of carnivores on oceanic islands, which usually lack a terrestrial carnivore. An empty niche is unlikely to be identical to the niche in the original range, since community composition will not be identical, unless the invasion is highly localised, and thus the resource partitioning in the community will vary.

Disturbance has been shown to be a stronger determinant of community invasibility than species richness (Fox and Fox 1986). Biota tend to move from high stability to low stability systems (Myers and Giller 1988b). Disturbance may prevent indigenous species from maintaining a balance between patch extinction and colonisation if it occurs at a scale not usually encountered. Disturbance also interferes with community interactions, and thus can open a niche for an invader (Orians 1986). The presence of an invading species can cause ecosystem restructuring and further disturbances, hence making the community more vulnerable to subsequent invasions, resulting in "invasional meltdown" (Simberloff and Von Holle 1999).

"Biotic release" has been seen to occur in the invasion of several species. Biotic release is the relaxation of the constraints of predation, parasitism, disease and competition encountered by an invasive species when it enters a community that has not co-evolved with the invader, and therefore lacks adaptations to restrain the spread of the invader (Sax and Brown 2000). Communities that have evolved in relative isolation, and not been exposed to a history of invasions tend to be susceptible to invasion for these reasons. Communities that have been repeatedly invaded are more able to resist subsequent invaders (di Castri 1991).

The probability of a species establishing is highly dependent on the number of individuals that arrive in the new area, or the propagule pressure (Grevstad 1999). There is no minimum population size below which establishment is impossible, but as population size increases the chances of demographic fluctuations and Allee effects causing extinction are reduced (Roughgarden 1986). An ability to rapidly increase population may overcome Allee effects but will cause a genetic bottleneck if the initial population was small; leading to further problems of lowered resistance to disease and a lack of genetic variation preventing adaptation (Grevstad 1999), as well as reproductive failure (Lindenmayer and Lacy 1995). Small populations can be highly susceptible to stochastic effects, such as inhospitable weather during the initial stages of an invasion. Also, the larger the number of arrivals the more likely it is that some will manage to find a suitable habitat patch before succumbing to predation or starvation (Williamson 1996). Invading populations that are able to maintain links with the parent population are more likely to establish, since the problems of small and isolated populations will be overcome. Alternatively, a viable propagule can be formed by the repeated invasion of several small populations.

The characteristics of successful biological invaders.

Successful biological invaders often possess the features of wide ranging species, including large body size and generalism. Widespread species are also more likely to encounter unoccupied but suitable territory, and thus spread further. Generalists have a wide resource base and broad tolerance limits, and thus are more likely to find a suitable habitat than a specialist invader (Samways *et al.* 1999).In addition, omnivory is also linked to broad tolerances and is associated with invasion success (Ehrlich 1986). Flexibility in behaviour, diet, physiology and reproductive strategies are preadaptations to success in novel environments, and have been associated with species adapted to fragmented habitats. Genetic variability and adaptability, as reflected in the existence of subspecies, facilitate adaptation to unfamiliar conditions (Ehrlich 1986).

A high rate of natural increase is associated with successful biological invaders (Williamson 1996). High levels of energetic investment in reproduction, and relative "r-selection" allow a population to rapidly increase. Flexible timing of reproduction is also important to reproductive success under new environmental conditions (Ehrlich 1986). Longevity, allowing time to adapt to the new range before reproducing, can facilitate invasion success (Newsome and Noble 1986). Individual longevity and extended reproductive periods also help to overcome the problem of finding a mate whilst living at very low population densities (Barrett and Richardson 1986), and are associated with humans (Key 2000; Mace 2000).

Social living likewise correlates with invasion success. Solitary animals will be affected by the problems of mate location at low population densities, whereas social animals overcome such problems of low-density population processes. However, a strongly clustered population is susceptible to greater levels of predation, disease and parasitism (Ehrlich 1986). A situation in which the population is divided into clusters, but linked by dispersing individuals that reduce inbreeding in each cluster, is most likely to produce a stable metapopulation (Hanski 1991; Lindenmayer and Lacy 1995). A moderate level of dispersal, allowing linkages between patches to reduce inbreeding, but preventing high mortality during dispersal, is favourable. Strongly dispersing species fail to establish a viable metapopulation because each habitat patch will not contain enough adults for successful reproduction to regularly occur, and low-density population processes will operate (Grevstad 1999).

Strongly competitive species are often successful invaders. An evolutionary history in a region that has high levels of species diversity and has experienced biological invasions will often confer strong competitive qualities on a species (di Castri 1991). Competitive ability is associated with large body size within genera, allowing larger species to exclude smaller species from resources (Ehrlich 1986). Species that live in large social groups are also able to out-compete more solitary species, either by direct aggression or by raising local population density to levels where other species cannot obtain sufficient resources (Ehrlich 1986). The ability to recognise and remember suitable habitat patches greatly increases the chance of a successful invasion (Pulliam *et al.* 1992) and may confer a competitive advantage over native species. Exploratory behaviour before permanent dispersal, allowing identification of suitable patches, is seen in the juvenile phase of many organisms (Shigesada and Kawasaki 1997). Species that evolved in communities that underwent repeated fragmentation are likely to have qualities allowing good patch colonising ability through the ability to disperse and compete efficiently (Malone 1987). Habitat fragmentation occurred in Africa during the course of human evolution and may have caused the evolution of strong patch colonising abilities in humans (Cachel and Harris 1998).

The process of spread in biological invasions.

The process of spread can be envisaged as a series of establishments in habitat patches. Movements are either local and referred to as "diffusion", or involve the establishment of satellite populations by "jump dispersal" over some distance from the main population front (Shigesada and Kawasaki 1997). The area between the satellite population and the parent population is then gradually infilled by diffusion. The constraints in operation at the edge of the species range are those that prevent establishment. The means by which these constraints are overcome are also adaptations, population growth and environmental change (Crooks and Soule 1999). A population must increase in order to maintain itself during spatial expansion. As patches are colonised population will gradually increase until dispersal of individuals into new patches takes place. This process highlights the mechanisms underlying the historical biogeographical process of diffusion, discussed below.

Once a species arrives in the new environment there is a time lag before the population begins to spread, termed the "establishment phase" (Shigesada and Kawasaki 1997). This delay can be caused by the need to build up sufficient population or to adapt to the new environment before expansion (Bazzaz 1986). The population may only expand once the initial range becomes saturated with individuals (Shigesada and Kawasaki 1997). Adaptations may take a significant time to develop in small populations, since genetic drift is more powerful than natural selection in small populations (Crooks and Soule 1999). A lag caused by the need for adaptation, or due to environmental change will be longer than a purely demographic time lag. Short generation times, allowing rapid adaptation, have been associated with species that have spread after establishment among invasive species in Chile (Fuentes 1991).

Once the species has completed the establishment phase it will enter the "expansion phase" (Shigesada and Kawasaki 1997). Three major types of expansion phase have been observed (Shigesada and Kawasaki 1997), as illustrated in Figure 2.1.

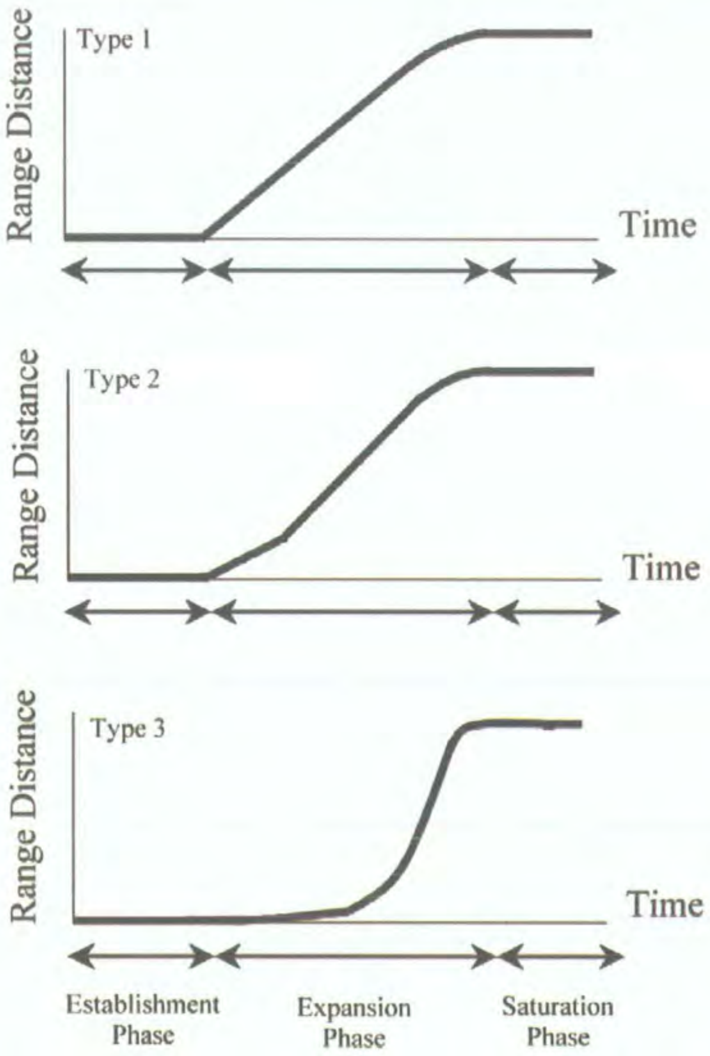


Figure 2.1 . Graphs showing the three types of increase in spatial area over time of a biological invader during the establishment, expansion and saturation phases. (After Shigesada and Kawasaki 1997)

The first model of expansion is of linear increase of the area of the range over time, although the rate will be faster in preferred habitat and slowed by inhospitable terrain or topographical barriers, and may also be seasonal (Hengeveld 1989). This model is frequently used in archaeological treatments of dispersal, which do not address other scenarios. The second model involves a slow linear expansion followed by a more rapid linear expansion. The third observed scenario is expansion at a continually increasing rate. In all three models the expansion phase is followed by the "saturation phase" in which expansion gradually slows to a halt. Species fitting the first model tend to diffuse locally, whereas models two and three are produced by species that spread locally and by jump dispersal far beyond the population front. The second model is differentiated from the third by the presence of satellite populations close to the primary population, which are reabsorbed relatively soon after their establishment. The third model describes species that spread by diffusion and jump dispersal over great distances, creating satellite populations that remain independent of the primary population for several generations. Alternatively, the third model may describe the expansion of a species that is adapting to its new environment. These spatial patterns of spread are shown in Figure 2.2.

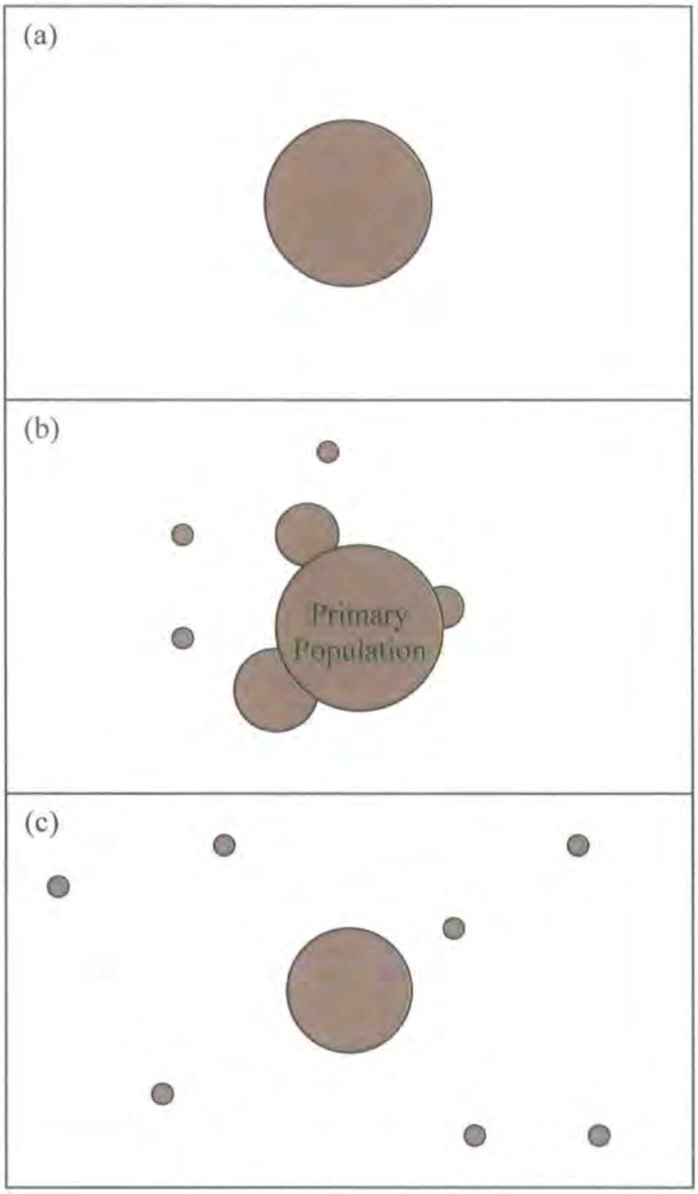


Figure 2.2. The patterns of spatial distribution of a biologically invading population during spread. a) Shows a population undergoing local diffusion. b) Shows a population with satellite groups close to the primary population. c) Shows a population with independent satellite groups far from the primary population. (After Shigesada and Kawasaki 1997)

Consequences of biological invasions.

A biological invasion will have repercussions in the community being invaded and on the invading species. Invasions will result in changes in resource allocation (Vitousek 1986), which can cause a decline and possible extinctions among the native species. In species-rich communities effects are likely to include extinctions since these communities are stable and the invading species is unlikely to be filling a vacant niche, and is therefore directly competing with native species. Prolonged or intense competition is likely to result in extinction (Marshall 1988). Competition between highly similar species will probably result in extinction, not character displacement, but this process will be prolonged (Simberloff 1981). Character displacement and niche shift is seen when species compete and are forced to separate ecologically, often becoming more specialised in a narrower niche (Schoner 1988). In spatially structured landscapes distributional heterogeneity may overcome the effects of competition and allow co-existence of similar species (Schoner 1988). A competitive inferior may survive by having greater patch colonising abilities than its competitor, and thus can maintain a metapopulation despite patch extinctions. Extinctions and character displacements following biological invasions should be detectable in the palaeontological record, and therefore it may be possible to reconstruct the ecological interactions between an invasive species and the native community.

Biological invaders will usually experience a genetic bottleneck during expansion, thus genetic developments resulting in physical changes are liable to occur. An invading population is likely to derive from a subset of the parent population, and may show reduced variability, thus invading groups can be close genetically, behaviourally and physically. Thus, the range of behaviours can be narrowed, or may change in comparison with the parent population. This creates difficulties in detecting the effects of differing competitive pressures forcing a shift of niche, from a bottleneck, since both cause behavioural change and niche narrowing. However, if biotic release has been experienced by the invader, a broader niche may accompany a niche shift. Close relatedness can cause greater co-operation between individuals and groups in the invading population (Suarez *et al.* 1999; Anderson 1987). Adaptational change can be very rapid, and may include niche shifts and behavioural innovation (Yom-Tov *et al.* 1999; Berkman *et al.* 2000). At the edge of the range the species is under the greatest pressure since conditions are the least like those adapted to at the core, hence direct selection on the phenotype is likely to occur (Parsons 1988).

Historical biogeography.

Historical biogeography considers range shifts to occur in a similar fashion to the processes predicted by ecological biogeography, as biotic constraints on the species change, by the extinction of a competitor or predator, or the movement of mutualistic species. Alternatively, climatic or tectonic change may cause changes in habitat availability and accessibility resulting in range expansion or contraction (Rosen 1988). Adaptation to conditions at the edge of the range may also allow a species to expand by changing the fundamental rather than the realised niche (Brown and Gibson 1983). Conversely, processes occurring at the centre of the range may drive changes at the edge (Briggs 2000). Biogeography treats species as constantly attempting to expand the limits of the range and maximise their realised niche, in a process termed "randomization" by Elton (1958).

Spread is the term used in historical biogeography to describe any process by which a species expands its range into formerly unoccupied territory (Pielou 1979). Spread has been divided into three major processes, relating to the mode of dispersal and nature of the means by which the species overcomes the constraints on its range. These processes are termed "jump dispersal", "secular migration" and "diffusion" (Pielou 1979). These processes are not discrete but do provide a useful conceptual division of the continuum of the temporal and geographical scales under which spread occurs, and the forms that spread may take.

Jump or sweepstake dispersal.

This model deals with dispersals that cross large distances or ecological barriers, as shown in Figure 2.3, in a short length of time relative to the lifespan of individuals of the species (Brown and Gibson 1983), such as the colonisation of oceanic islands by terrestrial species. A barrier is an environment very different from that to which the species inhabits (Brown and Gibson 1983). Physical barriers can be formed by temperature, moisture or chemical regimes beyond the tolerance limits of the species (Darlington 1957). For example, oceans form extremely strong barriers to terrestrial mammalian dispersals (Heaney 1986). Biotic barriers are caused by the inability of a species to compete, escape predation or reproduce successfully in peripheral areas (Baltz and Moyle 1993). Barriers are specific to individual species, and reflect tolerance limits and mode of movement. However, major discontinuities in habitat may affect entire communities (Brown and Gibson 1983). Jump dispersal occurs infrequently and the destination is often random. Jump dispersals will affect species singly, communities or guilds do not move by this mechanism.

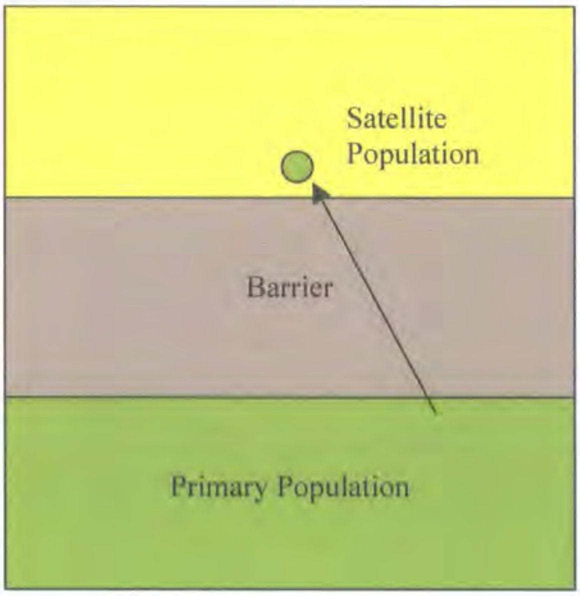


Figure 2.3. Diagram showing the mechanism of jump dispersal.

Species that disperse successfully by this means commonly have adaptations to long distance travel, such as dormancy whilst being passively transported over hostile terrain, or a small body size or a form that allows passive transport by wind or water. Large mammals are limited to active dispersal, requiring the ability to survive crossing the barrier before finding suitable habitat; therefore, large-bodied species are not suited to jump dispersal, and the rate of successful establishment beyond significant barriers is very low, Heaney (1986) has calculated that mammalian colonisation rates of islands isolated by 5-25 Km of sea channel during the Pleistocene was 1-2 species per 500 000 years. Nevertheless, hominid crossings of the Straits of Gibraltar would fit this model. The processes involved in the establishment of isolated populations are ecological (Myers and Giller 1988b) and have been studied in more detail by ecological biogeography, discussed above. The isolation experienced by successful jump dispersers can cause a genetic founder effect, and eventually speciation.

Diffusion.

Diffusion is the long-term consequence of the ecological process of patch colonisation. This mode of dispersal is likely to occur far more frequently than jump dispersal (Brown and Gibson 1983) and therefore is likely to have been a major determinant of species' ranges. Diffusion describes the spread of individuals into suitable habitat beyond but relatively close to the margin of the range, without crossing significant barriers (Pielou 1979). Inhospitable terrain may separate parts of the population, but at a geographical scale small enough to allow the exchange of individuals between subpopulations. Natal dispersal often occurs over short distances and individuals remain within the original mating network (Seddon 1971). Alternatively, group fission can result in dispersal to a new territory (Henzi *et al.* 1997). Diffusion results in the gradual expansion of the population beyond its former boundary, over many generations (Pielou 1979), and is associated with population increase, in order for a viable mating network to be maintained whilst spatially expanding (Seddon 1971). Population increase may be localised at the margin of the population, or affect populations throughout the range (Brown and Gibson 1983). Diffusion is likely to be triggered by environmental change or possibly adaptation if the population is relatively isolated from the effects of gene flow overwhelming local adaptation (Brown and Gibson 1983).

Diffusion may involve the spread of several species simultaneously via the same route in the geological record (Brown and Gibson 1983). The similarity of habitat into which diffusion takes place could result in many member species of a community eventually spreading into the extended range. Diffusion can be thought of as happening within a biogeographical corridor or filter, as shown in Figure 2.4. A corridor is a link between two similar areas of habitat, that acts as a route for the interchange of many or most of the species in each habitat, resulting in highly similar community composition on either side of the corridor (Simpson 1936), or a broad band of continuous habitat, facilitating free dispersal of species throughout a biome

(Udvardy 1969). A filter allows the exchange of some members of the communities to either side of the filter, but restricts the movement of others (Brown and Gibson 1983). A discontinuity of habitat or a change in abiotic parameters may account for the failure of some species to traverse the filter (Marshall 1981). A filter can be recognised by a gradient of community composition similarity from each end (Brown and Gibson 1983). Corridors can be thought of as weak filters, since over large areas of continuous habitat community composition will gradually change because not all species are equally capable of dispersing and maintaining a population over large distances. In addition, subtle changes in biotic and abiotic conditions may limit the spread of some species. Large mammals tend to be wide-ranging and capable of dispersal throughout wide expanses of similar habitat (Brown and Gibson 1983), and are therefore less affected by filters.

Diffusion may be associated with external changes in environmental conditions, which allow spread into previously unoccupied territory. Historical biogeography highlights climatic change as a cause of changing resource distribution, resulting in the opening of filters and corridors in the location of former barriers. Climate change has been given as the cause of the movement of communities and biomes (Woodward 1987) as well as individual species. A suite of species may respond to an external change in a similar fashion, and therefore move in the same direction. However, an individual species is constrained to a unique niche, which will react in an individual manner (Brown and Gibson 1983). At ecological timescales suites of species may not be seen to move together, whereas in geological timescales a clear association of species may be apparent. Diffusion may also be associated with community restructuring, causing the opening of an appropriate niche.

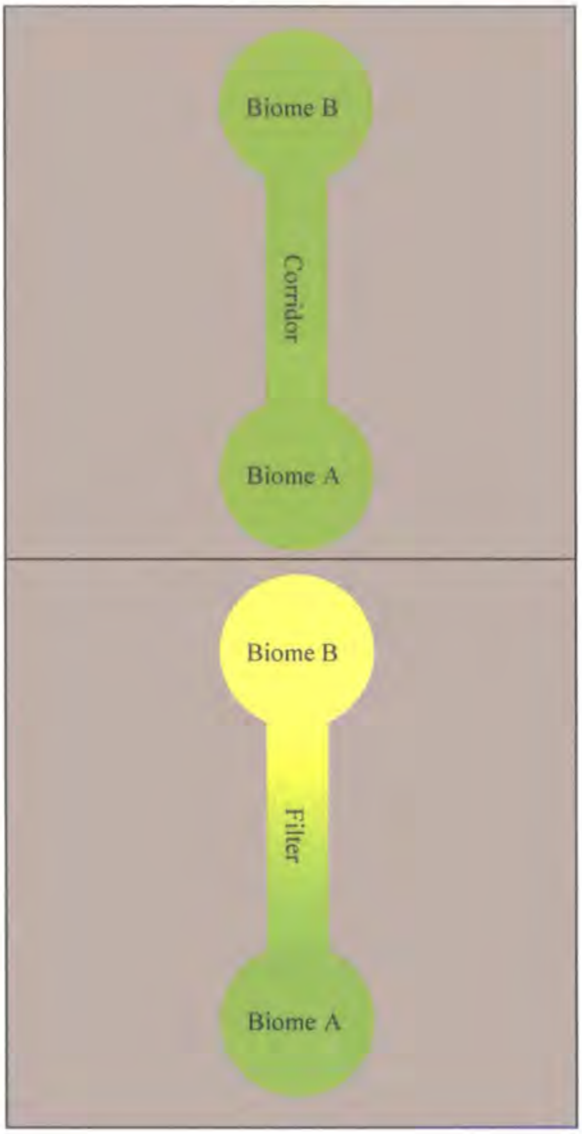


Figure 2.4. Diagram showing spread of a population by diffusion. a) Shows movement through a corridor. b) Shows movement through a filter.

Secular migration.

Secular migration is similar to diffusion, but is distinguished by expansion occurring at a rate so slow that it is detectable only over geological time (Brown and Gibson 1983). The species may undergo appreciable evolutionary and behavioural change during the movement, overcoming barriers by adaptation (Pielou 1979). Furthermore, the environments into which movement occurs may be changing. Speciation is likely to occur during this process, raising problems of the accurate reconstruction of phylogenies in order to infer that the movement took place, and to reconstruct the route taken (Enghoff 1995). Secular migration is not likely to provide a useful analogy for human population movements in later prehistory or historical periods.

Detection of biological movements in the archaeological record.

The ecological and historical biogeographical models highlight the climate and environment, the ecological community, spatial and temporal patterns, physical and behavioural traits, and subsistence as related to population movements. These factors can be investigated through the archaeological, fossil and environmental record of the Pleistocene, to investigate the processes that occurred during the movement of the initial occupants of Europe, and the spread of the Upper Palaeolithic.

Biological models predict that the level of similarity between the environment at the origin and destination of a movement is a major factor in successful establishment. Therefore, a pattern of hominid movement into areas with similar habitat to the conditions at their origin should be expected. Historical biogeography predicts that gradual adaptation to conditions will occur, and thus populations will spread through biomes in the order of their similarity to the familiar original habitats. Hominid dispersal therefore should follow a pattern of movement through a familiar habitat, adaptation, and then further spread through similar habitats until additional adaptation is required. The timing of movement can also be expected to coincide with, or occur after periods of European environments becoming more similar to the conditions previously encountered by hominids, thus a correlation with global climatic change is predicted. The European palaeoenvironmental record and the global climatic record of the Pleistocene can thus be used to identify periods when hominid colonisation should be facilitated. However, observed biological invasions suggests that adaptation can be rapid, and thus the rate of hominid expansion may have been too great for any correlations with environmental or climatic parameters to be discernable in the Pleistocene record of Europe. Moreover, the predictions of environmental matching rely on the source of the hominid groups in Europe being known, which is presently questioned. In the situation of jump dispersal, without links between the parent population and European hominids, establishing the area of origin would be extremely difficult.

Ecological and historical biogeography suggest that community interactions are central to successful dispersal. A context of faunal extinctions preceding arrival of a species reduces competition and eases establishment. Movement coinciding with the arrival of several other species would fit the predictions of climatic or environmental change resulting in the spread of a community or guild through a filter or corridor. Extinctions following hominid arrival can also be anticipated, as a result of heightened competition. Therefore, hominid movements are predicted to occur in a context of faunal turnover, which should be seen in the Pleistocene palaeontological record in Europe. A second link to the palaeontological record is the prediction of ecological models that successful invasion will occur in a community with little resistance to the influx of new species able to fill vacant niches. This situation may be detected in the palaeontological record by low species number and a high degree of endemism preceding hominid arrival.

Biogeographical models produce a series of spatial and temporal patterns that could be seen in the distribution of archaeological and hominid fossil sites in Europe, and potentially reveal the processes that took place during movements. Successful establishment is strongly linked to retaining connections with the parent population; therefore, spatially continuous occurrence of archaeological sites, without major uninhabited regions between groups, should be seen. Links between the parent population and European hominids could also be seen in a lack of physical differences between the two groups. Ecological biogeography predicts a two-phase process of movement, with initially limited establishment, followed by more rapid spread, and finally stabilisation. Spatially, populations are predicted to be clustered and constricted at first, with satellite populations later developing beyond the core group. Occurrence of some groups far beyond the consolidated core is possible. The stabilisation phase involves infilling between satellite groups and the core. Therefore, the patterning of sites in the archaeological record is predicted to be clustered, with large areas unoccupied. Beyond the region of entry into Europe, sites may be very widely dispersed and low in density. Historical biogeographical diffusion or secular migration envisage a gradual wave-front advance, resulting in a cline of dates of first appearance of Lower and Upper Palaeolithic sites across Europe from the point of entry.

Ecological biogeography predicts that establishment is unlikely to occur during the first entrance of a species into a territory; hence, hominid initial forays into Europe probably failed, and thus temporal discontinuities in the archaeological record are expected. The initial Lower Palaeolithic record can therefore be predicted to consist of few sites widely dispersed in time, before an established settlement took hold. In the situation of the Upper Palaeolithic movement into an already occupied Europe, failure may be seen by the brief appearance of Upper Palaeolithic traits, and then their disappearance, followed by later reappearances in larger numbers.

Patterning in the number of sites over time could also reveal processes of dispersal. Large initial population sizes correlate with increased likelihood of successful establishment, and could be detected in large numbers of sites from the earliest period of hominid presence in Europe, and the initial Upper Palaeolithic. Large assemblage sizes in the early sites may also reflect significant propagule pressure. A pattern of small steady population size initially, followed by linear or exponential growth has been observed during biological invasions, and may be detectable in the volume of the archaeological record over time. However, pre-saturation dispersal also occurs, hence large population sizes are not necessarily linked to movement. Moreover, these proxy measures of population size assume a direct correlation between the volume of remains recovered in the archaeological record and population size, unaffected by variation due to different levels of tool curation, or other taphonomic effects.

Behavioural changes have been observed during the spread of species. Rapid change is seen in some biological invasions, whereas historical biogeography predicts a process of gradual adaptation. Change is anticipated because it allows survival in novel conditions, overcoming the pressures of competition in a new ecological community, and is facilitated by isolation at the edge of the range. These processes may be seen through innovations in technology and particularly in subsistence tactics preserved in the zooarchaeological record. Therefore, patterning in the timing and spatial distribution of lithic innovations could reveal movement processes. Behaviours only occurring in the periphery of the population may explain a successful movement. Behavioural developments have also been proposed to spark movements, thus innovations appearing before dispersal could be the cause of human colonisation. A broadening of dietary breadth is predicted, as a response to the need for behavioural flexibility and generalism in movements, and resulting from biotic release. However, niche constriction and a reduction in dietary breadth, and the range of behaviours in general, could result from competition pressures from the European faunal community. Patterning in hominid dietary breadth could be seen in the number of plant and animal species preserved in archaeological sites, showing evidence of consumption. Biotic release can result in healthier populations, with increased reproductive success and longevity, compared to groups at the source. It is possible that these improvements in health could be detected in the hominid fossil record. Physical change, and possibly speciation is also anticipated to be seen in the hominid fossil record, particularly if jump dispersal occurred. However, isolated groups are less likely to survive and spread, and hence strong connections to the parent population are expected, which may limit physical and behavioural differences, and prevent speciation, especially in situations of diffusion. Moreover, as less successful and resourceful individuals are likely to be pushed into the periphery, innovation could also be limited.

Sociological and geographical approaches to migration.

The study of historical and current human population movements provides insights into the direction and volume of population flows, the motivation of migrants, the constraints on migration, and the effects of migration on communities at the source and destination. Several models of the form of migrations have been generated, and will be presented below. These models allow an understanding of the processes that take place during contemporary human movements and which may have been experienced by the groups moving into Europe during the Pleistocene.

The causes and nature of human migrations.

The first social science models of movement were based on economic motivations, such as employment opportunities and wage levels (Massey *et al.* 1993), which were heavily focused upon since Ravenstein (1885) listed his laws governing migratory flows. For example, spatial interaction models such as the gravity model (Zipf 1946), used population size as a proxy for opportunities, and modelled flows as being proportional to the sizes of the origin and destination. Distance has been considered to act as a proxy for the costs of migration, in terms of transport and social upheaval, the "cultural distance" (Millington 2000). In these approaches migrants are assumed to move to the nearest destination that will fulfil their needs (Stouffer 1940). Spatial interaction models do not take account of knowledge of the potential destinations affecting the choice of migrants. These models have not been found to provide useful predictions of migration flows in terms of volume or direction (Rogerson 1984) but remain current in archaeological approaches to movement.

The subsequent neoeconomic approaches to migration assumed that individuals make rational choices, based on complete knowledge of the circumstances, in order to maximise the benefits of migration over a lifetime, for the least cost (Sjaastad 1962). Individuals were assumed to be maximising the present value of future net income (Bravo-Ureta *et al.* 1996). Therefore, migrants were predicted to be young, since they will have more time to reap the benefits of a move and overcome its costs than older individuals. In addition, individuals possessing skills in demand at other locations were considered more likely to migrate than unskilled workers (Odland and Ellis 1987). Aggregate migration flows were thus the sum of individuals' decisions to move. These approaches do not address migrants' imperfect knowledge of the situation, or the historical context of migrations (Bravo-Ureta *et al.* 1996). Recent additions to the economic approach have included considering the decision to migrate as based in the household rather than being made by fully autonomous individuals. Households are thus treated as attempting to maximise returns and minimise risk (Massey *et al.* 1993). Migration can therefore take place in the absence of economic variations between regions. Attempts have also been made to model imperfections in the migrants knowledge of potential destinations, by using expected rather than actual returns (de Haan 1999).

Factors considered to be important to decision-making include economic maximisation, motivation, values and expectancies, place utility, community and social networks, environmental pressures and constraints, kinship structure and family strategies (de Jong and Gardner 1981). Motivation is assumed to be the maintenance or improvement of quality of life, particularly the attainment of social mobility. Dissatisfaction with the present situation is taken to start the decision-making process, and relates to perceived disparities of opportunities. However, perception of opportunities and the ability to act upon this information are affected by cultural values, education, communication channels and intelligence. When there is little information about destinations push factors are very influential in the decision to move. Personality traits, such as willingness to take risks, belief in the ability to control events and need for achievement, are important in determining which members of a community respond to a pressure to migrate (Haberkorn 1981). These psychological traits may be influenced by upbringing. The greatest constraint to movement seems to be the lack of knowledge and inability to conceive of the alternatives (Akerman 1978). Perceptions and motivations are likely to change through the life cycle due to increased experience and changes in social role.

Societal and cultural norms affect migration values and expectations (de Jong and Fawcett 1981). Pushes and pulls of locations, information and perceptions of costs and benefits of movement are mediated through family and household needs and decision-making customs (Anthony 1997). Community norms of behaviour and roles affect which members move and for what purpose. Gendered and age-structured norms result in different motivations and expectations among members of the group. Inheritance patterns and family structure can be influential. The position in the social hierarchy may be critical, some groups may be forced to move to achieve social mobility, or raised to expect to have to migrate, such as younger siblings (Anthony 1997). Movement may become normal and expected behaviour once it has been established in the community, hence migration can become a rite of passage to adulthood that is not caused by any economic motivation, but is encouraged by other community members. The history of movement within the community is very important in the perception of opportunities (de Jong and Fawcett 1981) and the choice of destination, since successful behaviours are copied by other members of the community. A family structure of flexible relationships and living arrangements, and strong attachments between the extended family supports migration (Harbison 1981). Personal values are expected to reflect cultural norms. However, individuals who resist these norms and set new behavioural patterns may act as pioneers and cause significant changes to the cultural values in the future. It seems likely that pioneering personalities exist, and are distinctly different from the personalities of those who follow well-established behaviours (Haberkorn 1981). Skeldon (1990) argues that norms are the product of, rather than the cause of migration.

Migrations have been found to occur within social networks, rather than breaking social ties. The vast majority of migrants move to a destination in which other members of their natal community are found, not the destination that would maximise economic returns (Wilson 1994). The strongest correlate of migration propensity is the possession of a relative who has migrated. Migrations can be modelled as having a pioneering and a following phase. Pioneering migrants move to relatively unknown destinations, but remain in contact with their home community and relay information about opportunities to other potential migrants (Anthony 1997). The risks and uncertainties of migration are therefore decreased for individuals that move to join a pioneer (Hugo 1981). As more individuals move, more information flows back to the source community, via return migration, and more individuals are connected to the social network of the migrants, encouraging further migration. Pioneers tend to come from higher social groups and are well educated; movement diffuses down the social hierarchy. Migration networks focus movement into specific destinations (Anthony 1997) and often distinct economic sectors (Skeldon 1990). Migrants thus stay relatively separate from the receiving community and retain their social connections with the community of origin. Membership of the social network involved in a migration may be determined by social status or kinship; therefore, movements are often restricted to certain sections of the community at the origin. Migration streams are strongly segmented and become increasingly entrenched over time (Rogerson 1984), despite changing economic conditions (Massey *et al.* 1993). Migrants may move on from the destination and create additional nodes to which migratory flows are directed (Wilson 1994). Migrations are better described and predicted by models that take account of past flows than by models that only use economic conditions (Anthony 1997).

The characteristics of migrants.

The specific socio-economic characteristics of migrant groups will vary between communities. However, certain characteristics are shared by the majority of migrants. Movements are generally undertaken by young adults, as these individuals are often the least strongly integrated into their natal community, and will have the most to gain from movement (Oberai and Singh 1983). Movements once a family has been established are relatively rare and usually over shorter distances. Once an individual has moved there are few ties at the destination preventing further movement, and therefore repeated movements often occur (Anthony 1997). The poorest and least educated parts of a population are often excluded from migration, as pioneering migrants tend to be relatively wealthy, to come from the higher classes of the society, and to be well educated (Skeldon 1990). Female mobility tends to decrease more rapidly with age than male mobility, and is more skewed towards the wealthier segments of the society.

Models of human migration.

Tilly (1978) defines migration as mobility that involves a significant distance and break with the place of origin. Tilly describes three major kinds of migration which could be relevant to population movements in the Pleistocene, distinguished by the social organisation of the movement: local, circular, and chain. Anthony (1997) suggests that these models are useful since they divide migration into categories distinguished by the constraints in operation, and the social effects caused by the movement, and therefore may be utilised in archaeological contexts. The models are somewhat overlapping, as each form of migration may lead on to another by changing the distance of movements, the length of residency, and the degree to which ties with the area of origin are maintained. Tilly's models do not cover the full range of possible forms of migration; for example, the models do not distinguish the movements of individuals from those of groups, or voluntary and coerced movements.

Local migration involves movement within the local labour market and social network, resulting in little disruption of social contacts (Tilly 1978). The destination will be familiar to the migrant and will be populated with known individuals. Little or no adaptation to the circumstances at the destination will be necessary; thus, major social changes are an unlikely consequence, since it occurs within a single community. Local migration may be undertaken by a broad array of community members (Tilly 1978). The distances involved may be large or small, depending on the spatial extent of the social network. These movements allow the creation and maintenance of regional cultural groups, and form the vast majority of movements (Anthony 1997).

Circular migration is defined as movement to a destination and then a return to the origin after some time (Tilly 1978), such as during transhumance or seasonal work. The distances involved in circular migration can be large, including intercontinental movements. The migrant will expect to return after achieving a specific goal in the receiving area. The motivation for migration is to attain additional wealth and prestige (Anthony 1997). Circular migration will involve little integration with the community at the destination, since settlement is not intended. The migrant will often stay within a social network of other migrants from the same community or region. Circular migration often affects a specific section of the community at origin, since it is associated with particular economic roles in the community (Tilly 1978). Thus, circular migration is often heavily sex biased, and can be confined to a certain age cohort. Circular migration may involve a range of destinations, or be geographically restricted, and can develop into chain migration if some of the migrants remain at the destination (Tilly 1978).

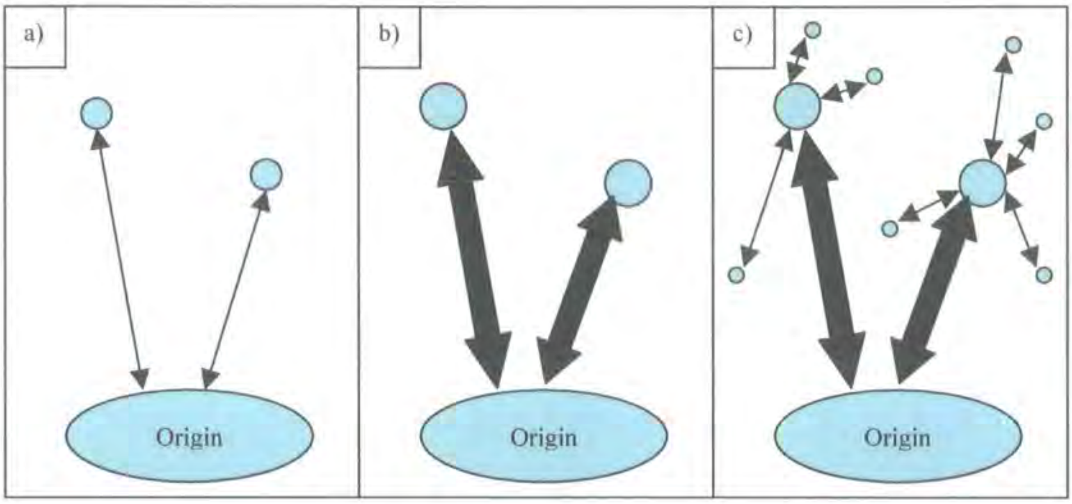


Figure 2.5. Diagram showing the pattern of movement between nodes during a chain migration. a) The initial exploration. b) The movement of large numbers of migrants to primary destination nodes. c) The development of a complex migration network with secondary destination nodes.

Chain migration describes the permanent or prolonged movement of migrants to a limited number of destinations far enough away from the source for a significant social upheaval to take place (Tilly 1978). The migrants follow pioneers, and maintain connections with their natal community, forming a migration network, displayed in Figure 2.5. The pioneers often assist the movement of further migrants from their community, by providing advice, accommodation and economic opportunities, thus reducing the barrier of poor information about the destination. Destinations between the source and the receiving areas will be bypassed because migrants lack information and social connections in locations outside of the network (Anthony 1997). Chain migration will involve exploratory moves and return flows from the destination to the source (Tilly 1978). The migrants are likely to cluster together and form a distinct ethnic community at the destination. Chain migrations allow individuals to overcome the costs and risks of long distance movements, that otherwise would inhibit emigration. The network of migrants tends to build up over time, and include a wider demographic representation of the source community. The pioneers are often single, male and relatively young. The motivation for migration is to increase wealth, prestige or security; therefore, chain migrations can also describe the processes of coerced movement (Anthony 1997). The pioneers and their families may gain social status and wealth from their assistance of the followers, which is likely to cause increased social differentiation at the destination (Anthony 1997).

Step migration is a common category of movement that is not addressed by Tilly's (1978) models, which takes place by a series of short distance moves, from a local centre to larger regional centres (Ravenstein 1885). This form of migration overcomes information barriers by initially moving within the local social network. Migrants will build connections at the first destination, and gain knowledge, experience and skills that facilitate further movements. Once a movement has taken place, the social ties and lack of experience that constrain many individuals from moving will have been broken, thus further movements are less costly. Migrants are therefore able to move out of their natal social network and region by incremental moves into other areas. This process minimises the costs of moving into unknown destinations, and therefore may be the model most appropriate to pioneering movements.

The consequences of migration.

Migration builds links between areas, the repercussions of which are felt at the destination and the origin. The effects of migration on the society and culture at the destination depend on the power relations that are established between the immigrants and the indigenes (Burmeister 2000). Migration can result in the spread of ideas, and the exchange of cultural forms between communities. However, the migrants or the receiving community may act to retain their identity and isolation from the other group; nevertheless, the presence of migrants will bring about eventual change (Castles and Miller 1993). The strength of the migrant network will determine whether the immigrants become a distinct ethnic group (Grieco 1998). Spatial mobility and ethnic change have been linked (Burmeister 2000). Ethnic identity is constructed, and is contingent upon the circumstances faced by individuals (Hamerow 1997; Jones 1997). Immigrants may assimilate into the native culture, and take on the native ethnic identity if this allows greater social mobility (Anthony 1997). Burmeister (2000) argues that assimilation may occur in the public sphere of life, but privately the migrants' original traditions and beliefs will be maintained. The presence of a strong network of migrants may prevent assimilation from occurring, as opportunities and support may be found within the migrant community itself, thus minimising the need to infiltrate the native community. Mutual acculturation may occur in this scenario, or when neither group strongly dominates the other (Burmeister 2000).

In the region of origin the migration may cause economic stagnation and conservatism since many of the most active members of the community will have moved (Lin and Liaw 2000). This will reinforce the attractiveness of the migratory destination(s) compared to the source area. A change in the age and sex structure of the population is likely to occur as migration removes specific parts of the population (Burmeister 2000). Remittances from migrants may assist the local economy (de Haan 1999). Return migrants will bring wealth and new knowledge into the area, which could stimulate social and economic change. An association of wealth and prestige with "foreignness" may develop and stimulate cultural change at the migration origin. However, in many cases migration is undertaken to achieve a specific purpose, such as to earn the money to build a house or buy some land (Massey *et al.* 1993). Therefore, the return migrant will retain the identity and attitudes of the source community, without attempting to integrate into the community at the destination (Massey and Espinosa 1997).

Detection of human migration in the archaeological record.

Sociological and geographical models of human movement highlight spatial and temporal trends in migration flows, and behavioural consequences of movement, which can be linked to the archaeological record. The potential sources of data related to these models include trends in site distribution, density and size over time, the range of activities represented at sites, and patterning in tool forms.

Spatial patterns revealed in the observation of human movements include the presence of networks of nodes. Chain and circular migration predict movement to firstly focus on few destinations, and become more dispersed later. These models suggest some long distance moves, with isolation from the population at the source resulting. Therefore, a pattern of sites clustered in few major nodes initially, with later dispersion into many smaller nodes should be seen in the archaeological record, if circular or chain migration occurred. The temporal patterning anticipated is a two-stage process, involving few migrants at first, with potentially exponential increase in the number of individuals moving later. This should be seen in the presence of small sites initially, reflected in assemblage sizes and spatial extent; followed by an increase in site numbers, extent, and assemblage sizes. The presence of few migrants at the outset is linked to a limited range of activities occurring, and may be seen by a restricted range of tool forms and other artefacts in sites from the pioneering stage. The archaeological record may therefore show the loss of certain tool types and manufacturing techniques during this initial stage of movement. Later sites should contain evidence for a broader range of activities, due to the presence of a wider spectrum of the community, and therefore should contain more diverse, as well as larger assemblages. These models allow rapid spread to occur, with long distance movements possible within a single lifespan. Therefore, the archaeological record may consist of sites appearing simultaneously across Europe. Moreover, the small population size and restricted activities of the pioneer phase could be virtually invisible in the archaeological record of the Pleistocene, and thus the second stage of substantial settlements would appear to represent the first migrants, already widely dispersed and in large numbers across Europe. It may be possible to differentiate circular and chain migration in the archaeological record by the presence of consistent seasonal indicators in circular migration sites; for example, shown by the stage of development of juvenile animal remains, or the presence of seasonally occurring structures such as antlers.

Step and local migration predict movement to occur over short distances, and therefore temporal patterning would not include the pioneer phase of movement restricted to a sub-set of the population. Thus, these models would be seen through the presence of the full range of activities throughout the movement. Moreover, initial site sizes will not necessarily be significantly smaller than later sites, as large and diverse groups of individuals will be prepared to undertake short distance movements. In addition, step and local migration will not include a phase of spatially restricted occupation in a small number of major nodes, because movement will occur within a familiar landscape that does not require exploration before dispersed settlement. Movement in these models would be substantially slower than in the chain or circular migration situations, and thus the archaeological record should preserve evidence of a gradual spread across Europe by a cline in the earliest dated sites. Despite these differences between the chain or circular migration models, and the local or step migration scenarios, all the models stress the importance of the social network in determining the destination.

Observations of human movements have also produced a series of predictions of the behavioural consequences, at both the source and destination of movements. The social isolation of migrants can result in novel behaviours, and strong expressions of identity. This may be seen in the archaeological record by the appearance of new types of artefact, especially strongly stylistic forms that visibly express identity. The strong social cohesion of migrant groups can also result in a uniformity of behaviours and expressions of identity. Therefore, strong similarities between artefacts in widely dispersed assemblages would reflect the presence of migrant chains. Migrants tend to be more dynamic than the individuals that remain behind, and therefore are likely to be able to rapidly adapt to the conditions at the destination. Their absence at the source can result in stagnation; hence, the archaeological record at the source is liable to be unchanged throughout the period of movement. However, chain migration involves return movement, which could trigger social change in the source area, resulting in a later appearance of the distinctive stylistic forms created by the migrants. It is possible that this situation could explain the later appearance of the Aurignacian in the Levant than in Europe.

Issues of interaction between migrants and indigenous populations are also raised in models of human movement. These problems can be dismissed in the case of the spread of the Lower Palaeolithic, but may be critical to the patterning of the initial Upper Palaeolithic in Europe. Migrants are often socially isolated, especially in a circular migration, and remain within a social group consisting entirely of other migrants from the same original area. Therefore, interaction and acculturation can be limited, and the migrants may be detected by the presence of culturally distinctive, and spatially separated and restricted communities. Aurignacian industries could fit these expectations. However, social isolation is not always the case, particularly in step or local migration when gradual infiltration of the indigenous community can occur. Chain migrants often intend to remain permanently at the destination, and therefore can be motivated to assimilate the indigenous culture. Thus, exchange of technologies and stylistic elements can occur, as has been suggested to explain the transitional industries, such as the Chatelperronian, in Europe (Mellars 1996).

Application of the biological and geographical models to the Pleistocene record of Europe.

These models provide a strong picture of the form that movement should take, and produce a consistent set of linkages to the archaeological record, that can allow their investigation in the European Pleistocene. Aspects of site distribution and size in time and space, and developments in the archaeological record have been highlighted as sources of information concerning the processes of movement. The hominid fossil record and the palaeoenvironmental and palaeogeographical record of Europe have also been revealed to be pertinent to the investigation of human movements. These features of the models could allow a stronger approach to population movement to be followed by archaeologists.

However, two major problems are produced by the use of biological and sociological models. Firstly, many aspects of the models contradict one another. For example, both behavioural innovation and stasis are predicted by both sets of models. Spatial patterning of occurrences during movement are modelled as clustered or dispersed, and as spreading linearly and gradually, or moving rapidly far beyond the core area. Ecological models suggest environmental similarities between source and destination, but also rapid adaptation and the occupation of empty niches in dissimilar communities. Therefore, the models create a set of data sources that are linked to migration or dispersal processes, but no consistent trends that always occur during movement.

Secondly, the models produce highly similar predictions concerning the archaeological record. Therefore, it is difficult to determine which set of processes produced the traces of movement preserved in the archaeological record. Biological and sociological models suggest a nodal pattern of movements, an exploratory phase preceding more major population flows, and behavioural changes among the migrants. Moreover, it is also difficult to discern which particular biological or sociological model applies to each event in the archaeological record of Pleistocene Europe. Chain and circular movement produce similar predictions, as do step or local migration. The features of local and step migration models are analogous to biological diffusion or a slow biological invasion. Jump dispersal results in patterning comparable to chain or circular migration, and is similar to some biological invasions. The models divide a continuum of processes, and therefore do not produce discrete markers in the archaeological record. Therefore, the archaeological assumption that the events of the Lower Palaeolithic can only be explained by biological processes, and the Upper Palaeolithic by social processes, cannot be upheld, as it is not possible to definitively divide the models when applied to archaeological events.

In conclusion, the models discussed provide useful criteria that could be applied to test the existing archaeological models of population movement in the European Pleistocene, as will be discussed in the following chapter. The models can be related to traces in the archaeological, palaeontological and environmental records, and suggest sources of data concerning movement processes that could be collected to investigate the archaeological approaches to movement. However, the problem of temporal resolution could undermine the possibility of detecting some aspects of the processes of movement. In addition, interaction and acculturation between incoming Upper Palaeolithic groups and indigenous Neanderthal populations in Europe could disguise the evidence for the processes that occurred during European colonisation. Nevertheless, the issues raised by these models demand investigation, in order to determine whether they can be usefully applied to the archaeological record, and whether archaeology can access issues of movement processes.

Chapter 3 : Analysis of the major archaeological models of hominid dispersal.

This chapter will present the models of four authors, Clive Gamble, Robert Foley, Nicholas Rolland and Eudald Carbonell, who were chosen because of their extensive work concerning hominid occupation of Europe. These writers have also been selected to represent a wide array of approaches to the archaeological record and processes of hominid movements. The authors chosen exemplify the full spectrum of theoretical and interpretive approaches to the Palaeolithic, ranging from the social models of Gamble to the evolutionary ecology of Foley, and incorporate ideas from archaeology, biogeography and evolutionary theory. The authors were also intended to show the variety of approaches to the use of data to construct models, and vary between the site-based style of Carbonell to the continental view of Rolland. The choice of these researchers was additionally intended to provide a range of views that would reveal the full breadth of narrative constructions of models of movement used in Palaeolithic research. These authors have constructed models concerning both the initial movement of hominids into Europe and the spread of early modern humans and the Upper Palaeolithic, allowing this analysis to tackle the issue of the differences in the treatment of the two major episodes of movement into Europe during the Pleistocene in archaeological literature.

The models will be presented in terms of the underlying aims and agenda of each author, their theoretical background, the narrative construction utilised, and their strengths and weaknesses. Narrative analysis will be used to provide insights into each author's organisation of the archaeological data to create the model, with respect to their manipulation of the data, grouping of material and approaches to change. The means by which the emplotment, argument and trope of these narrative constructions reinforce the theoretical viewpoint and ideology of the authors, and shape the predictions of the models will be highlighted. This chapter will begin with an outline of the narrative analysis approach used to examine each author's work. The models will then be presented and compared in terms of their narrative construction, relevance to the biogeographical, ecological and geographical models presented in the previous chapter, and their predictions with respect to the archaeological record.

Narrative Analysis.

Narrative structures underlie written academic discourse (White 1973). Factual accounts are unconsciously written as narratives, as "facts" or "events" are ordered into an understandable structured sequence (Mink 1978). The author arranges the material into a narrative in order to produce an account that is coherently argued, contains relevant information, and is easily comprehensible (Terrell 1990). The audience is able to make sense of a narrative because narrative forms are learnt from childhood and are thus familiar, providing a medium in which the communication of ideas from the author to the audience is facilitated (White 1978). Narratives are structured into a beginning, middle and ending, linked by a chain of events in the plot, implying relationships of cause and effect, and thus the importance of each of the elements to the eventual outcome becomes clear (Carr 1986). Narrative allows the movement back and forth in time to show how the initial events contribute to the conclusion, and how the ending is determined by earlier events, and hence creates meaning from seemingly unconnected events (Ricoeur 1980). The plot development is the structure familiar to the audience, and the meaning behind a sequence of events, or list of facts, is revealed when the story line is comprehended. Thus, any academic prose discourse that includes explanation and interpretation, rather than presentation of raw "data" can be considered to be a narrative. Narrative structure has been linked to the experience of reality (Carr 1986), and has been suggested to be central to the interpretative process as the means by which human consciousness can find meaning in lived experience (Mink 1978; White 1978, 1987).

Archaeological accounts of dispersal and colonisation in the Palaeolithic are structured as narratives, containing emplotted temporal sequences. The methods used to construct chronologies in archaeology can be seen to be linguistic devices. Data used to build temporality in archaeological writings may be produced by relative or absolute dating processes, but dates are selected to conform to the narrative being told. Relative dating depends on the building of sequential relationships between disparate objects in time and space, and has been a major aspect of archaeological research. However, archaeology has neglected the temporal aspect of its writings, by either the use of a spatial metaphor for time (Fabian 1983), or the use of atemporal models (Bailey 1983). Archaeological accounts contain "facts" or pieces of data emplotted into an argument presenting a description of past behaviour. Facts are selected for relevance and their ability to support arguments, emphasising some aspects of the data over the rest. The arrangement of facts into a plot with a coherent structure transforms the raw data into a narrative account. The facts can be judged to be accurate portrayals of the archaeological record, in terms of how well they correspond to the originally excavated material; however, the account produced cannot simply be compared against the archaeological record for accuracy, since interpretations of the facts have been made. Many interpretations of the same dataset may be possible, and thus the validity of the interpretation cannot be judged by factual accuracy alone; the strength of the account depends on the emplotment, argument and explanation by the author (White 1973).

Principles of narrative analysis have been established in the philosophy of history, and can be applied to archaeological writings. The structure of historical narratives, and a methodology for their analysis has been described by White (1973). White (1973), following (Frye 1957), argues that narratives contain four elements: emplotment, formal argument and ideological implication are the three explanatory codes, and underlying these codes are the conceptual strategies or tropes, which bring together the elements of the story.

Emplotment.

Emplotment is the structuring of facts into a coherent argument in the form of a story of a familiar kind. The facts become analogous to elements of fictional stories that form the plot (Propp 1968), moving the action through time towards the conclusion (Carr 1986). The types of plot defined by White (1973) are divided by the degree of control and choice the characters have over the outcome of their actions and the events that they experience. An account may be generally cast in one mode, but include episodes of another mode. The four archetypal plot structures are:

1. Romance: the hero transcends the world of experience, is victorious over situations presented, and is finally liberated. New forces or conditions in the world of experience are possible.
2. Comedy: partial liberation from fate occurs when the hero is reconciled to the world. The elements of the world are harmonisable, and the conflicts of the story result in positive outcomes. Novel conditions or forces may be produced.
3. Tragedy: the hero battles against fate and fails. The reconciliation at the end of tragedy is the resigned acceptance of fate. Forces and conditions of the world are fixed, and beyond the control of the protagonists.
4. Satire: the opposite of Romance, the hero is a captive of the world, unable to overcome the challenges encountered, and is unable to escape fate, or become reconciled to it. The structure and forces of the world are unchangeable.

Formal argument.

Formal argument uses principles of causal relationships to explain the sequence of emplotted events, as a process of development. The formal argument justifies the telling of the story as a particular kind of plot. A general rule is used to predict what should happen, and the events are deduced from this statement of expectation. Therefore, the sequence of events is explained in terms of predicted outcomes of the scenarios of the plot. This level of explanation is a nomological-deductive argument. The kinds of generalisations used at this level of explanation are debateable. White defines four paradigms of the form that formal argument can take, divided by the level of dispersion or integration of the elements. These modes of argument are:

1. Formist: aims at the identification of the unique attributes of the objects under discussion. Formism is the most dispersed mode of argument, involving little attempt at generalisation. Formism does not address causality or diachronic change; it is simply descriptive and classificatory.
2. Organicist: aims to be more integrative and reductive than Formism. Organicist arguments attempt to show how elements form part of a synthetic whole, in a microcosmic-macrocosmic relationship, as an integrated entity is shown to appear out of apparently dispersed elements. The focus is on

integration rather than depiction of elements. Organicist arguments reject restrictive laws of causation, in favour of human creativity and freedom. Organicist arguments include underlying principles, or essences, that link together the elements into a whole, hence the elements mirror the whole, and the stages of the process prefigure the outcome of the narrative. Organicist views are able to be diachronic or synchronic.

3. Mechanistic: aims are integrative, like Organicist arguments, but are reductive rather than synthetic. Events and elements of the account are seen as determined by generalised laws beyond the control of the participants. Elements are treated as forming part-part relationships rather than the part-whole relationships of Organicist views. These relationships are causes and effects. Mechanistic explanation focuses on the search for ahistorical laws to explain events. Mechanistic arguments are diachronic or synchronic.
4. Contextualism: aims to be less reductive and integrative than Organicist or Mechanistic views, but is less dispersed and impressionistic than Formist arguments. Events are explained by their context and functional interrelationships, rather than simply catalogued as in Formist accounts. The causality invoked in Contextualist arguments is specific to the events under investigation, and the generalised laws of Organicist and Mechanistic views are denied. Contextualism is inherently synchronic.

Ideological implications.

White claims that each of these forms of argument is equally epistemologically valid. The modes of formal argument are paradigms of the form that "correct" explanation is believed to take. The choice of the model of argument and explanation reflects the author's view of the form that investigation into human actions and society must take, and thus the choice of formal argument is an ethical and ideological decision. Representations of the past necessarily include a picture of the present, the nature of society, and the manner in which change occurs, because the past is continuous with the present. These ideological implications implicit in narrative are the third form of explanatory code. The ideological implications are divided according to the nature of change and the placement of utopia in time relative to the present. All the ideological forms admit that change is inevitable, but vary over its nature and desirability. The four ideological positions of academic discourse listed by White (1973) are:

1. Conservative: change is undesirable and should be gradual, at a natural rhythm. Society at present is the most desirable state to be reasonably hoped for.
2. Liberal: change involves limited adjustment, at the social rate of debate, but is more acceptable and rapid than in Conservatism. Present society is sound and could only be improved by minor changes. These improvements will produce utopia in the distant future.
3. Radical: society would benefit from major structural changes. These changes can happen very rapidly, but need to be actively encouraged to overcome the inertia of the present system. The ideal society can be achieved in the imminent future by revolution.
4. Anarchist: society should be abolished entirely. Cataclysmic change is immediately possible. Utopia is situated in the distant past, and can be reached at any time by rejecting the current social system.

Relationships between the narrative elements.

The three types of interpretative strategies are correlated with one another as shown in Table 3.1:

Mode of Emplotment	Mode of Formal Argument	Mode of Ideological Implication
Romance	Formist	Anarchist
Comedy	Organicist	Conservative
Tragedy	Mechanistic	Radical
Satire	Contextualist	Liberal

Table 3.1. The relationships between the mode of emplotment, formal argument and ideological implication.

These correlations are formed by the attitude towards fate of the protagonists. Comedy involves reconciliation to the nature of the world, which can be seen in Conservative acceptance of the current status quo, and Organicist optimism over human abilities. Tragic plots contain unavoidable and pervasive fate, analogous to the generalised laws of Mechanistic explanation and Radical views of the laws of history, for example Marxist views of historical change. Romantic plots allow the actor to triumph over adversity and reach an ultimate goal, as aimed for by Anarchists. The Formist emphasis on uniqueness of events and elements parallels the Anarchist ideas of individuality. Satire emphasises powerlessness and the inability to effect changes in a hostile world. This attitude is seen in Liberal ideology that claims that large-scale change is impossible and the goal of utopia is far beyond the reach of individuals in the present. Contextualists, likewise, make no claims to be able to generalise principles into patterns of history, or achieve broad understanding of the processes of history. However, the sign of a great work of narrative is to combine these elements in novel and unexpected ways, thus highlighting the possibility of alternative strategies of interpretation, and therefore challenging the reader and producing new understandings.

Linguistic tropes.

Underlying the three modes of interpretative strategies are linguistic tropes. White (1978) states that tropes prefigure perception into the modes of relationships seen in the interpretative strategies. The unfamiliar is compared to known experiences and is given meaning by its similarities and dissimilarities to comprehensible objects and events (Tilley 1999). The means by which these comparisons are made are those seen in poetic language. The concepts used to identify objects that demand explanation, and the kinds of relationships found between those objects, are the tropes of verbal representation. Through the construction of relationships of similarity and difference between the elements in an account, the tropes provide a linking structure relating the elements to one another. White (1973) lists the linguistic tropes underlying interpretation as being:

1. Metaphor: displays a similarity in a difference, and a difference in a similarity. Meaning is produced by equivalence or identity. Metaphors produce an analogy or simile. The comparison is between seemingly unrelated objects or events. Metaphor is a creative act, revealing the similarities and differences between the two objects under comparison. Metaphor is essentially

representational. Metaphor is the linguistic mode underlying Formist arguments that focus on description and classification.

2. Metonymy: the whole is reduced to a part. The meaning of the whole is taken to be present in all of its parts. Metonymy is reductionist. The name or meaning of a part of an object is taken to represent the whole object. Metonymy underlies the part-part relationships and search for laws linking elements into causes and effects of Mechanistic arguments.
3. Synecdoche: the parts are integrated into a whole. Individual phenomena are then understood only as part of the constructed whole. The whole is qualitatively identical to the parts that make it, and the parts symbolise a quality that is present in the whole. Synecdoche is integrative, and moves from parts to the whole, therefore it can be considered to structure Organicist explanations concerned with essences linking events.
4. Irony: The relationships constructed by metaphor, metonymy or synecdoche are undermined. Irony is negational. Irony reveals the problems of language itself by being sceptically aware of the limitations of linguistic constructs. Ironic statements often use absurdities and paradoxes. Irony sanctions Satire and Contextualism.

The tropes are related to the interpretive strategies as shown in Table 3.2:

Mode of Emplotment	Mode of Formal Argument	Mode of Ideological Implication	Trope
Romance	Formist	Anarchist	Metaphor
Comedy	Organicist	Conservative	Synecdoche
Tragedy	Mechanistic	Radical	Metonymy
Satire	Contextualist	Liberal	Irony

Table 3.2. The relationships between the mode of emplotment, formal argument, ideological implication and trope.

The analysis of the writings of the four authors will be presented in the following sections, using the narrative analysis methodology described.

Gamble's Dispersal Narratives.

Aims and agenda.

During the 1980s Gamble's writing focused on the themes of information and society, their relationship to the environment, and the means by which these can be investigated. The specific aims of Gamble's work were:

- to address social evolution in the Pleistocene (Gamble 1982);
- to document variation in the Palaeolithic record which can be understood as adaptation to environmental conditions (Gamble 1984);
- to study the ecology of colonisation (Gamble 1987);
- to provide an independent framework against which variation in behaviour can be measured, using the constants of latitude, longitude and relief to predict resource distribution (Gamble 1984) and thus escape the constraints of culture-history (Gamble 1986); and hence to avoid problems of regional research histories and paradigms (Gamble 1986).

Gamble's work in the early 1990s continued to focus on information and social behaviour, with the addition of exaptation as the explanation of change, as the two underlying themes. The key aims in these writings are:

- to show that exaptation rather than adaptation allowed global colonisation (Gamble 1993b);
- to answer why humans are the only species with a near global distribution (Gamble 1993b);
- to show that colonisation is the key to understanding how humanity developed (Gamble 1993b);
- to show that colonisation occurred because humans have purpose (Gamble 1993b).

The themes of the need for a social approach to the Palaeolithic and a universal methodology continue in Gamble's writing from the late 1990s. Additional themes appearing at this stage are the focus on a network approach to societies, and the manner in which individuals perceive the environment and thence build their societies. Gamble's specific aims during this period are:

- to propose a general model of hunter-gatherer colonisation (Housley *et al.* 1997);
- to show that it is a universal of modern human behaviour to be able to colonise areas of wilderness (Gamble 2000);
- to examine the environmental issues surrounding the earliest occupation of Europe (Gamble 1995c);
- to investigate hominid dispersal via the relationship between biological and cultural evolution in the context of geographical expansion (Gamble 2001);
- to show that the "release from proximity" in the construction of networks and the exertion of power and influence is the key development in prehistory (Gamble 1998a).

Theoretical view.

Gamble makes use of uniformitarian principles to interpret the archaeological record throughout his work. During the 1980s he followed the tenets of middle range theory, using ethnographic and ecological observations to justify his models. The Processual approach adhered to in his early models is reflected in the focus on environmental influences on the patterning and timing of dispersal. Culture is viewed as an adaptation to the environment, and colonisation is limited by the resources available and the hominids' ability to cope with the distribution of the resources. However, Gamble has also been concerned with social aspects of the Palaeolithic since his earliest work. Ethnographic analogies were used to access social life, providing a link between behaviour in the present and inferred behaviour in the past. The Processual viewpoint is also seen in his attempts to generate universally applicable models of dispersal.

In Gamble's later work he attempts to address more explicitly the social aspects of Palaeolithic life, but retains an interest in the environmental aspects of dispersal, thus much of his work becomes focused on the means by which the environment and society can be linked. This is seen in his interest in the manner in which the environment is interacted with, and constructed by individuals (Gamble 1999). However, Gamble (1998a) tries to retain a general, universal model of hominid environmental interactions, putting forward a model of the local hominid network and social landscape (see below), based on ethnographic observations that are extrapolated into the Palaeolithic, in a similar manner to his earlier work. Although interested in different themes, he can thus be seen to continue to use interpretive principles similar to those of the middle range theory followed during the 1980s. Recently, he advocated moving between ecological and geological timescales, and between high and low resolution archaeological remains, in order to reconstruct behaviours in the Palaeolithic (Gamble 1996b, 1999). This process is used to bring together different scales and resolutions of data to build an overarching model of Palaeolithic life, in a strongly integrative approach, linking together all available data.

Gamble views social life as central to all aspects of behaviour throughout prehistory, focusing on internal, social explanations of developments that allow hominids to expand into new territory. In his early strongly Processual phase, variance in the archaeological record is explained as the result of selective pressures of the environment mediated by society (Gamble 1986). However, change is always viewed as an internally driven process, society changes itself to better match the demands of the environment, and therefore is able to expand into previously uninhabitable areas. During the late 1990s he suggests that the environment can be seen as part of the social world, since both the social and physical world of an individual are constructed through perception (Gamble 1999). Thus, Gamble internalises the external environment, leaving social behaviour as the only element of any importance in hominid life. This attempt to link the environment to social life is a means by which social concerns attain supremacy over environmental or biological explanation.

Gamble's (1993b) explanation of behavioural change and global colonisation by exaptation rather than adaptation relates to this social agenda. Exaptation is the co-option of existing capacities and behaviours for a novel purpose. To support exaptation as the cause of colonisation he argues that colonisation does not coincide with biological speciation, technological development, or cognitive changes, therefore it can only be explained by a change in social behaviour. Colonisation cannot be explained by the environment alone, as climatic conditions have undergone many cycles but colonisation did not occur in every period of opportunity (Gamble 1993b). He further contends that the physical barriers to Europe were highly permeable, thus social behaviours rather than the external environment must have been the constraint (Gamble 1995c). To provide further support for social causes of colonisation he also argues that colonisation is an event, related to behavioural developments, not a continuous process, hence social behaviour must be able to support rapid and large scale expansion. As a K-selected species, hominids are claimed to have depended on making well informed decisions about relocating, thus sociality and intelligence are linked to colonisation (Gamble 1993b). Therefore, he is able to put forward a claim that colonisation must be purposive.

A further stated aim of Gamble's work is to write a single prehistory for all humanity, highlighting the commonalities in all periods of the Palaeolithic. This aim is related to the desire to write a social archaeology of the Palaeolithic, as it is social life that is emphasised to provide a link between all periods of human existence. Demonstrating that early Palaeolithic hominids possessed complex social worlds would fulfil his agenda of creating a method of examining the Palaeolithic record in a unitary fashion, by providing social life and social explanation as common to all periods and therefore making it possible to treat all periods of the Palaeolithic with the same models.

However, Gamble persistently creates a strong dichotomy between the Upper Palaeolithic and earlier material. He divides the archaeological record into two major categories, the earlier Palaeolithic corresponds to the traditionally defined Lower and Middle Palaeolithic, and the later Palaeolithic is the renamed Upper Palaeolithic (Gamble 1986). This binary division is found throughout his writings, with a major boundary in behaviour being emphasised at the division between the Middle and Upper Palaeolithic, and behavioural continuity reinforced within the two categories. However, during the 1990s he uses the terms "Pioneers" (Gamble 1993b), "transitional" phase (Gamble 1999), or "late Middle Palaeolithic" (Gamble and Roebroeks 1999) to attempt to break down the binary division constructed in his earlier work. The later Middle Palaeolithic is shown to have significant behavioural developments after 70 Kyr BP, and to be more similar to the Upper Palaeolithic than previously portrayed. Nevertheless, a binary division in the form of the "local hominid network" and the "social landscape" (Gamble 1998a) is maintained despite his attempts to show behavioural continuity, and coincides with the Middle-Upper Palaeolithic transition, mirroring the previous divisions. Hence, despite attempting to unify the Palaeolithic, he retains the established divisions and reserves "modernity" and "humanity" for the Upper Palaeolithic.

Models of dispersal.

The regional environmental model of the 1980s.

Gamble attributes the ability to occupy an environment to having the appropriate social behaviours necessary to cope with the level of mobility and group fission and fusion demanded seasonally, as well as networks to support sufficient information flow. Group fission and fusion, and high levels of personal mobility are argued to be necessary to cope with highly seasonal environments (Gamble 1993b). Specialised environments, in terms of low resource diversity, such as glacial northern Europe, would demand spatially extensive social networks to decrease risks of local resource failure, which requires good communications (Gamble 1980, 1982). Therefore, global colonisation depended on improvements in communications. Information transmission via stylistic encoding would be required in spatially extensive and large social systems (Gamble 1982), and thus should be associated with specialised environments. These alliance networks for information exchange and resource buffering should be seen through exchanges and raw material transfers, as well as shared stylistic elements (Gamble 1983).

Gamble (1993b) proposes that population continuity in changing environments shows that social organisation had overcome these environmental problems; therefore settlement continuity reflects the presence of a network, and discontinuities show its absence (Gamble 1983). Upper Palaeolithic occupation should be more continuous than earlier settlement, due to the presence of more developed networks. He (1993b) argues that "modern" behaviour reflects this shift from local self-sufficiency to social storage as a risk buffer. Earlier Palaeolithic settlement should ebb and flow with climate due to a lack of sufficient social networks to overcome environmental fluctuations, especially in the higher latitudes with more specialised ecosystems and greater susceptibility to climatic perturbations (Gamble 1983). He (1986, 1987) contends that presence in the archaeological record implies successful adaptation, as failed colonisation will not be archaeologically visible; therefore, the volume of finds in a region reflects the level of environmental adaptation (Gamble 1984); and can be used to infer the population density, which in turn reflects adaptation to the environment (Gamble 1995c).

The colonisation of Europe in the Lower Palaeolithic is linked by Gamble (1999) to changes in the climatic cycles of the Pleistocene, creating environments more suited to hominid occupation, thus behavioural developments were not an aspect of range expansion. Delay in occupation of Europe was caused by the lack of matching between the long term biological and social strategies of the hominids, and the wavelength and frequency of environmental change (Gamble 1987). The resources to support hominids in Europe were always present, although an increase in herbivore diversity and a decrease in carnivores in the early Middle Pleistocene may have facilitated colonisation (Gamble 1999). However, changes in hominid social behaviour were needed to match the distribution of resources and diachronic changes of the environment, before colonisation could occur (Gamble 1986). Lower Palaeolithic groups are portrayed as autonomous breeding units with no extensive social networks, and therefore depended on high mobility within the range to buffer risks (Gamble 1987, 1995c). The lack of appropriate social networks constrained the range of environments in which these hominids could sustain occupation, due to the need for resources to be distributed at a scale that allowed personal mobility to access all necessary resources (Gamble 1987, 1995c). Therefore, Lower Palaeolithic occupation of Europe is expected to be restricted to low cost and high predictability areas of resources, such as river valleys (Gamble 1987) during intermediate conditions, with favourable and low cost resource distribution (Gamble 1986).

Hominid occupation of Europe occurred against a backdrop of changing frequency and amplitude of climatic cycles, which resulted in the dominance of conditions intermediate between full glacial and interglacial, with high faunal diversity and a mosaic structure of resources (Gamble 1995c). Gamble (1995b) predicts selection to result in hominids becoming more adapted to the intermediate conditions than extreme conditions due to the longer duration of these environments. These intermediate environments are argued to have possessed habitats and resources distributed in a fashion suitable for Lower Palaeolithic hominids dependent on personal mobility to exploit resources. Therefore, hominids are expected to have been absent from fully interglacial forests and harsh glacial tundra/steppe, as these are specialised homogenous environments. The preferred environment of Middle Pleistocene hominids is argued to be open woodlands with a mosaic structure of resources (Gamble 1995c). Furthermore, he suggests that the environments occupied by hominids were resilient in terms of having short recolonisation distances, therefore when local fluctuations in resources occurred replacement was rapid, and risks to the hominid population were minimised, allowing rapid recolonisation (Gamble 1995c).

Gamble (1984, 1986) uses a generalised model of Pleistocene environments in Europe. He divides Europe into nine regions, shown in Figure 3.1, based on latitude, longitude and relief. Culture is viewed as an adaptation, and thus behaviour is predicted to vary with the distribution and organisation of energy in the environment, and should vary between the nine regions of Europe (Gamble 1984, 1986). However, Gamble predicts that the only differences to be seen in the Lower and Middle Palaeolithic record of each of his regions will be variations in population density and continuity of occupation, regionally specific behaviours are restricted to the Upper Palaeolithic and later.

Seasonality is argued to be the major constraint to hominid colonisation, as it requires a high level of mobility and flexible group structure through the year. Gamble (1995b) explains the lack of Lower Palaeolithic occupation of Northeast Europe by the greater levels of seasonality resulting from continentality compared to the west, which produced spatial structuring of resources with greater distances between patches, compared to oceanic environments. He proposes that hominid social behaviour was not sufficient to cope with the extensive social networks required by the spatially extensive distribution of resources in Northeast Europe during the Middle Pleistocene. He (1986) suggests that the other eight regions of Europe were colonised simultaneously, as they form regions of complementary resources, thus hominids would have been dependent on Mediterranean, Southern and Northern resources.

Figure 3.1. Map showing the regions of Europe used in Gamble's regional environmental model. (After Gamble 1986)

Gamble's (1995b) argument that the need for complementary environments would require the simultaneous occupation of most regions of Europe leads him to support the short chronology for European colonisation between 600-500 Kyr BP. The short chronology rejects the possibility of an early ephemeral occupation of the Mediterranean and the south before adaptation to the conditions in Europe and movement into the north. The short chronology is upheld by the rejection of the possibility of a low intensity, non-handaxe phase of occupation, denial of the possibility of typological dating (Gamble 1998b), and refusal to allow variation within Lower Palaeolithic assemblages to be meaningful. Gamble (1995b, 1998a) favours the short chronology because it supports his theoretical view that change occurs by exaptation and colonisation used existing behaviours and physical traits. A longer chronology would allow time for adaptation to conditions in Europe before occupation became more substantial at 500 Kyr BP.

Modifications to the regional environmental model.

The regional model put forward in the 1980s and early 1990s is replaced by a biome based model in the late 1990s. Colonisation of Eurasia is predicted to have followed habitat types or biomes initially, with infilling of areas later (Gamble 1998b). The habitat first colonised would have been the grasslands, since these are the most similar to the African habitats occupied by early hominids, following Foley's (1987b) proposals. Behavioural developments through exaptation would then allow the colonisation of further habitat types. This model suggests that Southern Europe would be occupied substantially earlier than the north, accommodating recent evidence for late Early Pleistocene and early Middle Pleistocene sites in Southern and Mediterranean Europe, but not further north.

The "release from proximity" model of the late 1990s.

Gamble's model of the environment being key to colonisation, in the context of social behaviour, has resulted in his model of "local hominid networks" and "social landscapes" (Gamble 1998a). This model integrates the physical environment into social behaviour by considering how the environment is experienced, interacted with, and produced through individuals' perception. Society is argued to be a network of personal networks. It is the increasing size of personal networks, and the release from the constraints of building relationships by face-to-face interactions during the Palaeolithic that allows global colonisation.

Gamble (1998a) identifies four levels of social network, with recurrent demographic sizes. The intimate network contains between three and seven people, who are in regular contact with the individual at the centre of the network, and is built using predominantly emotional resources, to create long lasting relationships. The effective network contains roughly twenty-five people, and is constructed with more material than emotional resources. The intimate and effective networks are built and maintained by face-to-face contacts using bodily resources as a reference for power, learning and imitation, and therefore do not require symbolic reinforcement since the information and memory requirements of individuals are relatively low. The third level is the extended network, consisting of distant friends and relatives, who may be rarely in personal contact. This network is mainly built and maintained with symbolic resources, as relationships are negotiated *in absentia* between large numbers of individuals. The key difference between the extended network and the intimate and effective networks is that artefacts retain their significance and associations with individuals despite physical separation from the actions of their manufacture and use, and therefore can be used to negotiate relationships at a distance. The use of these symbolic resources results in individuals' ability to maintain their networks despite prolonged physical absence from other members of the group. The limits to the size of these networks relate to temporal and cognitive constraints on the ability to maintain relationships with network partners (Gamble 1999). The fourth level is the global network, containing all strangers with whom an individual has no links. However, strangers can be assimilated into the extended network by negotiation of a relationship.

The local hominid network is common to all hominids throughout history and prehistory (Gamble 1995b, 1996a), and is based on the intimate and effective networks (Gamble 1998a), forming the spatial component of these social negotiations (Gamble 1996a). Within the local hominid network social life is based on the exclusion of individuals from other networks (Gamble 1995b). The local hominid network encompasses the physical and social environment of individual hominids, including other hominids, non-hominid competitors and resources (Gamble 1993a, 1996a). The spatial area covered by the local hominid network is the home range of the individual, within which all resources are local and familiar; thus, behaviours are routinised using generic skills (Gamble 1993a, 1996b, 1998b). In a local hominid network spatial extension is limited since movement beyond its spatial boundaries results in social isolation due to the lack of extensive networks (Gamble 1996a). The importance of emotional ties and the intimate network in the Lower Palaeolithic is argued to have limited innovation and created redundancy in technological acts (Gamble 1999). Gamble focuses on increased raw material transfer distances in the late Middle Palaeolithic as evidence for larger social networks, and an intensification of the effective over the intimate network, providing more opportunities for variation (Gamble 1998a, 1999).

The social landscape contains local hominid networks linked together by negotiation (Gamble 1995b). These societies can be inclusive as well as exclusive, and contain distant relatives and strangers in an extended network (Gamble 1993a, 1996a). The social landscape is defined by the "other" of the global network of complete strangers (Gamble 1998a). In the social landscape objects become associated with people, and are therefore symbolic. Locations and routes are also linked to individuals and may be furnished with objects imbued with symbolic associations, creating a place holding these associations and meanings for the actors using it (Gamble 1995b, 1996a, 1998a). The use of material culture in social network negotiations results in regional patterning of styles of objects and a substantial increase in variation among archaeological assemblages (Gamble 1996a). These networks are spatially extensive and include potentially hundreds of individuals (Gamble 1998a).

The ability to build networks without the constraint of face-to-face negotiations allows the colonisation of environments that demand flexible social groupings, due to unpredictable resource distribution in time and space, because relationships can be maintained despite physical separation. Therefore, Gamble argues that global colonisation is the by-product of the social landscape. Furthermore, social landscapes allow frequent dispersals and decrease the chances of local extinctions, reducing population ebb and flow related to environmental fluctuations (Gamble 2001). Social landscapes are exclusive to modern humans and appeared abruptly at around 50 Kyr BP, explaining the differences between the Middle and Upper Palaeolithic (Gamble 1993a). These developments required individuals to be able to remember large volumes of information about members of the extensive networks, therefore a simplification of information used in negotiations, in order to reduce ambiguity, appeared in the form of symbols. Gamble (1996a) argues that dispersal in a social landscape is purposive and relates to asymmetries in knowledge and power.

The local hominid network and social landscape can be spatially defined by studying the distribution and transfers of materials (Gamble 1995b). Local hominid networks are characterised by transfers of non-symbolic materials over short distances since procurement is direct and takes place within the home range, as part of the routines of social life (Gamble 1993a). The materials moved furthest within the local hominid network will be in the later stages of the manufacturing sequence (Gamble 1996a). Gamble (1993a) suggests an upper limit to local movements of materials of between 80-100 Km, but with a more usual limit of roughly 40 Km, with the variation caused by ecological conditions. Social landscapes will have long and short range transfers of materials, and may also have transfers of symbolically and socially significant materials such as beads, ornaments and jewellery, because materials will be moved by exchange as well as direct procurement (Gamble 1993a). The social landscape is expected to result in a change in organisation of procurement of raw materials, with movements beyond the local range into the regional scale of extended networks as individuals began to be able to exert power at a distance (Gamble 1993a, 1999).

Narrative analysis.

Gamble has emplotted the majority of his material as a Comedy. Hominids are shown to be subject to the forces of the world, the environment, but are able to bring about change and generate new conditions for existence by their social behaviour. The focus on behaviour and the active construction of societies, within the constrictions of the environment reinforces the Comic plot. Moreover, Gamble (1998b) states that it is the ability to adjust behaviour to novel circumstances and create the environment in which to live that is the distinguishing feature of hominids, allowing eventual global colonisation. He explicitly links humanity and the ability to create new conditions within environmental constraints, which is at the heart of Comic emplotment. However, during the 1980s Gamble portrays pre-modern hominids as less capable of change and control over their destiny, as the environment constrained the extent of colonisation, and influenced behaviour in the occupied regions, creating a Tragedy.

Gamble uses one major strategy to organise his material, the integration of material into major categories. The categories constructed are then linked together by underlying commonalities, for example the presence of universal personal networks in both the local hominid network and the social landscape (Gamble 1998a). His argument is therefore predominantly Organicist, integrating together the evidence by using sociality and humanity as underlying all behaviours. For example, networks are argued to link all individuals and the environment. This Organicist argumentation reflects his use of Synecdoche, binding together parts to the whole via social behaviour as a linking essence. The emphasis on human ability to make choices within environmental constraints shows a rejection of Mechanistic environmental determination hinted at in the Tragic plot of the early model, in favour of Organicist reasoning. Nevertheless, the tendency to try to search for universal patterns of behaviour is seen in Gamble's later work, when he explicitly attempts to search for general patterns of colonisation throughout prehistory (Housley *et al.* 1997).

Organicist argument and Comic plot are associated with a denial of significant diachronic change, creating a Conservative ideology. The Conservative concern of downplaying the importance of change results in Gamble portraying the archaeological record as having long periods of stasis, and then problematic radical change at the interface between his periods. This creates the crises of change at the division between his categories, and the emphasis on the underlying sameness of hominid behaviour, since radical change contradicts Conservative ideology. Gamble (1986) partially overcomes this contradiction of stasis interrupted by episodes of radical change by sub-dividing the archaeological record to remove the revolutionary change at the Middle-Upper Palaeolithic transition by emphasising behavioural continuities on either side of the transition. This is achieved by reinstating the Lower and Middle Palaeolithic and dividing the Middle and Upper Palaeolithic into an early and a late phase, with the early Upper Palaeolithic showing less distinct chronological and regional patterning than later industries, thus being more similar to the late Middle Palaeolithic, which possesses specific skills associated with an internal dynamism similar to that of the Upper Palaeolithic. Gamble can therefore be considered to have abandoned Conservatism, and to be taking a Liberal attitude towards change, with developments happening slowly at a social pace. Liberalism overcomes the problem of the need to deny change in a Conservative agenda, and allows him to focus on social explanations. The idea of exaptation as an explanation of change (Gamble 1993b) can be linked to the Liberal agenda of Gamble's writing, since it shows change to occur through the co-option of existing behaviours, resulting in gradual developments caused by social dynamics.

Gamble's early models at times use Mechanistic reasoning, and a Tragic plot, which would be expected to result in a Radical approach to change. However, he rejects Radicalism as it requires external causes of change, which cannot be accommodated in his view of social behaviour underlying all change. Thus, he attempts to follow a Liberal ideology. However, the attempt to use social behaviour to integrate all aspects of the archaeological record and environment is a key agenda in Gamble's work, and hence he can be seen to be writing in a Synecdochic trope. This exercise in integration requires that the Satire and Contextualism associated with Liberal ideology be replaced with Organicist argument and Comic plot. However, this approach leads to further problems since a high level of integration and linkage between all elements results in all aspects of the archaeological record being shown to be similar and thus no change occurs, creating the Conservative approach. The changes in Gamble's arguments over time are the result of attempting to resolve the contradictions and problems in dealing with the nature of change in a Conservative ideology, and the conflict between his desire for both Liberalism and Organicist integration.

Throughout his work, Gamble aims to demonstrate that social developments are the key to understanding all aspects of the Palaeolithic. The social, Liberal stance of his work should be associated with Satirical emplotment, Contextualist reasoning and an Ironic trope. However, his second concern and motivation is to integrate the social and the environmental, in order to produce a model that deals with all aspects of hominid life. Integration of material into a general approach cannot be accommodated in a Contextualist argument, hence he turns to Organicist reasoning as an attempt to move beyond individual incidents and circumstances, and formulate a universally applicable model. The concern with universalism and creating a model of colonisation for the whole of prehistory could be viewed as the result of Gamble's academic background in the Processual approach to archaeological reasoning during the 1960s and 1970s. This background of a scientific, universal approach to argument and ideology is seen in the greater tendency in his early work to use Mechanistic argumentation and emplot the narrative as a Tragedy. The increasing focus on agency and individuals in Gamble's later work is the outcome of the attempt to universalise interpretation and argumentation whilst concentrating on social behaviour.

Strengths and weaknesses of the model.

The theoretical viewpoint.

Gamble's theoretical stance leads him to focus on social and behavioural explanations of the timing and patterning of hominid colonisation. This is admirable as an attempt to add social behaviour to the evolutionary and ecological approaches traditionally used in the study of the Palaeolithic. However, he concentrates almost exclusively on social behaviour as the explanation of all aspects of the Palaeolithic, including colonisation. This approach is limited since the Pleistocene climatic record clearly shows major fluctuations that would have induced large-scale environmental changes. Therefore, it seems to be a significant omission to dismiss environmental change as having had no impact of any importance on hominid dispersal. For example, Gamble (1993b) dismisses environmental explanations of colonisation by claiming that the physical and biological barriers to Europe were highly permeable, thus social behaviour must have been the constraint preventing earlier occupation of Europe. The permeability of the barriers needs to be established before this claim can be sustained.

Gamble's concentration on social explanations, and exaptation rather than adaptation, also leads him to attempt to deny that biological or evolutionary developments could be linked to increasing colonisation ability. Gamble (1993b) admits that biological changes in hominids, such as increased body size, bipedalism, and increasing generalism, facilitated colonisation, but insists that these were not its cause. However, large body size and generalism are traits commonly seen in wide ranging species, since they free the species from resource specificity, and improve tolerance of a broad range of climates. These traits appeared during the evolution of the genus *Homo*, as early members of *Homo erectus/ergaster* are claimed to have limb proportions and body mass more similar to modern humans than apes (Ruff and Walker 1993). Archaeological evidence suggests that increased carnivory also appeared in hominids during the Plio-Pleistocene (Bunn and Kroll 1986). This development would have broadened the niche of members of the genus *Homo*; therefore, these hominids can be considered more generalist than their predecessors. Moreover, carnivores are better dispersers than herbivores because they inhabit larger ranges and are less tied to particular habitats (Mace *et al.* 1983). Thus, biological changes are seen in the hominid fossil and archaeological record, which suggest that hominids may have become physically pre-adapted for dispersal.

Gamble (1993b) argues that colonisation is the result of exaptation and social developments because it does not coincide with biological speciation, technological developments or cognitive changes. However, his use of extremely broad categories to classify both hominids and archaeological assemblages obscures any biological or technical developments within the divisions he employs. Thus, he prefigures the data to fit the model of social explanations of all developments, by removing variation in any other aspect of the archaeological and environmental records; for example, his denial of any technological developments before the late Middle Palaeolithic, despite substantial changes occurring, such as the appearance of Levallois technology. It is necessary to test at a finer resolution, whether technological or biological novelties are associated with colonisation. This denial of change within the broad categories used by Gamble reflects his Conservative ideology and Organicist argumentation.

Gamble (1993b) argues that colonisation is a purposive event and not an ongoing process, and therefore must be explained by social behaviour. However, it is extremely likely that colonisation in the Pleistocene was a lengthy process, as both ecological and ethnographic observations of movements show that large-scale population shifts are processes, not events (Williamson 1996; Castles and Miller 1993). He does not explain how colonisation could be purposive whilst also being a brief event and leading towards a previously unoccupied, and therefore unknown destination. Without knowledge of the destination the colonisers could not have been purposefully setting out to colonise, and if the movement was a brief event no time would have been available to gain knowledge of the destination and communicate it to further migrants. The social networks suggested by Gamble (1986, 1996a) to have allowed occupation of marginal environments would result in a shifting population within the landscape, responding to environmental conditions. This situation could result in colonisation, but as a process based on knowledge transfers between individuals within a landscape which was familiar by previous experience. The act of leaving the known territory at the origin could be purposive, but the outcome of this action, the colonisation of a continent, could not have been known and therefore could not be purposive under the circumstances propounded by Gamble.

Gamble aims to create a unified model of colonisation applicable to the whole of prehistory. However, throughout his work he maintains a strong distinction between the modern Upper Palaeolithic and the archaic Lower and Middle Palaeolithic, by prefiguring the differences between the earlier and later Palaeolithic. The differences in material culture are focused upon and continuity is downplayed by portraying the Upper Palaeolithic as showing chronological developments, regionally distinctive industries, and more visible archaeological remains than earlier periods. Similarities in the archaeological record are interpreted as differences between the periods, for example the discarding of unbroken material in the earlier Palaeolithic is considered as expedient behaviour, whereas the same patterning in the Upper Palaeolithic is described as caching of tools, and thus is evidence of curation and planning. This is also seen in the interpretation of raw material transfers in the earlier Palaeolithic as simply reflecting home ranges, whereas in the Upper Palaeolithic transfers were produced by exchange among social networks. Gamble (1986) also claims that the interdigitation of industries in the early Upper Palaeolithic reflects different industrial groupings replacing one another in time and space, whereas the same phenomenon in the earlier Palaeolithic represents variation within a single industry. Gamble is thus treating the material in an inconsistent manner, in order to reinforce his models.

The regional environmental model.

Gamble (1986) proposes that areas with highly specialised ecosystems would have been uninhabitable to Lower Palaeolithic hominids as they required group fission and fusion and strong social support networks, whereas Upper Palaeolithic groups had the social capacity to cope with these environments. This is a useful suggestion since landscape physiognomy and resource patch distribution have been observed to affect habitability of areas by ecologists studying non-human species (Hanski 1991). However, most of these observations have been made on small mammals, and the extent to which these factors would affect large mammals is debated, since larger mammals have greater tolerance levels to climatic and resource variations. Gamble does not consider how non-human species survive in specialised environments. Large mammals may be affected by patterns of resource distribution, but the separation of resource patches must be at a sufficiently large scale to become problematic. Gamble (1986) argues that strong continentality and seasonality in Northeast Europe resulted in resource distribution at scales larger than could be coped with by personal mobility. The details of resource distribution across Europe need greater exploration before this assertion can be confirmed. It is also necessary to establish the scale of resource separation that would have prevented hominid survival. Moreover, even within areas with specialised ecosystems and large distances between resource patches, there are places that are less homogenous and specialised, such as river valleys. Thus, hominids can be expected to be found at some locations within the Northeast region, as habitat characteristics are unlikely to have been identical over such a large area.

Gamble (1986) suggests that evidence for the social networks necessary to inhabit Northeast Europe can be seen in the Upper Palaeolithic regional stylistic elements, such as distinctive tool forms and artistic traditions, and in long distance exchange and raw material movements. Gamble argues that these features express group identity, which would have facilitated mutual support between groups, allowing occupation of marginal territory. This is supported in ethnographic studies, however Gamble claims that this form of social organisation was exclusive to Upper Palaeolithic and later populations. In order to support this model it is necessary for him to show that the late Middle Palaeolithic distinctive regional forms are not an expression of group identity and the kind of networks that he wishes to reserve for the Upper Palaeolithic. Gamble does not address the appearance of regional industrial traditions in the Middle Palaeolithic, such as Mousterian of Acheulean Tradition backed knives in South-western Europe, and the leaf point industries of Central Europe, thus prefiguring the data to support his model. The distances and the volume of long range transfers do increase in the early Upper Palaeolithic, but Gamble (1993a) admits the only major restructuring of procurement occurs at the transition from foraging to farming, when "exotic" material begins to dominate assemblages. Furthermore, Middle Palaeolithic groups in Central Europe moved lithic material over 100s of kilometres, beyond the limit of the local social network (Féblot-Augustins 1993). Moreover, Neanderthals were able to inhabit northeastern Europe (Pavlov *et al.* 2001), without the stylistic elements of the Upper Palaeolithic that Gamble (1986) claims to be essential in such a continental environment.

Gamble treats behaviour as adaptation to the environment and thus predicts that differences will be seen in hominid behaviours in each of his regions, due to variation in resources. However, differences between the regions in the Lower and Middle Palaeolithic are argued to simply result in variable density of finds and continuity of occupation (Gamble 1995b, 1996b, 1997). Variations in assemblages are attributed to site function, raw material qualities or environmental conditions (Roberts *et al.* 1995; Gamble 1995c). For example, the increased distance of raw material transfers in the higher latitudes is attributed to the demands of the environment driving hominids towards greater carnivory, demanding larger home ranges (Gamble and Steele 1999). Lower Palaeolithic hominids are thus portrayed as possessing only generic skills, which can be applied to any environment, without regionally specific skills developing. The issue of the significance of non-handaxe assemblages is dismissed as an aspect of Acheulean behaviour (Gamble 1999), and the significance of non-handaxe assemblages is further undermined by an attempt to show that most do actually contain handaxes (Roberts *et al.* 1995). Thus, Gamble prefigures the material into a single industry, the Acheulean, and creates support for his model of a single wave of colonisation of Europe matching the predictions of the short chronology. Distinctive technological variants are admitted, such as the scrapers at High Lodge, or the bifaces on flakes at Warren Hill, but these unusual assemblages are used to emphasise the lack of chronological patterning in the Lower Palaeolithic, rather than innovation or regional technological traditions. The variation within the Lower Palaeolithic is thus constructed into being driven by environmental conditions acting on a package of generic skills, again reflecting Gamble's Conservative ideology and Organicist integration of elements.

Gamble links the possession of extensive social networks with the ability to continuously occupy a territory despite environmental fluctuations, as social networks would provide buffering against resource failure. Therefore, he suggests that Upper Palaeolithic regional occupation, particularly in northern Europe, should be more continuous than that of earlier periods. Gamble uses the density of finds in a region as a proxy for population size, and thence of adaptation to the environment of the region. However, for this method to work it must be assumed that taphonomic effects and regional research traditions will not have affected the volume of finds across Europe in any significant manner. This is not a valid assumption since material from the Lower and Middle Palaeolithic has experienced far longer periods since deposition, in which sites may be destroyed, especially in northern latitudes, which have undergone several glaciation events since the initial occupation of Europe. Also, Upper Palaeolithic material is more distinctively humanly manufactured and therefore is more likely to be recovered by non-specialists, thus earlier material may be under represented in areas that have not been systematically surveyed for Palaeolithic remains. Moreover, northern Europe was abandoned for substantial lengths of time during the Upper Palaeolithic glacial maximum, thus the social networks of the Upper Palaeolithic could not buffer populations against all environmental fluctuations.

Gamble (1986) suggests that hominid colonisation occurred once social systems had developed sufficiently to cope with European habitats. However, during the Pleistocene, climatic cycles were variable, changing in amplitude and frequency, and resulted in European ecological communities undergoing a series of changes. Therefore, it is possible that ecological rather than social developments allowed hominids to occupy Europe. Gamble (1999) admits that climatic change influenced European environments, making them more suitable for hominid survival by creating habitats that matched the scale of hominid social life, allowing colonisation; thus, he retains a social explanation despite environmental influences on hominid distribution. This contradicts his former stance that social changes alone were responsible for colonisation timing and extent, but is an improvement on the purely social model.

Gamble (1986) proposes that hominids would have become adapted to the most prevalent conditions in Pleistocene Europe, which were intermediate between fully glacial and interglacial environments, and thus should not be found in either extremely cold glacial landscapes, or in warm interglacial forests. The logic of this proposition is flawed, as it implies that selection on hominid behaviour was directed towards the most long lasting and therefore advantageous environments. There is no reason why hominids should not have adapted to short lasting conditions of fully glacial or interglacial Europe, and have been forced to abandon Europe during intermediate conditions. Adaptation can only result in increased suitability to future conditions fortuitously, since it acts on existing behaviours and physical traits in the present environment. Selection provides contingent solutions in ecological time, not optimal solutions in evolutionary time.

In the regional model of the 1980s very broad and generalised categories of environments are used. Gamble (1986) acknowledges that this is a simplification, and admits that local variation would have existed, but continues to use the highly generalised categories in his model. Variation in climate and environment is downplayed by Gamble (1984) since he argues that hominids would have been adapted to the long lasting and stable intermediate conditions. Thus, he prefigures the climatic data into broad categories in order to support his behavioural model. Furthermore, he dismisses evidence of occupation during climatic extremes as poorly dated, or as representing occupation during stadials or interstadials rather than the full glacials or interglacials, due to poor correlations with ice core evidence.

Gamble argues during the 1980s and early 1990s that occupation of Europe should have occurred virtually simultaneously across all regions except the Northeast, because northern and southern Europe possessed complementary resources. Thus, he argues that occupation of any single region of Europe would have been dependent on occupation of the other regions. It is difficult to see how this model can be upheld. Gamble portrays Lower Palaeolithic hominids as having highly localised lives, and depending entirely on personal mobility, hence it is unclear how contacts with neighbouring regions could be sustained. Moreover, the extremely generalised and large-scale division of Europe into environmental regions used by Gamble obscures the variation present on a local and sub-regional scale. Hence, the complementary resources that Gamble considers vital to hominid occupation may have been locally available, even in the Northeast.

The modified environmental model.

The modified regional environmental model, of hominids moving across Europe in stages, by occupying habitats most similar to the familiar African environments, and then exapting behaviours to expand into additional biomes (Gamble 1998b), is a significant improvement on the original regional model. Similarities between the original habitat and the area being colonised are significant factors in the success of the majority of biological invasions observed by ecologists (Samways *et al.* 1999), therefore, this model is ecologically highly plausible. Moreover, recent evidence of earlier occupation in Mediterranean Europe than in the north lends support to this scenario, since the Mediterranean is the most similar area of Europe to Africa and the Near East in terms of climate and ecological community.

The "release from proximity" model.

The model of four levels of social network put forward by Gamble (1998a) is a useful attempt at linking objects, spatial networks and social behaviour. Gamble is trying to find a universal means of relating spatial behaviour to use of artefacts and sociality. However, two aspects of this model are questionable. Firstly, the size of each of the social networks is highly variable between individuals. This raises the question of whether the levels of networks are distinct, or whether they divide a continuum of means of forming and maintaining relationships. Secondly, he uses observations of modern human social relationships to create the model, which suffers from the problem that other species of hominid may have been distinctly different in their social behaviour. Furthermore, the limits on the size of the personal networks are stated to be related to cognitive constraints of the number of relationships that can be remembered. Cognitive abilities were evolving in hominids during the Pleistocene, therefore the size and extent of social networks is likely to have been evolving, and may have been very different from modern human networks.

Gamble (1998a) attempts to define the local hominid network both socially in terms of social network size and nature, and spatially by the local area traversed by hominids. He does not discuss whether these two definitions may lead to different results. It is assumed that the social networks map perfectly onto the spatial networks, and can be detected through raw material transfers. Gamble gives the upper limit to the size of the local hominid network as between 80-100 Km, but more often as 40 Km (Gamble 1993a), with the variation caused by ecological conditions. This spatial definition is derived from the distances that raw materials are found to move during the Middle Palaeolithic. He considers that Middle Palaeolithic hominids lacked the social landscape, and therefore that their movements must correspond to a local hominid network. The fact that Middle Palaeolithic raw material transfers do not exceed the limits inferred for a local hominid network is then used to argue that they lacked a social landscape. Also, as local hominid networks exclude individuals from other networks, exchange of materials between groups is impossible, therefore he assumes that Middle Palaeolithic raw material transfers directly reflect personal mobility. This means of defining the local hominid network is clearly circular. His model rests on the assumption that Middle Palaeolithic hominids could not have possessed a social landscape, and therefore treats material from the Upper Palaeolithic differently to the same type of data from earlier periods. For example, Gamble (1999) glosses over the appearance of regionally distinct tool forms in the late Middle Palaeolithic, as these are predicted to be outcomes of the social landscape not the local hominid network. Furthermore, increases in raw material transfer distances corresponding to the appearance of Levallois technology, are explained by increased personal mobility and group range size, linked to an increasingly meat based diet (Gamble 1999; Gamble and Steele 1999), rather than increased size of social networks as in the Upper Palaeolithic. Moreover, the variation in the size of the local hominid network as a response to environmental conditions can be seen as special pleading; if the environment required extensive social networks, hominids without a social landscape should not have been able to occupy these areas, rather than stretching their social networks to match the ecological constraints.

The proposition that the social landscape was necessary in order to survive in unpredictable environments because it increased social flexibility (Gamble 1998a) is a development of the earlier model of hominids requiring appropriate scale social networks in order to survive in specialised environments (Gamble 1986). The social landscape is a useful model because it directly addresses how individuals survive in marginal areas, when population density is very low and resources are unpredictable. The social landscape provides an explanation of how groups maintain relationships and gain additional resources through exchange of goods and members, when groups are widely dispersed and may meet very infrequently. Populations in marginal environments do suffer from problems of maintaining sufficiently large numbers to sustain a mating network, whilst limiting local population density to low levels in order to cope with poor resource availability.

However, Gamble's claim that the development of the social landscape allowed modern human global colonisation has several drawbacks. Gamble requires the social landscape to be limited to *Homo sapiens*, which demands the rigid denial of any pre-Upper Palaeolithic social developments as seen in his earlier work. A further problem concerns the timing of the appearance of the social landscape. In order for the model to work, all populations expanding should show the long distance exchanges and symbolism of the social landscape. In Europe this is seen, but Upper Palaeolithic industries are not globally distributed. Moreover, modern human expansion into Asia may have occurred well before the date of 50 Kyr BP given for the emergence of the social landscape. Furthermore, for the colonisation to be explained by the social landscape these social behaviours should appear immediately preceding the expansion. However the appearance of complex "modern" behaviours has been argued to occur during the Middle Stone Age in Africa (McBrearty and Brooks 2000), substantially before 50 Kyr BP and the spread of Upper Palaeolithic groups. This raises the question of why these African populations did not expand earlier if they were in possession of social landscapes. These problems could be overcome by focusing less on the European Upper Palaeolithic, thus African and Asian Middle Stone Age or Middle Palaeolithic behaviours could show evidence of social landscapes, but this would require the inclusion of European Middle Palaeolithic groups as possessors of this form of social behaviour. Therefore, it is difficult to directly correlate the appearance of the social landscape and global colonisation.

In summary, Gamble links colonisation to the possession of symbolic communications and raw material transfers in the Upper Palaeolithic. He also has produced environmental predictions concerning the timing of arrival, the order of habitats to be occupied and the level of continentality and seasonality that could be endured during the Lower Palaeolithic. In addition, he highlights the intensity and level of continuity of occupation of each region as reflecting colonisation processes. These predictions will be tested by the data collection and analysis presented in the following chapters.

Foley's Dispersal Narratives.

Aims and agenda.

A major concern in Foley's approach to the archaeological record is to bring evolutionary theory to the interpretation of past behaviour and morphology. Foley's stated aims in this regard are:

- to bring neo-Darwinian theory of natural selection into archaeological interpretation (Foley 1984a);
- to establish that change occurs by selection and thus is gradual and additive (Foley 1984a);

- to show that hominid behaviours have functional causes, related to their environment, and are therefore adaptations (Foley 1984a);
- to demonstrate that adaptations are the product of natural selection occurring in the context of the biological community on pre-existing morphology and behaviour (Foley 1984a);
- to reveal that human evolution took place due to the same biological processes that operate on all species, and can be explained by general evolutionary principles (Foley 1984a, 1987b, 1995a).

Foley's approach is strongly ecological, and a key aim of his work is to relate adaptations to their environmental causes. Specifically his ecological agenda is:

- to investigate the archaeological record in terms of its ecological basis (Foley 1981);
- to identify universals of behaviour, relating to ecological conditions, which can be used to reconstruct hominid behaviours (Foley 1981);
- to explain hominid characteristics in terms of adaptations providing solutions to environmental problems (Foley 1987a);
- to examine how ecology structures relationships between individuals and their environment (Foley 1987a);
- to show that biology is the key to understanding human behaviour (Foley 1987a).

Foley is also concerned with the use of the archaeological record to shed light on evolutionary processes. His aims reflecting this agenda are:

- to use the fossil record as a framework for understanding the pattern of lithic technology during the Pleistocene, and thus investigate hominid behavioural evolution in the context of phylogeny (Foley 1987a);
- to explore the link between hominid species and technology, and thus to determine the extent to which archaeological data can be used to infer evolutionary relationships (Foley and Lahr 1997).

Theoretical view.

Foley's theoretical view centres on evolutionary approaches. He argues that hominid behaviour was subject to selection pressures stemming from the competitive environment occupied, acting on pre-existing ancestral behaviours (Foley 1984a, 1987b, 1995a). Principles of evolutionary ecology and socioecology are used to explain the patterns of the archaeological record. Foley (1982) links the distribution of resources in the environment to patterns of subsistence and social grouping, thus he makes generalisations about past behaviour by using predictions from the ecology of the habitats and communities occupied (Foley 1992). This approach is dependent on nomothetic principles, derived from cross-species comparisons and theoretical predictions of evolutionary ecology, such as optimal behaviour models (Foley 1985). The patterns of behaviour seen in the other African apes, and the catarrhines in general, are used to infer the ancestral condition of hominid behaviours, in the context of the ecological problems facing hominids (Foley 1989a, 1992, 1995a). Modern hunter-gatherer adaptations are treated as the outcome of hominid evolution, and used to infer the results of selective pressures, therefore forming an analogy for hominid behaviour (Foley 1984b). Foley applies two forms of analogy, ecological and phylogenetic, to reconstruct socioecological conditions.

Foley advocates the use of "middle range theory"(Binford 1981), using the principle of uniformitarianism, to produce linkages between processes happening in the present and those that created the archaeological record in the past (Foley 1981). He relates ecology to distribution patterns, morphology and behaviour, to derive the behaviour of hominid species. The linking principle applied is the distribution of energy in the environment, inferred from climatic parameters, which underlies subsistence, and therefore the dispersion of individuals, reproductive strategies, social behaviour and technology. Ecological parameters are utilised to generate the laws of behaviour used in interpretation, because ecology is independent of the specific context of observable behaviours, and can therefore be generalised into other contexts (Foley 1981, 1987b).

Hominid behaviour is treated by Foley as species specific. He pictures behaviour as being derived from an ancestral African ape condition, which underwent a process of divergence as each hominid species became ecologically distinct. Species are treated as bounded in behaviour as well as morphology and reproduction. Foley links behaviours, such as the manufacture and use of tools, to cognitive ability, which in turn is the product of selection acting on the ability to find subsistence and reproduce (Foley 1987b, 1991). Complexity in subsistence tactics, and the ecological environment in the habitats of hominids, created a pressure that drove encephalisation and increased intelligence (Foley and Lee 1991; Foley 1995a). Also, group size and social complexity are linked by Foley (1992) to cognition, but group size and sociality are in turn connected to subsistence and resource distribution. However, as this is a selective pressure acting on each species individually in their niche, cognitive ability is also species specific; hence, technological manufacturing techniques can be linked to hominid species. Each species inhabited a unique cognitive world, in which interactions with other species would have been limited by a lack of shared communication systems and abilities. Foley explicitly connects archaeological industries and the species of their manufacturers (Foley 1987a; Lahr and Foley 1994). He treats behaviours as biological traits inherited vertically, with no possibility of horizontal transfer, and uses cladistic techniques to investigate archaeology.

Foley (1984b; 1994) advocates gradual rather than punctuated evolution. He explains the processes of change in behaviour, distribution and morphology as solving problems created by the environment. Behavioural change is described as building on pre-existing behaviours, thus strong continuity is expected in the archaeological and palaeontological records (Foley 1984a). This gradualist perspective justifies his search for continuities, and long time depth to the appearance of human behaviour and biological traits (Foley 1987b). Change is treated as additive and occurring at the microscale, with behavioural change preceding morphological changes. Technological change is predicted to occur by a process of isolation, analogous to allopatric speciation, and adaptation to local conditions (Foley 1987a) and hence reflects population history (Lahr and Foley 1994; Foley and Lahr 1997). Even the appearance of human culture does not release hominids from the forces of selection and evolution (Foley 1991). The continuities between elements of culture, such as sophisticated communication and horizontal transmission of behaviour, with the behaviours of non-human species are used to argue that culture evolved via the same processes as biology, and that many of the significant features of human culture are epiphenomenal consequences of other adaptations, such as increased cognitive ability (Foley 1991). Thus, biology is the key to understanding human behaviour.

Models of dispersal.

Foley (1987b) describes the sequence of events in hominid colonisation as:

1. Between 1.5-1.0 Mya expansion of *Homo erectus* into southeastern Asia from sub-Saharan Africa took place, and by inference hominids must have occupied the regions of the Old World tropics between Southeast Asia and Africa.
2. At 1.0-0.7 Mya the warm temperate zones of Eurasia were occupied.
3. Between 0.7-0.3 Mya the northerly temperate environments of Eurasia were colonised.
4. 0.3-0.04 Mya saw occupation of northerly latitudes but not extreme arctic conditions. This coincided with the evolution of archaic *Homo sapiens* from *Homo erectus*.
5. After 0.04 Mya the rest of the globe was colonised by modern *Homo sapiens*.

The pattern of colonisation is explained by geographical and ecological barriers acting as constraints. Foley (1988) argues that hominids colonised new habitats and regions in ways more similar to other large mammals than to modern humans. He claims that the sequence in which habitats were colonised reflects their level of similarity to the tropical grasslands of Africa in which hominids evolved (Foley 1987b). Hominids were therefore preferentially occupying habitats with familiar resource types and habitat structure. The stages of colonisation proposed track a sequence of adaptations and behavioural changes that overcame the biogeographical barriers encountered during the dispersal process, and are explicitly linked to the species that Foley (1987b) proposes undertook these movements. For example, Foley (1992) suggests that expansion into temperate and seasonal environments beyond the tropics would have demanded adaptations to more dispersed resources, such as longer foraging distances, increased foraging efficiency and larger group sizes.

Foley (1984b) explains the spread of *Homo erectus* out of sub-Saharan Africa as the product of climate change causing the redistribution of habitats and the expansion of grassland biomes. Hominid dispersal is connected to the biogeographical conditions caused by Pleistocene climatic cycles, which induced habitat movements and acted as a constraint and a release at different periods (Foley 1987b), because all species are confined to certain habitats by physical or competitive barriers; thus, movement occurs with habitats or when constraining barriers are removed. Biogeographical conditions are argued to suit spread northwards from Africa during interglacials, as the Sahara was moister and no longer a barrier. During glacials habitat contraction would isolate Africa from Eurasia, but a corridor east-west across Eurasia would allow movement (Lahr and Foley 1998, 2003), as represented in Figure 3.2.

Ecological theory has associated environmental conditions of habitat fragmentation and unpredictability with adaptations for dispersal between habitat patches, hence Foley (1985) uses these conditions in Plio-Pleistocene Africa to explain the evolution of biological and behavioural qualities in hominids enabling colonisation of new environments. For example, increased body size provided broader environmental tolerances such as wide dietary breadth and the ability to survive fluctuations of resources and temperature (Foley 1984b). Evolution in fragmented and unpredictable habitats is also associated with opportunism and a high degree of flexibility in behaviour, leading to broad dietary tolerances, improving success in novel environments (Foley 1985).

Foley (1987b) links the development of higher levels of carnivory among hominids to dispersal. Carnivores are portrayed as surviving in a broader range of habitats than herbivores, because they depend on less specific resources. Furthermore, as carnivores are high in the trophic pyramid they must live at relatively lower population densities and in larger individual home ranges than herbivores of equivalent body size. Hence, carnivore generalism and large range size could have promoted hominid dispersal. Foley (1987b) specifically links carnivory with the ability to occupy Europe, because at the time of hominid arrival several other large bodied, social carnivores also appeared, suggesting that carnivore niches were open to invasion.

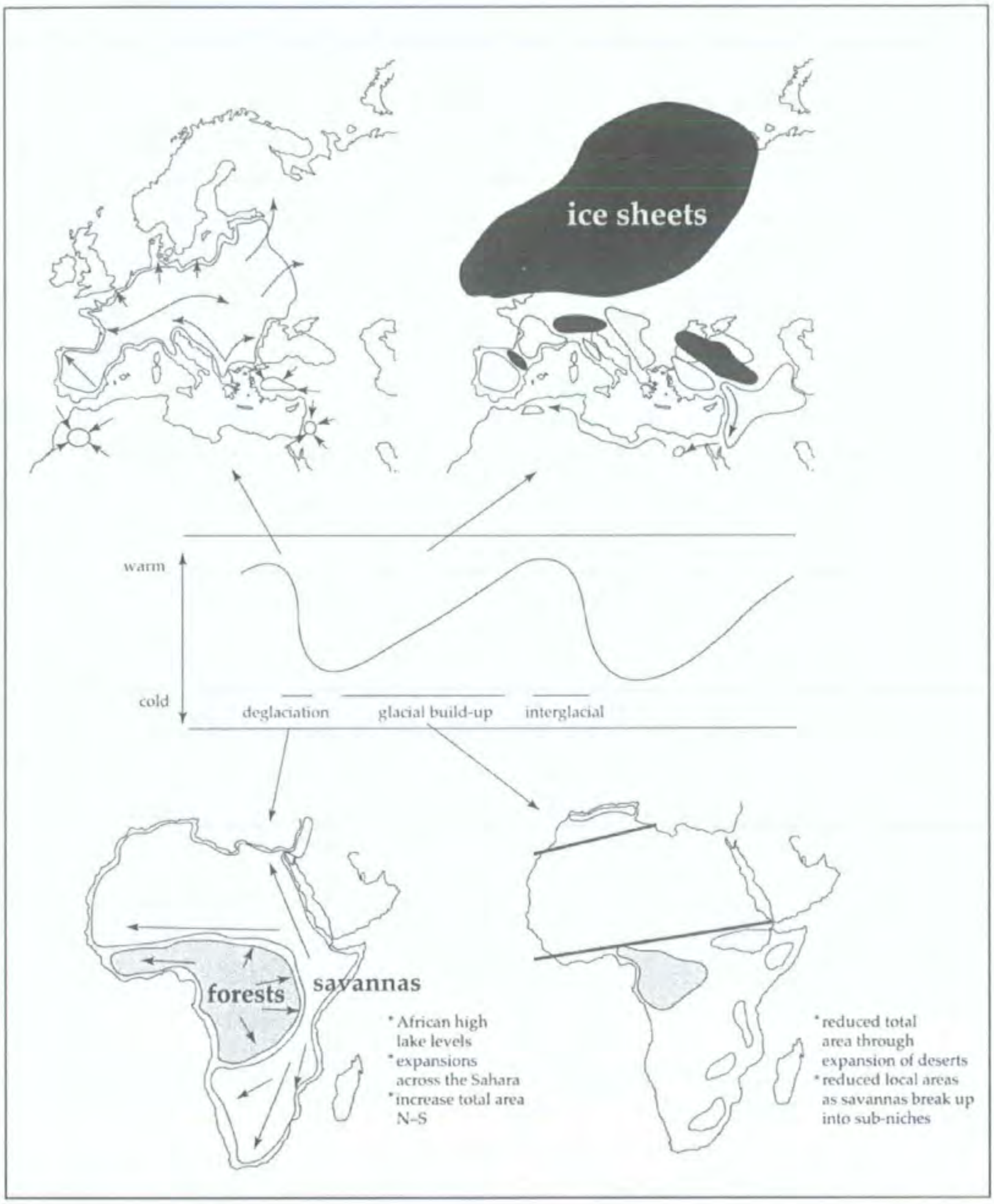


Figure 3.2. Diagram of the effect of glacial cycles on habitat distribution and biogeographical relationships between Europe and Africa. (After Lahr and Foley 1998)

Foley (1987b, 1995a) argues that hominids were successful colonisers because they were not native to the communities that they moved into, and therefore did not have co-evolved competitors to limit their resource availability, and as generalists hominids could avoid direct competition with native species, and thus were able to easily establish populations. Moreover, newcomers may spread diseases that diminish the ability of native species to resist their spread. Foley therefore argues that hominids were successful in new areas simply because they were new. This process is used to explain both the spread of *Homo erectus* and of modern humans (Foley 1987b, 1995a, 1989b). Foley (1995a) connects the rapid spread of biological invaders studied in ecology, and the rate of spread of modern humans, to justify the biotic release analogy. Furthermore, modern humans are claimed to have had the ability to rapidly reproduce from populations of a few individuals, as do most biological invaders, in order to maintain their competitive advantage (Foley 1989b; Lahr and Foley 1994).

Foley (1987b) cites population increase as the cause of dispersal, because prior to the development of modern behaviour, population increase would have resulted in dispersal rather than intensification of resource utilisation (Foley 1995a). He argues that patriliny and male kin alliances developed as an elaboration of the male bonded ancestral state of African apes, and would result in strong territoriality among hominids (Foley 1989a, 1992, 1996; Foley and Lee 1989, 1996). This form of social structure encourages dispersal, since population increase within groups causes fission due to resource limitations, forcing the daughter group to move to an unoccupied range to avoid conflict with existing groups. This process is seen in most species (Foley 1987b) but in humans is intensified due to selection for dispersal abilities as adaptation to fragmented and unpredictable habitats of Plio-Pleistocene Africa. Also, in *Homo sapiens* the patrilineal groups may retain contact and provide a wider network for exchange of mates and resources, increasing the chances of successful colonisation. Foley (1992, 1996) argues that the trends suggested in the evolution of hominid social groupings are seen most fully in modern humans, in the form of large social groups and strong male-kin associations, which explain the success of *Homo sapiens* in replacing other hominids. Larger social groups also increase foraging efficiency and competitive ability.

Foley (1987a, 1995b) links stone tool industries to the species of their manufacturers. He identifies geographical and temporal trends in assemblage forms and correlates these to hominid phylogeny, as depicted in Figure 3.3.

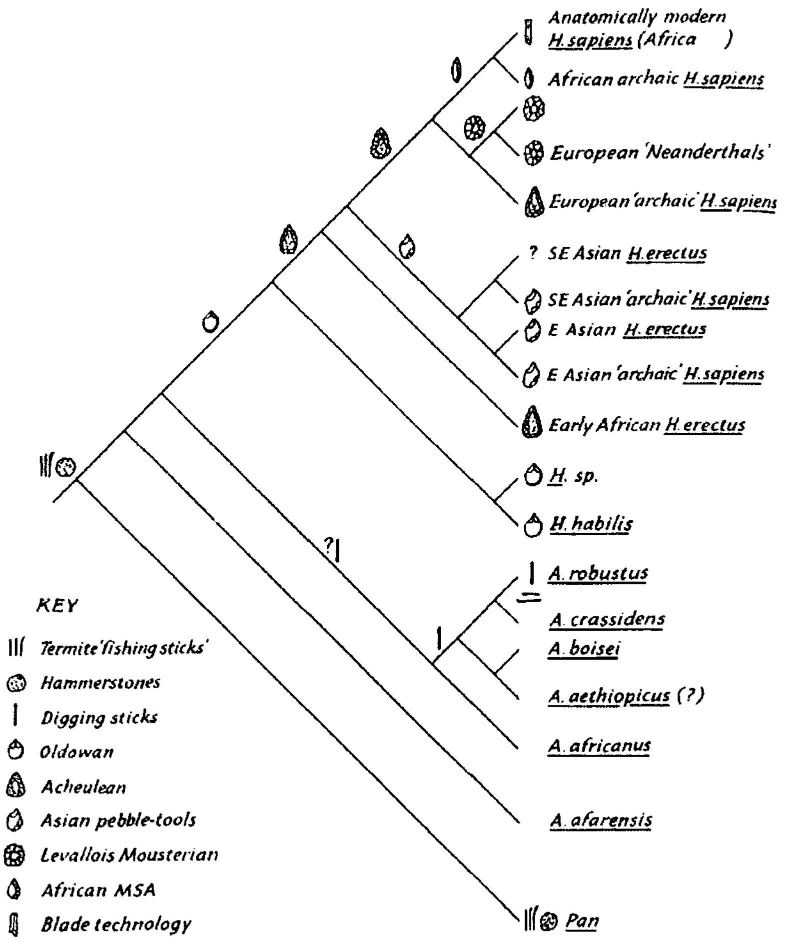


Figure 3.3. Cladogram of hominid evolution, emphasising the divergence of hominid taxa and technology associated with each taxon. (After Foley 1987a)

The examples used to justify Foley's approach of using technological modes (Clark 1977) are: the appearance of the Oldowan, mode 1, at the time of the evolution of *Homo*; the development of the Acheulean, mode 2, and *Homo erectus*; a lack of mode 2 in the Far East corresponding to the isolation and late persistence of *Homo erectus* in East Asia; the Mousterian, mode 3, matching the distribution of Neanderthals in Europe and the Near East; and the appearance of blade technology, mode 4, with *Homo sapiens*. Blade technology explains modern human dispersal as it is argued to be used in the manufacture of more efficient projectiles than those used by archaic hominids (Foley 1989b). In the Levant, anatomically modern humans are correlated to the Tabun C phase, rather than blade technology, and Neanderthals to the Tabun B phase (Foley and Lahr 1992). Foley (1987a) argues that technological and morphological continuity in Africa throughout the Pleistocene demonstrates that

Africa is the area of evolution of modern humans, whereas discontinuities in areas outside of sub-Saharan Africa reflect replacement by species dispersing out of Africa.

Recently, Foley has linked *Homo sapiens* and Neanderthals with mode 3 technologies in order to overcome the problems encountered with associating anatomically modern humans and mode 4 (Foley and Lahr 1997). This removes the lack of correspondence between the appearance of mode 4 and *Homo sapiens*, and the lack of mode 4 technologies in areas of the world in which anatomically modern humans were present. Mode 3 technology is treated as common to all modern humans, and mode 4 as a regional development with no cognitive implications. Therefore, the dispersal of *Homo sapiens* is not associated with significant developments in technology. Foley argues that the appearance of the Upper Palaeolithic was a significant break in the archaeological record of Europe, but the change was not revolutionary, given the antecedents to Upper Palaeolithic behaviours in Africa, thus on a global scale the Upper Palaeolithic is the mark of one population, not the whole of modern humanity.

Foley (1995b) uses the proposed relationship between technology and phylogeny to link the African and European Middle Pleistocene hominids using regional variants of prepared core technologies. Behavioural similarities are used to infer recent common ancestry for the Late Pleistocene hominids of Europe and Africa. Foley and Lahr (1997) propose that a speciation event occurred in Africa leading to the species *Homo helmei* at 300-250 Kyr BP, which possessed mode 3 technology, and subsequently dispersed throughout Africa, the Near East and Europe, illustrated in Figure 3.4. The continued presence of mode 2 elements in Europe is suggested to reflect intermixing of hominid groups without complete replacement of the early Middle Pleistocene Europeans. The Neanderthals therefore were cognitively and behaviourally more similar to *Homo sapiens* in Africa than the earlier European populations. This model explains the origins of Levallois industries in Europe by the dispersal of populations using this technology into Europe from Africa. The dispersal resulted from the increased efficiency of tool production by Levallois techniques, over that of mode 1 or 2 technology, creating a competitive advantage.

The evidence used to support the “mode 3 hypothesis” is: the similarity between the lithic technology in Africa and Europe; the earliest appearance of prepared core technology in sub-Saharan Africa; technological continuity between the African modes 2 and 3 and discontinuity elsewhere; genetic coalescence between Neanderthal and *Homo sapiens* mitochondrial DNA; morphological similarities such as enlarged cranial capacity; and behavioural similarities in the form of burial of the dead and use of fire, inferred large group size, and possibly language. Using correlation of brain size and group size, Foley treats cranial capacity of over 1000cc as a critical threshold, beyond which group size would require language to maintain group coherence (Dunbar 1993). This demanded significant changes in ontogeny and parenting tactics, causing further changes to social grouping, and drove the rapid increase in encephalisation after 300 Kyr BP (Foley 1995b, 1996). It is the changes in brain size and life history, which caused the novel social formations that drove the dispersal of *Homo helmei*. The dispersal is proposed to coincide with the oxygen isotope stage 7 interglacial at 250-200 Kyr BP, which would have provided suitable biogeographical conditions for dispersal from Africa to Eurasia.

Anatomically modern human dispersal is explained in the multiple dispersal model (Lahr and Foley 1998), which suggests that human diversity developed in Africa because of habitat fragmentation leading to population isolation after the evolution of *Homo sapiens*, and before the dispersal to the rest of the world. Diverse groups with different technologies moved from sub-Saharan Africa via either a northern route to the Near East, or an eastern route to Arabia, at around 50 Kyr BP. The Upper Palaeolithic in Europe is the result of a group following the northern route and developing the Aurignacian in North Africa. Modern humans are taken to be the culmination of the processes of human adaptation as a successful coloniser, resulting in a competitive advantage, and complete replacement of other hominid species.

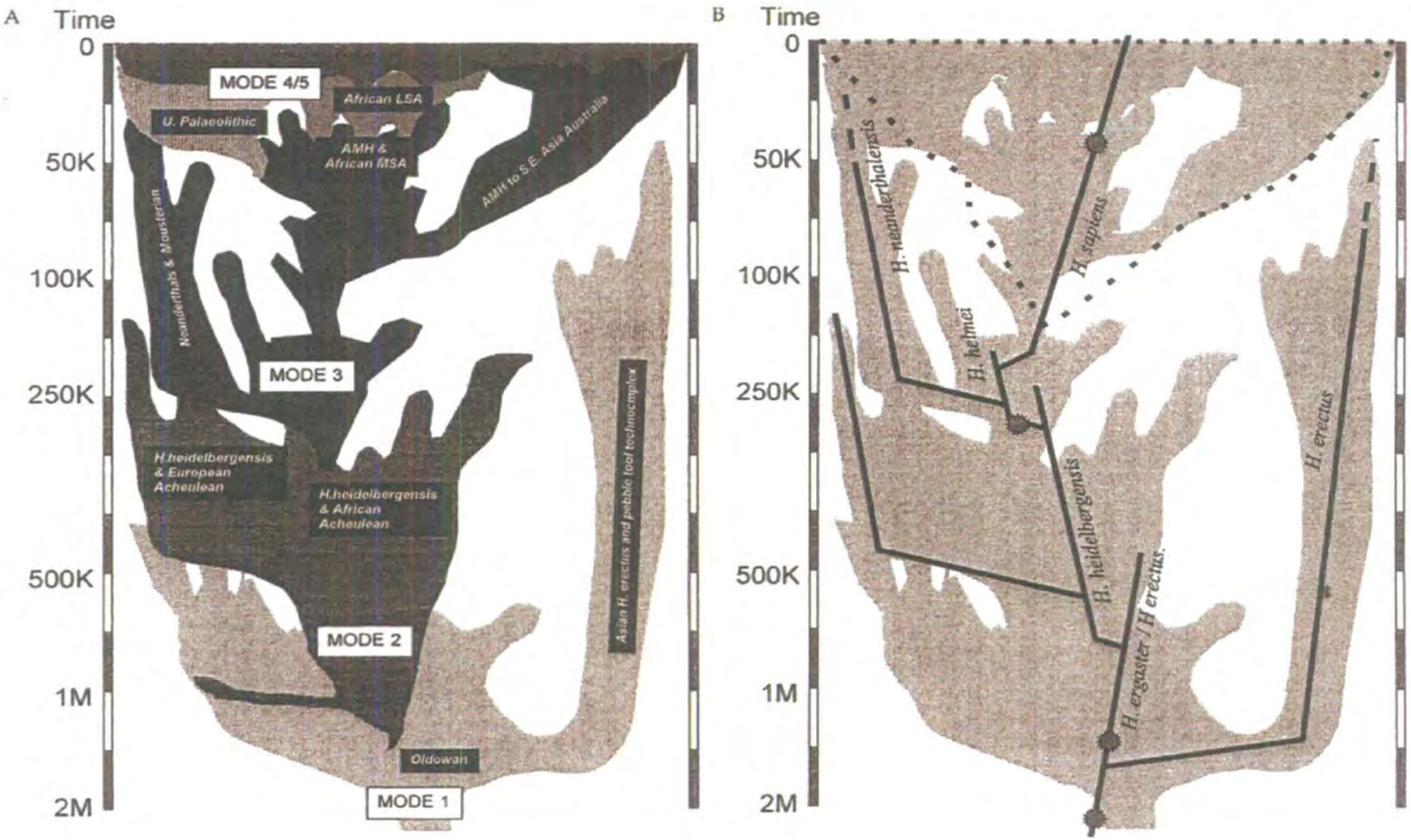


Figure 3.4. a) Summary of the distribution in time and space of the radiations of the technological modes proposed by Foley. b) Superimposition of hominid taxa on the modes, showing major cladogenic events (stars) and major changes in technological modes. (After Foley and Lahr 1997)

Narrative analysis.

Foley portrays all change as gradual and incremental, due to natural selection acting on pre-existing material. He can therefore be regarded as following a Liberal ideology, with change happening at a social pace, gradually fine tuning behaviour. Despite the extremely slow nature of change described, a Conservative ideology is rejected since change is treated as positive, due to the nature of evolution. This slow and additive view of technological change justifies his linkage of populations and species of hominids to specific industries, as assemblage similarity will trace population history. However, modern human behaviour is shown to be markedly different to that of other hominids, in the rapidity of change of technology and speed of colonisation. The differences in technology between *Homo sapiens* and other hominids, especially the possession of blade technology are emphasised. Anatomically modern human biology is described as revolutionary among later hominids by following a trajectory towards gracility. The distinctions between *Homo sapiens* and other hominids in Foley's writings can be seen as a moment of Radical change. However, he claims that modern human abilities were latent in "archaic" *sapiens*, thus there is continuity despite outward revolutionary change. The processes of dispersal in all events are the same in Foley's model, but become more fully developed and successful over time.

Foley considers all change to result from adaptation and selection, and hence ultimately to have environmental or ecological causes. This is Mechanistic argumentation, and is seen throughout his writings, in the attempts to find general principles to link the palaeoenvironmental record to evolutionary and behavioural patterns and thus reconstruct hominid adaptations. His use of middle range theory is explicitly mechanistic, relying on uniformitarian assumptions to extrapolate processes operating at ecological scales observable in the present, to geological scales of evolution (Foley 1992). Foley's explanation of dispersal patterns as reflecting the distribution of habitats and hominid adaptations is Mechanistic, because hominids are forced to move during environmental changes and are unable to overcome these external determinants. His (1987a) call for the integration of archaeological and evolution theory and the creation of a set of universal interpretive procedures can also be seen as an argument for the use of Mechanistic principles to decipher the past. He (1995a) also employs an explicitly reductionist strategy of explaining complicated phenomena with elemental processes, an aspect of Mechanistic argumentation.

Mechanistic argumentation is associated with the lumping of data into broad categories. However, Foley emphasises variation in hominid behaviour and biology, since variation is necessary for selection to occur. This is reflected in his tendency to divide the fossil record into many species. Foley supports the division of *erectus*-grade hominids into an Asian and an African species, providing a phylogenetic explanation for the differences in the Lower Palaeolithic record of the Far East compared to the rest of the Old World. He also proposes the existence of *Homo helmei* based on one fossil, in order to explain the appearance of mode 3. However, in his treatment of the archaeological record variation is condensed into only five technological modes. Finer grain differences are only considered when the broad scale patterning does not fit the proposed linkage between hominid species and assemblage types, as in the Levantine Mousterian. The organisation of the archaeological record into such generalised categories removes the need to address change, except at the boundaries, providing support for his assertion that populations and species can be linked to tool assemblages since these are relatively unchanging. Furthermore, the portrayal of lithic industries as static allows change to be explained as relating to the movement of populations rather than indigenous development.

The focus on the ecological determinants of behaviour and dispersal throughout Foley's writings reflects a Tragic emplotment. The uniqueness of hominids is constantly denied, and their subjection to the principles of evolutionary ecology is emphasised. The environment is the key constraint in the evolution and colonisation patterns of hominids. Hominids are shown to be subject to the forces of adaptation to environmental conditions and are unable to escape their evolutionary and phylogenetic heritage. Foley denies that culture can free humans from selection. The low levels of change and variation before the appearance of *Homo sapiens* are linked to hominids being portrayed as only responding to external causes of behaviours. The denial of internal mechanisms generating change reinforces the Tragic plot. Anatomically modern humans are granted the ability to escape a degree of environmental constraint, thus following a Comic plot as innovative behaviour allows the external forces of the environment to be somewhat released and rapid dispersal to occur, but this is still the result of evolution and environmental pressures.

Overall, Foley is writing in a Metonymic trope. Metonymy is seen in the use of lithic assemblages to represent species. Tools are taken to indicate the behavioural package of the species, thus a part stands for the whole. Each species has its own industry, which corresponds to the fossils and cognitive ability of its makers. Metonymy is also seen in the use of ecological analogy, as the presence of hominids in a habitat is taken to represent the presence of behaviours allowing occupation throughout similar areas. The Metonymic trope is associated with Tragic plot, Mechanistic argument and Radical ideology. Foley's writing fits the expectations of these relationships, with the exception of the ideology. Foley only displays Radical moments of change in his treatment of the emergence of modern behaviour, and he attempts to overcome this by emphasis on continuities, following Liberal ideology.

The strengths and weaknesses of the model.

Ecological aspects of the models.

Foley's models are based on biogeographical models of dispersal. His assertion that hominids should expand as part of broader biogeographical events, in the context of habitat expansions is supported by biogeographical theory. Climate change is predicted to cause redistributions of resources, which are responded to by faunal communities (Seddon 1971). Although each species inhabits a unique niche, sympatric species with similar ecological requirements are expected to move as a community under conditions of expansion. Therefore, Foley's prediction that hominids will spread during episodes of grassland habitat expansion is ecologically sound. However, an internal change, such as a behavioural innovation, would allow range expansion without other members of the original faunal community. Likewise, an external driving force moving a community may not act equally on all members. Thus, hominids need not have expanded when other members of the sub-Saharan grassland fauna moved. Biogeographical associations merely suggest that conditions could have allowed hominid expansion without significant behavioural adaptations.

Foley (1987b) claims that hominids occupied the major biomes in order of their similarity to African tropical grasslands. This is also a sound proposition and has been observed during episodes of biological invasions and termed "environmental matching" (Williamson 1996). Foley (1992) suggests that the constraints limiting expansion beyond the tropics were due to the more dispersed nature of resources in time and space associated with temperate seasonality, requiring improvements in foraging efficiency, longer foraging distances, more dispersed foraging patterns and increased group size. Temperate environments do pose more of a problem to survival in terms of time stress, due to seasonality of daylight. However, the grain scale of the environments needs to be quantified before these kinds of assertions can be made, and at present the resolution of palaeoecological reconstructions may not be sufficient to test these claims. Therefore, Foley is making a valid point that foraging efficiency may have been key to occupying these environments, given the constraints of daylight hours, but the link to resource structure is unclear, and the inferred shifts in foraging patterns, group size and social structures also require further substantiation.

Foley (1987b) asserts that the characteristics of the habitats preferred by hominids are environments with a high turnover of energy. These kinds of environments are associated with biological invasions, as high-energy turnover occurs in the early stages of an ecological succession when rapid colonisation specialists, or "weeds", occupy an area. Foley implies that hominids formed part of the weed community, and were adapted to successful biological invasions. However, not all successful biological invaders are weed species (Williamson 1996), and as relatively slowly reproducing species, hominids are unlikely to become weeds, which are usually r-selected. Therefore, the specific characteristics that allowed hominids success in range expansion, and the elements in the environment that were attractive to hominid occupation, or were acting as constraints need to be established, and the sequence of occupation of different environments requires confirmation.

Foley (1985, 1987b) lists body size increase, behavioural flexibility, and carnivory as explaining hominid colonisation success, by allowing the competitive and physical barriers at the edge of the range to be lifted. Body size increase does help to overcome cold stress and habitat fragmentation, and is associated with broad dietary tolerances (Ehrlich 1986). However, species with small body size and rapid reproduction can be as successful in new habitats as species with large body size, broad environmental tolerances and slow reproduction (Ehrlich 1986; Williamson 1996). Behavioural flexibility and opportunism are linked to evolution in fragmented and unpredictable environments and have been observed among successful biological invaders (Newsome and Noble 1986; Williamson 1996). Therefore, if hominids can be shown to have possessed these traits, Foley is making an ecologically valid statement about the causes of hominid success as a coloniser.

Foley (1987b) links increasing carnivory in the hominid diet with increasing generalism and broader environmental tolerances. This is based on observations that carnivores are able to sustain larger species ranges and individual home ranges than herbivores (Watts 1971), and therefore is plausible. However, the large range sizes of Middle Pleistocene hominids are used to infer significant carnivory (Foley 1987b), creating circularity in the argument. Moreover, the level of carnivory that is significant enough to produce these effects has not been researched, and the degree of meat eating among hominids is debatable, as hominids were omnivores not carnivores. Foley states that by the time of hominid dispersal from sub-Saharan Africa there is clear evidence of involvement with carcasses in the form of cut-marked bones, but he admits that the overall importance of meat in the hominid diet is not know. Nevertheless, he (1982) argues that in grassland environments most of the edible resources for hominids would be other mammals, therefore carnivory would have been advantageous and is likely to have been an important adaptation. However, not all selectively advantageous behaviours develop to the levels predicted by such optimality-based arguments, and the significance of carnivory to hominid dispersal ability needs further investigation. Furthermore, behavioural changes would undermine the need to explain dispersal by physical adaptations.

Foley (1987b) makes the argument that hominids were successful colonisers because they were newcomers, and were able to avoid competition from co-evolved competitors. This concept matches that of "biotic release" observed during biological invasions, in which species rapidly spread because the constraints of competition, disease and predation that were limiting in the native community are no longer in place (Sax and Brown 2000). However, this biological model applies to species spreading at enormous rates in ecological time, such as rabbits in Australia. It is not clear whether hominids spread at these velocities; hence, models derived from the most extremely successful biological invaders observed by ecologists may not be suitable for the processes that affected hominids. The rate of spread needs to be assessed before ideas of biotic release, and other characteristics of biological invaders can be applied to hominid dispersals. Slower rates of spread than those observed among contemporary invading species may require different ecological interactions to explain their mechanisms. Furthermore, this explanation does not consider the specific context in which hominid range expansion took place. Any species can become intrusive in a new community and become successful, but this does not examine how or why the original expansion occurred, or what form of biological release caused the success, thus this argument is too general to be explanatory.

Foley's (1987b) argument that dispersal is caused by population increase is ecologically plausible, as spatially expanding groups must increase in population size or face population density reductions, which may lead to the breakdown of mating networks (Hansson 1991). Furthermore, demographic increase is liable to cause resource stress, thus individuals may have higher reproductive success by moving to areas of lower population density, thus selection will favour individuals who disperse (Stenseth and Lidicker 1992b; Belichon *et al.* 1996). However, this argument remains non-explanatory, as it does not address why the population increase occurred to drive the range expansion. Biological theory assumes that species will expand demographically and geographically until constrained. Geographical expansion is associated with demographic expansion, but the factors releasing the constraints on the species need to be delimited in order to use this relationship as a model for expansion in range. Moreover, pre-saturation dispersal has been observed among expanding species, demonstrating that demographic increase is not necessarily connected to spread (Hansson 1991; Swenson *et al.* 1998).

Foley (1996) argues that dispersal is a factor of patrilineal grouping with associated territoriality. This argument is based on the ecologically solid proposition that as group size increases resource pressure will drive group fission, with at least one group moving to a new range (Henzi *et al.* 1997). As habitats within the existing species range become filled by this process pressures to adapt and move into new habitats will build. This argument suffers from the same problem as that of population increase driving dispersal, which almost certainly happened but because this process is so widespread in ecology it does not explain why it happened when it did, dispersal becomes inevitable. The argument that patrilineal groups with strong territoriality would have enhanced the process of group fission is superfluous, because resource pressure would drive dispersal without inter-group conflict. Nevertheless, territoriality may be associated with enhanced levels of group dispersal in order to avoid conflict. However, the degree of territoriality among hominids is questionable because of the inferred low population density during the Lower Palaeolithic.

The patrilineal grouping described by Foley is built on the assumption that social grouping is phylogenetically conservative, and that female dispersal and male residency is the ancestral pattern inherited from the common ancestor with chimpanzees. However, ecological analogies suggest that primates in open environments subject to predation pressure are unlikely to have female natal dispersal patterns due to the high dangers of dispersal. Furthermore, recent studies of inter-group dispersal suggest that primate natal dispersal is fluid, contextual, related to social ranking and often involves dispersal of both sexes (Anderson 1987; Ron *et al.* 1994). Strengthened inter-group networks could have provided improved colonisation success rates by creating a support network of reliably available resources and mates, but this does not depend on patriliny.

Archaeological aspects of the models.

Foley's (1987a) proposition that lithic assemblages are correlated with hominid species is problematic on several levels. He treats behaviour as an aspect of the species phenotype, transmitted vertically from parents to offspring, denying the possibility that horizontal transmission, through observation and learning from the peer group, took place before the advent of *Homo sapiens* and modern behaviour, despite suggestions of horizontal transmission of behaviours among non-human primate groups (Hohmann and Fruth 2003). Therefore, Foley argues that the spread of a technological practice must reflect movements of biological populations rather than diffusion of ideas. However, horizontal transmission is difficult to dismiss as hominid species were living in sympatry at several times and places, seen in the finds of multiple species at sites in East Africa. It is therefore difficult to attribute the manufacture of lithics to any single species, as several had sufficient manual dexterity (Susman 1991). Foley argues that the appearance of lithic industries at the time of hominid speciation events suggests that the new species was responsible for the technological developments. However, this argument does not rule out the possibility of spread of innovations across species barriers after the initial development of the technology. Furthermore, it seems likely that competition from a new species would induce behavioural changes among the existing members of a community. Foley (1987b) argues that the modes of technology linked to each species reflect cognition, and the cognitive differences between species would be too great for transmission of concepts of technology. However, as technological options and innovations in lithic manufacturing during the Palaeolithic were limited it seems possible that a species capable of mastering one technique may have been able to learn another, especially once Acheulean levels of technical complexity and cognitive ability were attained (Wynn 1979).

The second theoretical criticism of Foley's correlation of lithic assemblage types and hominid species is that he does not consider multiple origins of lithic innovations. Foley treats technological innovations as physical traits, developing as solutions to environmental problems under isolated conditions, via allopatry. Traits originated in a single time and place, and spread by the dispersal of individuals. Convergence or parallelism is considered highly unlikely; therefore, similarity of form is a marker of shared population history. This is unlikely to be a valid approach to the archaeological record because tools have many functions that solve different problems, and the same technological development may solve problems in several contexts (Rolland 1981). Furthermore, lithic reduction is constrained by the properties of the raw material (Dibble and Rolland 1992); thus, innovations in knapping strategies are limited in possibility. Variation in the form of the final product is potentially great, but variation in the techniques of manufacture is constrained; hence, it is possible that the same developments in lithic technology appeared at several points in time and space, and do not have significance in inferring population history (Kozlowski 2001).

Empirically there are problems with the model of a direct correspondence between tool assemblages and hominid species. *Homo erectus* in Africa is associated with the Acheulean, whereas in Asia *Homo erectus* used a chopping tool culture lacking handaxes (Lahr and Foley 1994). Foley (1987a; 1992)explains this as resulting from loss of Acheulean elements as the result of dispersal across tropical Asia and the use of organic materials in technology, which requires him to reject proposed early dates for the site of 'Ubeidiya in Israel, and the earliest dates for the occupation of Java. Alternatively, the lack of handaxes in Asia is explained by the dispersal of hominids into Asia before the development of the Acheulean in Africa at 1.6-1.4 Mya, and subsequent isolation preventing the dispersal of the new technology (Lahr and Foley 1994; Foley and Lahr 1997), relying on early dates for occupation of Southeast Asia at c.1.7 Mya (Swisher *et al.* 1994) being correct. The early dating of hominid fossil material from Java has been questioned on the grounds of geology and the fossil provenance (Langbroek and Roebroeks 2000). Foley can be seen to be selecting dates to fit the model of dispersal favoured. Furthermore, the lack of Acheulean technology in eastern Asia has also been challenged (Yi and Clark 1983; Schepartz *et al.* 2000), suggesting that eastern Asia may not have been as isolated from the rest of Eurasia as previously believed. Moreover, Foley ignores the presence in western Asia of the Acheulean from 1.4 Mya at 'Ubeidiya (Bar-Yosef and Goren-Inbar 1993) and at Gesher Benot Ya'aqov at 750 Kyr BP (Goren-Inbar *et al.* 2000), in order to show that the Acheulean appears as a result of a dispersal event at c.500 Kyr BP associated with the spread of "archaic" *Homo sapiens.*

Foley links the Mousterian to the Neanderthals in Europe and the Near East. However, at the sites of Skhul and Qafzeh in Israel, anatomically modern humans are associated with a Levallois-Mousterian technology. Foley and Lahr (1992) attempt to overcome this problem by associating the Tabun C phase of the Levallois-Mousterian with *Homo sapiens* and the following Tabun B phase with Neanderthals. However, the female Neanderthal fossil Tabun C1 is poorly provenanced and could be derived from the level C deposits rather than level B, therefore being associated with the presumed anatomically modern human industry (Vandermeersch 1989). Furthermore, the Tabun sequence shows technological continuity between phases and does not fit a model of separate technologies of the species (Jelinek 1990). Lahr and Foley (1994) admit that there are no clear technological distinctions between the Neanderthals and *Homo sapiens* in the Levant.

Foley also suggests that blade technology is exclusively associated with *Homo sapiens*. This proposition does not imply that all anatomically modern humans possessed blades, but that no other species made blades. The early "transitional" industries of the African Middle Stone Age, such as the Howieson's Poort and Stillbay industries, are taken to be markers of the development of modern behaviour and blade technology in Africa, with continuity from the Middle Stone Age. The Middle Palaeolithic in areas beyond sub-Saharan Africa is portrayed as more static and showing no developments towards the Upper Palaeolithic. However, there is technological discontinuity after the Howieson's Poort and Stillbay industries, as Middle Stone Age industries re-appear in South Africa (Wurz 2002). Moreover, Foley makes no mention of European Middle Palaeolithic sites with blades, such as Seclin (Bar-Yosef and Kuhn 1999; Kozlowski 2001). He also attributes the "transitional" terminal Middle Palaeolithic industries in Europe, such as the Chatelperronian and the Szeletian, to acculturation of the Neanderthals in the presence of *Homo sapiens*. However, Neanderthal acculturation contradicts his theoretical justification for the model, as it could only occur by cross-species horizontal transmission of technological concepts. Foley shifts emphasis in the mid 1990s from the problematic association of modern humans with blade technology to the link between anatomical modernity and prepared cores.

The mode 3 hypothesis put forward by Foley and Lahr (1997) suggests a dispersal of mode 3 bearing hominids from Africa to the Near East at c.250-300 Kyr BP. This has the virtue of providing an explicit reason for the similarity in behaviour and technology of the African Middle Stone Age and the European Middle Palaeolithic. However, several problems arise from this hypothesis. The fossil morphology of hominids in Europe during the Middle and Late Pleistocene of Europe shows strong continuity until 45 Kyr BP (Stringer and Hublin 1999). Foley and Lahr (1997) admit this is the case, but suggest that emergent Neanderthal traits in European *Homo heidelbergensis* could result from convergent trends in hominid evolution to cold environments. This is special pleading as the model is designed to overcome the problem of behavioural convergence. Foley and Lahr also suggest that shared traits of European *Homo heidelbergensis* and the Neanderthals could be primitive retentions from their common ancestor, or the result of admixture. The lack of chronological resolution of the European fossils, and of an African fossil record at this period, and the evolutionary proximity of the African and European groups suggested undermine attempts to use the fossil record to test the model. Furthermore, the genetic evidence supporting the timing of the common ancestor of Neanderthals and modern humans at less than 500 Kyr BP in the mode 3 hypothesis (Foley 1998) is based on very small sample sizes and is liable to reinterpretation as more evidence becomes available.

The mode 3 hypothesis depends on the earlier appearance of Levallois technology in sub-Saharan Africa than elsewhere. The model predicts a lack of evidence for indigenous development of prepared core technology from the local Lower Palaeolithic outside of Africa, which has been challenged (White and Ashton 2003). Foley and Lahr (1997) admit that there is some evidence for the presence of Levallois in Europe before their proposed dispersal date, but explain this away as evidence of further dispersal events. The suggested timing and direction of the spread of *Homo helmei* into Europe during an interglacial at 300-250 Kyr BP is plausible in terms of biogeographical opportunity allowing spread north from sub-Saharan Africa during interglacials, but this does not confirm that dispersal took place, only that the opportunity for its occurrence is conceivable. However, the appearance of Levallois technology in the OIS 10 glacial in Europe (Kozlowski 2001) undermines the claim that hominids could only move north from Africa during interglacials, if the emergence of mode 3 does represent population movement.

The mode 3 hypothesis assumes that the technological modes defined by Clark (1977) correspond to cognitive levels. However, as the stages are additive, a hominid with one mode will also be able to make one of the lower level modes, thus the technological modes do not support linear change (Bar-Yosef and Kuhn 1999), contra Foley's interpretation of the temporal sequence of modes. Therefore the continued presence of mode 2 in Europe after mode 3 appears does not necessarily mark the presence of two hominid species, it is possibly the result of technological variation within one population. Foley and Lahr (1997) claim that technological modes are normative, describing the general behaviour of a population, allowing comparison without having to consider small variations and deviations from the norm. However, individual assemblages are defined by the presence or absence of particular tool forms, or technological manufacturing techniques; the presence of one handaxe results in the assemblage being attributed to mode 2, or one Levallois core to mode 3. Hence, the technological modes do not describe the normal patterns of behaviour of hominids, and comparison between regions in terms of cognitive abilities, or technological potential, based on the use of technological modes is misleading. Moreover, Foley (1995b) creates a cognitive threshold of 1000cc at the appearance of *Homo helmei*, which he claims required radical restructuring of subsistence and ontogeny to support growth of large brained infants, which led to changes in group size and the development of language. Foley claims that only an influx of hominids from Africa could explain these changes in Europe, since so many developments happened contemporaneously. However, these processes are the result of his splitting of a continuum of fossil cranial capacity, prefiguring the revolutionary changes and need for dispersal as an explanation.

Empirical and theoretical problems also arise from the multiple dispersal model of modern human origins put forward by Lahr and Foley (1994, 1998). Lahr and Foley (1994) admit that there is little fossil evidence supporting the archaeological evidence in Africa in the Late Pleistocene of pre-existing diversity before dispersal. This model uses technological patterns to track the movement of *Homo sapiens* groups, by assuming that archaeological assemblages can be directly correlated with ethnic groups. However, behavioural change is associated with dispersal or colonisation (Skeldon 1997). Often the most resourceful and innovative members of the population migrate; therefore, colonising groups are expected to show dynamic behaviour and high levels of innovation, thus the potential for the linkage of archaeological assemblages and populations is likely to be weakest during episodes of movement. The attempt to show the origins of the Aurignacian in North Africa and its arrival in the Levant by 50-45 Kyr BP (Lahr and Foley 1994) is unnecessary. The population that eventually moved across Europe with the Aurignacian may have originated in North Africa, however, the Aurignacian "package" of behaviours could have come together at any stage *en route*, and is unlikely to have been fully formed at the origin. The Aurignacian could be the outcome of movement, rather than its cause as envisioned by Foley. Foley and Lahr do not consider human ability to generate change; all behaviour is treated as historically and biologically determined and the equivalent of biological adaptations, leaving no room for ideas of agency.

The routes proposed for the dispersals out of Africa are suggested because of faunal movements across these areas during interglacials in the Pleistocene. However, there is a lack of direct evidence in the form of fossils or archaeology for the eastern route via the coast of Arabia. There is archaeological evidence in the Sahara at roughly 50 Kyr BP, but no associated fossil material (Vermeersch 2001). Assuming a route was viable because it has been used by other species during other interglacials is not sufficient evidence to support the model. Lahr and Foley (1994) argue that the northern route regularly opened during early interglacials due to wetter climatic conditions. However, the constant presence of the Nile corridor is not mentioned, prefiguring the argument towards the ecological reasons put forward for the timing and route of hominid dispersal. The limits to the dispersal of anatomically modern humans into the Levant are argued to be due to competition from other hominid populations around the Mediterranean and in Asia. Moreover, the timing of *Homo sapiens* appearance in Europe during OIS 3 refutes Foley's model of movement into northerly latitudes being restricted to interglacials. Furthermore, the earlier opening of the eastern route than the northern route is explained by competition from other hominids in the Levant, without consideration of the possibility of populations being present in southern Asia. Foley and Lahr (1997) argue that the eastern route is consistent with the use of watercraft, as a coastal adaptation, explaining the ability of this group to reach Australia. However, this route is used by Foley and Lahr to explain earlier events without considering if watercraft were necessary to cross from Africa to Arabia.

In summary, Foley highlights the ecological background to dispersals, and predicts that spread should proceed through habitats in order of their similarity to African environments, during interglacials. Foley lists the adaptations of hominids that allowed dispersal as large body size, generalism, carnivory and behavioural flexibility, and puts forward population increase and environmental change as the causes of dispersal. Foley links technological developments to hominid speciation, thus movement is predicted to follow the appearance of new physical and technological traits. The data collection and analysis in the following chapters will attempt to detect evidence of these features of movement.

Rolland's Dispersal Narratives.

Aims and agenda.

The focus of Rolland's writings about colonisation concerns the routes and timing of hominid movements, in order to discern the behaviours involved. Rolland's specific aims are:

- to ascertain the date of the earliest hominid presence in Europe (Rolland 1978, 1992, 1998b);
- to delimit the nature of the first industries in Europe and thus determine their point of origin (Rolland 1978, 1992, 2001);
- to resolve whether migration and diffusion of technology, or indigenous development and technological convergence explains assemblage similarities between regions (Rolland 1986);
- to establish the routes of hominid penetration into Europe and subsequent cultural or population movements within and outside Europe (Rolland 1986, 1992, 1998b);
- to explore the effects of physical and climatic barriers on hominid colonisation of Europe (Rolland 1992, 2001);
- to integrate hominid colonisation into a biogeographical and socioecological framework (Rolland 1978, 1992, 2001);
- to reconstruct the behaviours and adaptations that contributed to dispersal (Rolland 1998b, 2001).

Theoretical view.

Rolland argues that socioecological principles derived from non-human primates, modern human hunter-gatherers and social carnivores can be used to interpret the archaeological record. He applies ecological, but not phylogenetic analogies, as social carnivores are used equally with primates. He employs historical biogeographical models, using uniformitarian logic to create linkages from observable ecological patterns in the present to unobservable processes in the past. He does not explicitly discuss the justification behind the interpretive models he borrows from biogeography, beyond arguing that hominids should be investigated as members of an ecological guild and community, and thus general ecological principles should apply equally to hominids as to other species.

Rolland treats hominid behaviours as environmental adaptations, analogous to those of other species. Behaviour is seen as gradually changing in response to the external environment. Adaptations to environmental conditions are taken to be generalisable across regions; for example, hominid presence in temperate China indicates ability to occupy temperate Europe at the same time (Rolland 1998a). Throughout his writings technological variation is considered to coincide with climatic change and to be environmentally driven. Behaviours are linked to mechanistic economic principles of resource availability determining the extent of usage (Rolland 1986). Thus, he follows ahistorical laws of interpretation, derived from ecology and economics.

Rolland adheres to a gradual view of change, justifying the deep time depth of behaviours such as fire use, hunting of large mammals and food sharing (Rolland 1978), and the lengths of time between colonisation events into different habitats (Rolland 1998b). The presence of these behaviours is then linked to the ability to colonise new environments. Hominid behaviour is portrayed as flexible and responsive to external forces of the environment, allowing eventual adaptation to overcome barriers; thus, biogeographical principles govern the route and timing of colonisation. Therefore, Rolland (1999) predicts that movements will follow ecological zones, proceeding through habitats in order of their similarity to African tropical grasslands, and proximity and ease of access to hominids.

Rolland regards change as a linear process, with no possibility of reversals. He (1992) argues that once a technological stage has been reached then reversion to former technologies cannot occur. He does not allow mode 1 (Clark 1977) industries to persist once mode 2 has appeared, total replacement occurs. The presence of non-handaxe industries in the Far East is argued to be a modified mode 2, not mode 1, because mode 2 had already developed. Separate handaxe and non-handaxe traditions within regions are rejected (Rolland 1998b) due to the presumed open nature of

Lower Palaeolithic social and demographic groups, and the behavioural flexibility of hominids. However, Rolland (1978) rejects the idea of typological dating in the Palaeolithic, and the assumption that in every region there should be a linear progression from pebble-tool industries to the Acheulean.

Gradual and linear change justifies Rolland's view that similarities in lithic industries during the Lower and Middle Palaeolithic can be attributed to population movements or diffusion of ideas. Rolland (1986) acknowledges that there are limited possibilities available for lithic reduction, and supports the independent invention of prepared-core techniques in several areas during the Middle Pleistocene as a logical outcome of Acheulean reduction sequences. However, similarities in the details of technology of the Lower Palaeolithic are considered unlikely to be independent inventions. Therefore, he believes that idiosyncrasies in technology shared between regions in proximity to one another represent population movement (Rolland 1986). Nevertheless, Rolland (1998b) admits that some assemblage modification may have occurred before and during dispersals. He focuses on the fine scale divisions within Palaeolithic industries in order to determine their relationships to one another. He (1978) does not correlate technological divergence with speciation. He expects regional traits to develop in manufacturing techniques as hominids became established across the Old World, but does not anticipate biological divergence because gene flow maintained the species unity. He allows hominid species to be technologically flexible, and even accepts cross-species transfer of technology (Rolland 1978). The only linkage drawn by Rolland between hominid phylogeny and technology is the appearance of the Acheulean and *Homo erectus*; subsequent technological developments are linked to populations, not species.

Throughout Rolland's work early hominids are portrayed as possessing culture and being on a trajectory towards modern human behaviours and release from intimate ties to the ecosystem. Thus, socioecological principles are not able to elucidate all hominid behaviours, and environmental adaptations were not the only developments in hominid behaviours before the emergence of modern behaviours. He argues that hominid behaviour, especially technology and culture, released the ecological constraints limiting primates, resulting in hominids becoming socially specialised. Thus, he justifies his search for aspects of modern behaviour in pre-modern hominids, and the gradual emergence of these features. Furthermore, this perspective supports the use of ethnographic rather than ecological analogies.

Models of dispersal.

Rolland's approach centres around two themes, that hominid dispersal needs to be considered in biogeographical context, and that similarities in lithic technology can be used to trace connections between regions. Palaeogeography is used to predict routes and archaeological similarities are then used to choose between alternatives.

The Biogeographical Models.

Historical biogeography attributes movement to either population growth or environmental change. Population growth is predicted to create pressure on resources and result in the evolution of a propensity towards migration (Rolland 1998b). Environmental change induces habitat shifts and thus movement occurs within the original biome. Environmental change drives evolution and co-evolution with other members of the community, and therefore is linked to the development of new adaptations allowing spread beyond the original range. For example, carnivory is associated with dispersal, because it allowed hominids to become more generalist, and required maintenance of low population densities (Rolland 1998b). Rolland (2001) also associates bipedalism and a capacity for culture with the ability to disperse in hominids, although the reasons for these linkages are not explained.

Rolland (1992, 1998b) describes movement as occurring through corridors, filters or sweepstake routes, and being prevented by barriers. Corridors are areas where the chances for large-scale spread are high, because of the presence of few natural barriers; for example, the Eurasian corridor linking Europe and China, and the Levant corridor between Africa and the Near East. Filters allow spread between regions of only certain species due to a selective barrier; such as crossing the Sahara via desert oases (Rolland 1992). Sweepstake routes are crossings occurring during brief windows of opportunity and are highly improbable, due to the effective barriers to movement that they cross. Sweepstake routes are traversed by single species or populations, for example modern human colonisation of Australia. Rolland (2001) expects colonisation to happen by a process of stochastic and repeated movements into new regions, with extinctions of overstretched founder populations before establishment. Patches of suitable habitat will remain uncolonised due to the nature of the demographic processes involved.

Barriers to dispersal into Europe are both physical, in the form of mountains or seas, and environmental due to temperature, seasonality, resources, competition and day length. Palaeoecological and palaeogeographical reconstructions are central to the placement of barriers. Highlands and seas are assumed to constrain hominids, but their ability to overcome these hindrances varies through Rolland's writings. Physical barriers delimit the likely routes of hominid movement, by reconstructing areas hominids could not pass through. This process relies on inferring environmental tolerances and adaptations, and thus changes as interpretation of hominid behavioural capacities shifts. However, the routes taken are also used to reconstruct the adaptations that hominids must have possessed to survive in the environments which they passed through, and hence the causes and processes of the colonisation event.

Rolland (1992) also attempts to link hominid movements to the dispersal of other mammalian species, especially large social carnivores. He argues that movements of prey and competitor species should be considered in explanations of dispersal. Thus, hominid dispersal should be treated as the expansion of a species of the Ethiopian faunal region into the Oriental and Palaearctic regions (Rolland 1998b). He argues that the movements of other fauna show the routes that were habitable and open to hominid colonisation, for example the Galerian faunal dispersal from Asia to Europe within the Palaearctic faunal region (Rolland 1992). Rolland assumes that communities or faunal guilds, rather than individual species are the unit of dispersal. However, jump dispersal applies to species moving individually, thus when hominid movements cannot be accommodated in community dispersal biogeographical principles still apply.

Routes and timing of dispersals.

Rolland's models have responded to the findings of new sites and changes in the accepted date of hominid appearance in Europe, therefore his models will be presented in chronological order.

Rolland (1978) places hominid colonisation of Eurasia at 0.7 Mya at minimum. The early occurrences in Europe may have been sporadic, and were mainly located in Mediterranean and Western Europe, with few in Central and none in Eastern Europe; due to the need for adaptation to temperate, cold and glacial climates. The earliest European industries are non-handaxe or "Pre-Acheulean". Rolland admits that these early sites contain small assemblages, and therefore could represent brief occupations with an impoverished Acheulean repertoire. However, he suggests that their distinct chronological clustering does represent a pre-Acheulean phase of occupation, contemporaneous with Acheulean industries in Africa, and thus handaxes absence requires explanation.

Rolland (1978) proposes two possible routes into Europe: indirectly through Southwest Asia, or directly between Tunisia and Sicily or Morocco and Iberia. The third alternative across the Eurasian steppes from Central or Eastern Asia is dismissed due to a lack of sites. The route via Gibraltar is supported because of similarities between the non-handaxe industries in the Maghreb and Iberia in the early Middle Pleistocene. This is despite the lack of a biogeographical context for movement, as no other species used this route, thus a landbridge is unlikely to have existed. Rolland attempts to overcome this problem by suggesting that a landbridge existed briefly during a Middle Pleistocene glacial. He also connects the Acheulean in North Africa and Southern Europe, claiming technological distinctions from the Northern European industries, by the presence of flake-cleavers. Therefore, hominid movement between Africa and Iberia may have happened more than once. He further suggests that regional idiosyncrasies of the European Acheulean might be explained by several diffusionary waves from different directions. Alternatively, he proposes in situ development of the Acheulean variants. Moreover, he suggests that Levallois techniques developed in Northwest Europe from bifacial technology, whereas in Southwest Europe prepared-core technology emerged from the Southern Acheulean and its links to Africa.

Rolland (1986) continues to support the route across the Mediterranean for the Southern Acheulean, because of the technological similarities. Crossing of the straits of Gibraltar is justified by analogy to Australian colonisation in the late Pleistocene. He treats the Northern and Southern Acheulean industries as belonging to distinct, isolated groups; cases of interdigitation of the industries in France, at the border between the regions, are explained by environmental fluctuations causing population movements as habitat zones shifted across Europe. The Northern Acheulean either derived from industries in the Levant via a route through Anatolia and Greece, or developed independently in Northwest Europe. The emergence of the Middle Palaeolithic in Europe either resulted from the Southern Acheulean tradition, with links to the Victoria West industries of Africa (Rolland 1986), or from the indigenous Acheulean without population movements from Africa (Rolland 1988).

Rolland (1992) retains a pre-Acheulean European occupation, dating to 900-550 Kyr BP. This requires the rejection of early dates for Acheulean sites in Europe, but acceptance of non-Acheulean occurrences, prefiguring the data into the pre-Acheulean category. Initial occupation took place in the late Lower Pleistocene, earlier than in his previous writings. He states that evidence exists for the occupation of Asia beginning at 1.25 Mya; the colonisation of Europe was later, and the reasons for this need addressing. The solution forwarded is that Southern Asia provided habitat continuity for a tropical African species and therefore was easier to colonise than temperate zones in Europe and Northern Asia, which required adaptations.

Rolland (1992) rejects the pre-Acheulean phase in Europe as a belated persistence of the Oldowan, because the Acheulean replaced the Oldowan in Africa before the colonisation of Eurasia began at 1.25 Mya. Moreover, he emphasises that the level of technology and variation in the assemblages reflects an Acheulean mode 2 (Clark 1977) industry, only handaxes are absent. He dismisses the loss of handaxes as a result of adaptation to European climate, since the climate cycled several times before the appearance of the Acheulean, without corresponding changes in technology. Therefore, the colonisers must not have possessed the Acheulean before entering Europe, and their source was in areas also lacking in handaxes. The Levant and the Maghreb are dismissed as sources because they lack a non-Acheulean phase, and there is no biogeographical faunal dispersal context for hominid movement either across the Mediterranean or from the Levant to Europe. This requires rejection of the non-handaxe horizon proposed by the excavators at 'Ubeidiya (Bar-Yosef and Goren-Inbar 1993) as being distinct from the Acheulean, prefiguring the data into his model.

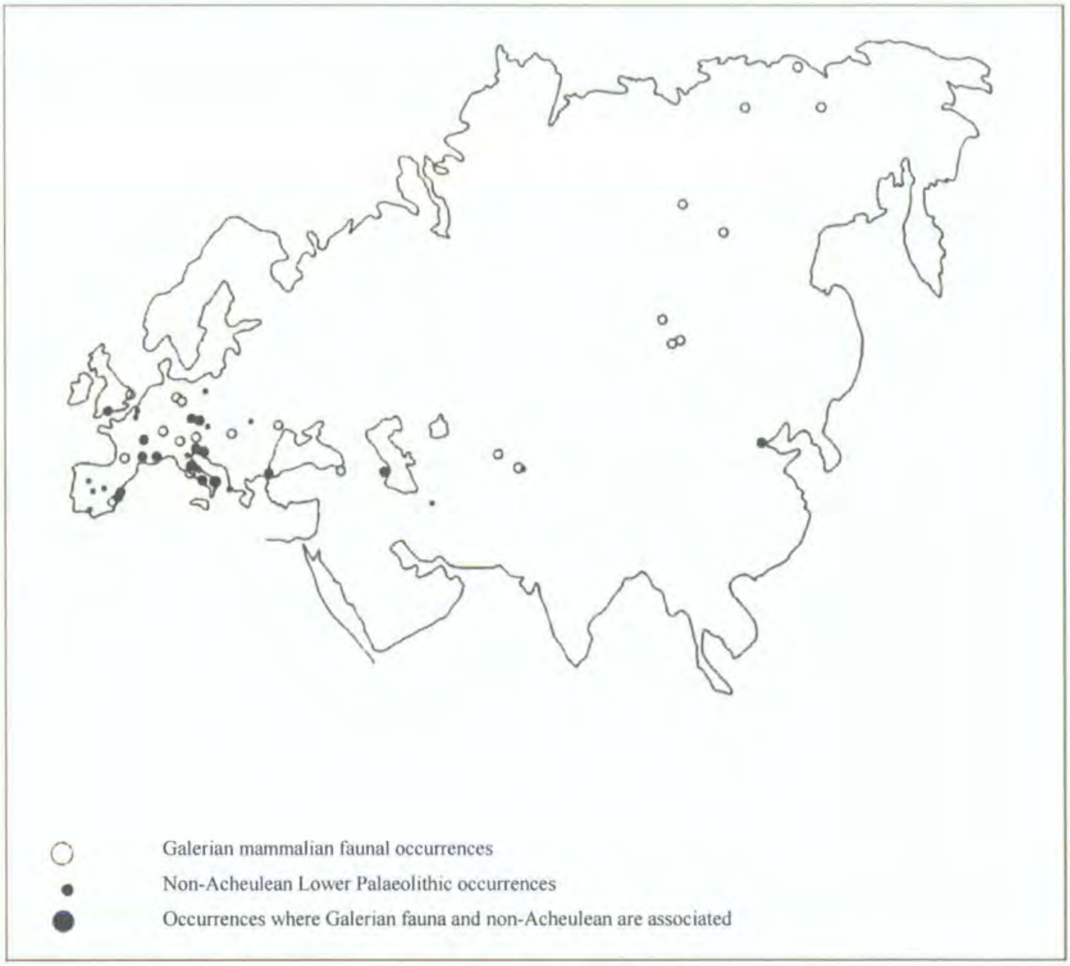
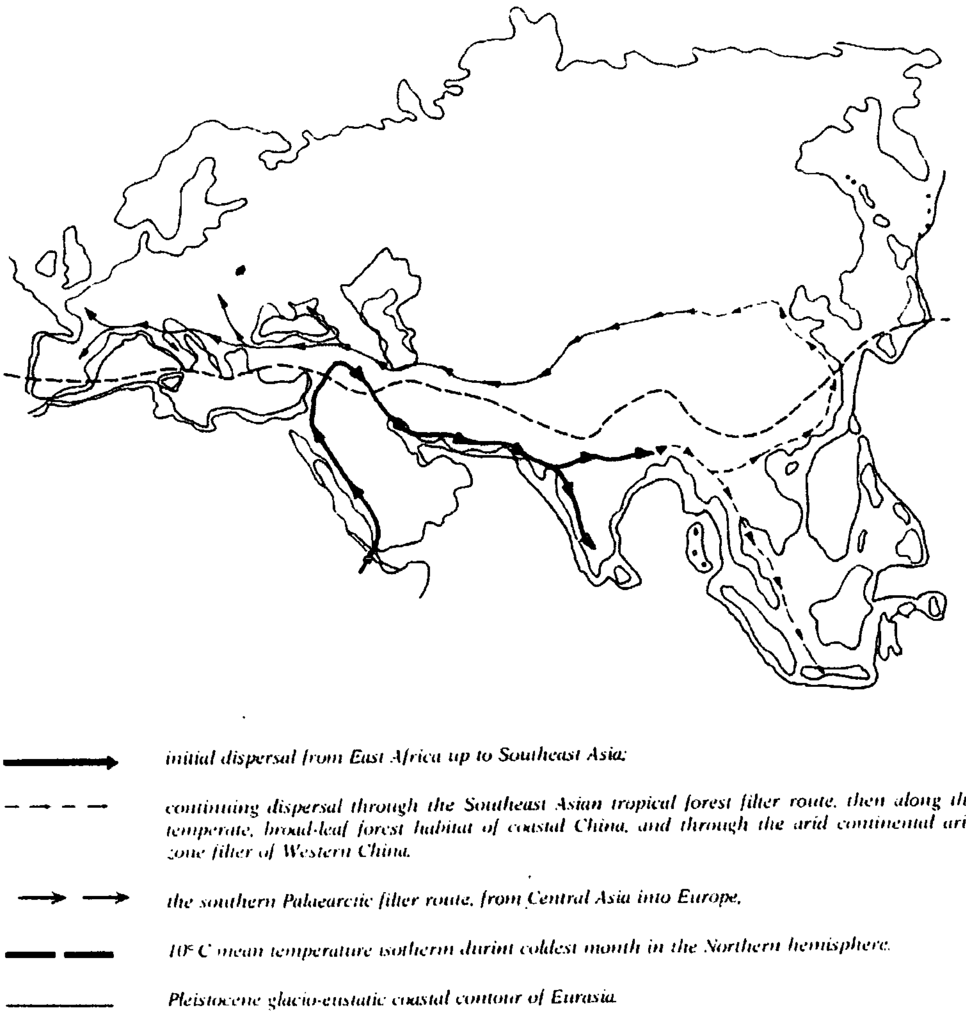


Figure 3.5. Map showing the locations of Galerian faunal sites and non-Acheulean archaeological sites. (After Rolland 1992)

A Far Eastern origin with movement across Central Asia is favoured, because of shared non-Acheulean mode 2 industries, dating from 1.1 Mya in Northern China, providing an antecedent for the European pre-Acheulean phase. Moreover, several species dispersed from Central Asia into Europe along the proposed route, during the Galerian faunal turnover, supporting the existence of a biogeographical corridor at this time, shown in Figure 3.5. Non-Acheulean assemblages in Central Asia, coincident with the appearance of Galerian fauna corroborate this route. It also circumvents the mountains and high plateaux, and Mediterranean, Black and Caspian Seas blocking the entrance to Europe from the Levant, and provides a gradual transition between ecological zones, allowing adaptation to overcome the 10° isotherm during winter; and the ecological barrier of 30-40° latitude, shown in Figure 3.6. However, Rolland continues to cautiously support a North African origin for the Acheulean.



initial dispersal from East Africa up to Southeast Asia;

continuing dispersal through the Southeast Asian tropical forest filter route, then along the temperate, broad-leaf forest habitat of coastal China, and through the arid continental arid zone filter of Western China.

the southern Palaearctic filter route, from Central Asia into Europe.

10° C mean temperature isotherm during coldest month in the Northern hemisphere.

Pleistocene glacio-eustatic coastal contour of Eurasia.

The large-scale loop shown on the map traces hominid population dispersal route circumventing the major East-West trending mountain barrier of Eurasia.

Figure 3.6. Map showing the proposed routes of hominid dispersal out of Africa, through southern Eurasia, and westward into Europe. (After Rolland 1992)

Rolland (1998b) discusses two chronologies for European colonisation. The long chronology involves a pre-Acheulean phase, explained by dispersal into Eurasia predating the appearance of the Acheulean at 1.4 Mya. This scenario is dismissed because regions adjacent to Europe contain Acheulean assemblages by 0.9 Mya, the earliest plausible date for European occupation. Moreover, it depends on Asian colonisation before 1.4 Mya, which he rejects for a maximum date of 1.25 Mya. Thus, the source of a pre-Acheulean European population must be the Far East, following the 1992 model. The short chronology of European colonisation at 0.6-0.5 Mya, implies Acheulean occupation, as it post-dates Acheulean development; thus, non-handaxe occurrences are modified mode 2, not mode 1. This places the non-handaxe sites as contemporary with Acheulean assemblages, explained by variation within the Acheulean. He continues to reject the idea that handaxes could be lost during colonisation of Europe, but admits that the Levant could be the source, as it contained Acheulean assemblages. However, he argues that barriers to movement between the Levant and Europe would still exist; supported by rare, late and atypical assemblages in Anatolia and Eastern Europe compared to the West. He therefore favours a route via Gibraltar, because of technological similarities. He proposes brief periods of opportunity for hominid crossings of the straits during OIS 12 and 16 when sea levels were extremely low. This is justified by the sudden appearance of abundant and widespread archaeological evidence in Western Europe, which is compared to a biological invasion breaching a barrier and rapidly spreading through suitable habitat. Furthermore, *Homo erectus* presence on the island of Flores in Indonesia is used to infer that hominids could cross marine barriers (Rolland 1998a).

Rolland (1998a, 1998b) proposes that both the long and short chronologies may apply, because exploratory episodes could occur before major colonisation. He (1998b) suggests a series of sporadic and insubstantial incursions before the appearance of the Acheulean at 600-500 Kyr BP, as an alternative to origination in the Far East, to explain the long chronology. Rolland (1998a) warns that this intermittent settlement may be untraceable in the archaeological record, but could be seen in repercussions in the faunal community. He demands that the pre-Acheulean nature of early assemblages be tested, as there is no intrinsic reason to assume that a long chronology must have a pre-Acheulean phase. He warns against dismissing the long chronology by rejecting bona fide sites in secondary context, and the danger of assuming that no new evidence will be found.

Rolland (1998b) discusses the same ecological, topographical and climatic barriers as before. Physical barriers are treated as more significant than climatic barriers. Ecological barriers are given little importance since adaptation could overcome these restrictions, and hominids had adapted to Mediterranean habitats well before the occupation of Europe (Rolland 1998a). Following the principle of environmental matching during spread, he suggests that adaptation to fluctuating climate and habitats of Northern and Central Europe occurred later than occupation of the south (Rolland 1999). Therefore, initial occupation of temperate zones took place during interglacials, with retreats to refugia during glacials. Hominids begun to expand their range of food resources during OIS 11, and by the end of OIS 9 were associated with steppe fauna. He links the expansion into cold steppic habitats of northern Europe and continental Asia, and high altitude areas, with the development of the Middle Palaeolithic.

Rolland (2001) suggests environmental fluctuations exposed hominids to new habitats into which they subsequently dispersed, thus movement coincided with climate change. He asserts that by 800 Kyr BP large areas of Eurasia had been settled, but a barrier existed at 40-43° latitude, relating to the lack of fire making technology, and cold winters with short daylight hours. He repeats the association of hominids with the Galerian faunal dispersal, but denies hominid movement from the Far East to Europe, as lacking evidence to the west of Iran. He reiterates the two phase model of European colonisation, with the south-west occupied between 900-780 Kyr BP via Gibraltar to Iberia but not beyond; followed by more substantial occupation throughout Mediterranean and temperate Europe by 600 Kyr BP, after major adaptive shifts. Movement from the Maghreb to Iberia was possible during the OIS 22 low sea level. The initial phase of occupation was either atypical Acheulean, resulting from small assemblage sizes within a highly variable technocomplex, or was a pre-Acheulean horizon. He questions the validity of a pre-Acheulean phase, prefiguring the data to the expectations of a route from the Acheulean of the Maghreb.

Narrative analysis.

Rolland writes in a Metonymic trope, similar to that of Foley. He uses lithic industries to represent populations rather than species, but tools remain a substitute for the hominids. Rolland's Metonymy is expressed in his association of hominids with faunal communities, for example, the Galerian fauna (Rolland 1992). The presence of the fauna is used to infer the location of the hominids. A further use of Metonymy is the extrapolation of behaviours between hominid populations widely separated in space, such as the ability to cross oceanic barriers in Indonesia, used to justify movement from the Maghreb to Iberia (Rolland 1998b). A behaviour in one group implies its presence in all other contemporary groups, thus the date of an assemblage stands for the abilities of its makers, and all behaviours are potentially ubiquitous. A link is also drawn between the environments colonised, the technology possessed, and the timing of colonisation, thus the Later Acheulean equates with ability to survive in northern Europe, and the Middle Palaeolithic is associated with high altitudes and continental habitats. A Metonymic trope is associated with Tragic plot, Mechanistic argumentation, and Radical ideology.

The plot is Tragic in the majority of Rolland's writings. The route and timing of hominid movement is determined by external environmental circumstances. The barriers to dispersal are physical constants, over which the hominids have no influence. However, he (1998b) suggests that development of the ability to cross water released the constraints preventing hominids in the Maghreb from colonising Iberia, thus behavioural change removed an external constraint, and hence is a moment of Comedy, as hominids escape the forces determining their behaviour. Nevertheless, the proposed times of the crossing of the Straits of Gibraltar are forwarded due to global lowering of sea level, which facilitated the crossing, thus an external environmental factor underlies dispersal, and overall Tragedy is retained. Behavioural developments that help to remove environmental barriers to dispersal are themselves the product of environmental adaptation, and are constrained by external forces of climate, conforming to a Tragedy.

The argumentation used by Rolland is Mechanistic. Environmental and palaeogeographical reconstructions determine where hominids could survive, and how they adapted. For example, environmental matching predicts spread across southern Asia to India in the grassland biome, before dispersal into areas requiring adaptation to new habitats. Also, handaxe loss in Southeast Asia, but not elsewhere, relates to tropical forest adaptation (Rolland 1992), with environments used to predict hominid behaviours, which are then extrapolated to other areas with similar habitat, and dissimilar areas are given different explanations. It is assumed that the same process cannot act in different environments. Explanation of variance in industries is by lithic economy, in which raw material utilisation is predicted from the ease of acquisition, and then is used to predict lithic forms. Thus, all variance relates to general economic principles and is Mechanistically linked to environmental parameters. Rolland's approach is strongly integrative, putting hominids within their biogeographical context and ecological community. He uses a systemic view of behaviour, with all elements interacting. For example, Middle Palaeolithic expansion into high altitude and cold continental habitats is explained by changes in subsistence and group structure, related to technological developments such as fire production, which resulted in home base centred settlement systems and lithic changes (Rolland 1996, 1999). This strong degree of integration is an aspect of Mechanistic reasoning.

The treatment of change in Rolland's writing focuses on gradual developments. The rate of change is exponential, depending on the existing state, and creating gradual accumulations of developments (Rolland 1999). He (1978) states that variation is expected but directional change is rare. Modern behaviours evolved over considerable periods of time, thus long-term directional trends are present (Rolland 1996). Rolland's support for the "mature Europe" model, with a phase of exploration before successful colonisation relates to his gradualist perspective, with long periods of exposure to new conditions being necessary before adaptation. Change occurred when the external environment demanded new behaviours. Rolland follows Radical ideology, as change is downplayed and innovation dismissed unless forced by environmental circumstances. External forcing of change due to the intrinsic inertia of behaviour is central to Radicalism. Also, the rarity of developmental change as opposed to stochastic variation creates punctuations, as expected within Radicalism, but Rolland attempts to overcome punctuated change in his writings by emphasising

Conservative continuity. For example, the novelties seen in the Upper Palaeolithic are described as latent capacities in the Middle Palaeolithic (Rolland 1990). However, despite the slow pace of change described, the mechanisms that bring about behavioural developments conform to Radical ideology.

Strengths and weaknesses of the model.

Rolland's use of biogeography has both strengths and weaknesses. His description of barriers, corridors and filters is correct. However, his view of sweepstake routes is incomplete. Rolland (1998b, 2001) suggests that hominids dispersed over the Straits of Gibraltar using a sweepstake route. Sweepstake routes involve movement of a single species over a barrier strong enough to prevent permanent survival within it, and thus must be crossed very rapidly, usually by passive means such as accidental rafting (Brown and Gibson 1983). Hominids might have been accidentally swept across the Straits of Gibraltar, but as a large bodied and slowly reproducing species, it is unlikely that transport was passive, or that a sufficiently large founding population could be established without active movement. Moreover, the currents through the Straits are treacherous, and do not flow from North Africa to the Iberian coast (Garcea 2004). Rolland describes sweepstake routes as representing short windows of opportunity for colonists when the route is open. However, the presence of a landbridge would allow other species to disperse, forming a filter. Crossing by artificial means, without other species, involves the removal of the barrier, and again is through a filter. Rolland (1986) argues for the ability to cross water, using the analogy of modern human colonisation of Australia in the Upper Pleistocene, which is difficult to uphold as it extrapolates behaviours between species, over vast stretches of time and space. Moreover, hominid presence on Flores during the Lower Palaeolithic, if true, does not imply that hominids in the Maghreb were capable of water crossings, as these populations would not have been in direct contact to exchange innovations.

Rolland's conception of corridors and filters does fit biogeographical theory. However, natural communication corridors between areas may have a history of repeated faunal immigrations, resulting in resistance to further invasions, thus producing a biotic barrier, not a corridor (di Castri 1990). Therefore, status as a corridor needs testing rather than asserting. Corridors and filters are dynamic because habitats shift as climate changes; thus, Rolland (1992, 1998b) is correct in predicting climatic change to result in range shifts and dispersal. However, hominids dispersed from Africa into markedly different habitats, hence movement cannot have only been through corridors. He attempts to show that hominids were moving with other species, thus ecological conditions allowed the movement, since environmental changes affect the distribution of many species simultaneously (Myers and Giller 1988b). For example, Rolland (1992) links the distribution of archaeological and Galerian faunal sites across Eurasia, but does not consider problems such as poor research history in Asia, lack of sites across wide areas, and lack of chronological precision that could result in a false positive association between the datasets. The timing of expansion is therefore critical to its explanation, as the chronology determines the environmental circumstances in which the movement occurred. Furthermore, explanation of spread by environmental change requires high quality palaeoenvironmental reconstructions. The presence of other African species in Eurasia needs to be assessed to determine whether other species moved, and thus a filter was present, or whether hominids did move alone across ecological barriers.

Rolland, like Foley, uses the evolutionary principle of gradual adaptation to explain the spread of hominids into areas significantly different to African savannahs and woodlands. He suggests that hominid movements can be explained by a series of expansions following an environmental matching model into areas similar to the source, which is ecologically highly plausible (Michaux *et al.* 1990). Thus, hominids never moved into extremely unfamiliar habitats, they only expanded into areas after familiarisation and adaptation.

On a more fundamental level, Rolland's association of hominid movement with that of other species is questionable. He attempts to reserve movement independent of other members of the community for *Homo sapiens*. He proposes adaptations to novel conditions that allowed gradual expansion in a stepwise fashion. Adaptation implies that the movement demanded novel behaviours in order to survive. There is no ecological reason to expect that all, or even several, species in a community would undergo adaptation and expansion simultaneously. Biogeographical "events" are not necessarily unitary at ecological timescales (Myers and Giller 1988a), and Rolland

(2001) admits that the Galerian faunal turnover may be an ongoing process rather than an "event". Co-evolution does result in species improving survival in one another's presence (Simberloff and Von Holle 1999), but success of individual biological invaders attests to the potential for spread of individual species across community barriers. Biotic release in the absence of co-evolved competitors, predators and parasites can be enormously advantageous, leading to rapid and successful colonisation (Sax and Brown 2000). However, ecological biogeography also predicts invasional "meltdown" in which several co-evolved species move together, or sequentially, facilitating each other's spread by diverting resources from native species to their co-evolved companion species (Simberloff and Von Holle 1999). Invasional meltdown would appear to be simultaneous movement of species at geological time scales. Nevertheless, there is no intrinsic reason to assume that hominids moved in a community or guild. Moreover, correlating hominid movements with those of other species does not explain the timing and nature of the range shifts.

Rolland uses the biogeographical principle of barriers to predict routes of hominid movement. The model of barriers constraining the edge of the range due to a lack of suitable resources is ecologically observed (Virgos and Casanovas 1999). Rolland (1992) correctly identifies barriers by high levels of faunal endemism, revealing isolated communities, although endemic communities may be easily invaded if the surrounding barriers are breached (di Castri 1991). He assumes that high altitudes, high latitudes and oceans or seas would prevent hominid colonisation. However, hominids were able to survive in highlands at Gadeb in Ethiopia since the Developed Oldowan at 1.4 Mya (Haileab and Brown 1994), therefore high altitude is not intrinsically uninhabitable. Rolland (1992) argues that Anatolian aridity created a barrier, but as African savannah adapted primates, aridity is unlikely to have greatly affected hominids. Barriers are not intrinsically marginal; they are uninhabited due to the subsistence and reproductive behaviours of adjacent populations (Hanski and Gilpin 1991), and can be overcome by behavioural or biological changes, allowing adaptation to the conditions of the barrier (Pielou 1979). Barriers are also liable to change over time through adaptations and environmental fluctuations. Rolland uses barriers to infer hominid behavioural capacities, by predicting the presence of behaviours necessary for survival in a habitat. Areas of similar habitat to the origin of hominids are presumed to be corridors, and thus are routes of movement. This argument is circular, as the routes are considered to show the adaptations, but the adaptations reveal the routes. Rolland's (1992) claim that physical barriers are stronger than ecological barriers, because adaptation can overcome the latter is incorrect; adaptation can also overcome physical barriers. Moreover, ecological barriers can be strong, due to co-evolved communities without empty niches available to a potential invader (Case 1991).

Rolland (1978, 1998b) argues that a route from the Maghreb into Iberia is supported by the rapid appearance and density of archaeological finds in the west of Europe compared to the east, and follows the model of barrier breach, into an area of suitable habitat, through which rapid expansion and establishment occurs. This statement is plausible as an explanation of the distribution of Lower Palaeolithic material in Europe. Nevertheless, there are several limitations to this application of biological invasionary modelling. It would be plausible, if the areas through which hominids rapidly expanded were highly similar to the Maghreb. Iberia was ecologically close to North Africa, but the rest of southern and western Europe had distinctly different ecology. Thus, movement beyond Iberia would demand adaptation, as argued by Rolland (2001). There are also problems in the assumption that expansion was rapid enough to justify the analogy with biological invasions. The timescale of the expansion is unclear, and cannot be specified more precisely than to within one interglacial, which is far longer than the observations used to generate the model, thus the analogy may be inappropriate and other processes could apply. An alternative interpretation is that the oceanic climate of western Europe provided the optimal habitat, as winters would have been less severe, and resources would have been available throughout the year (Gamble 1986). Thus, the clustering of archaeological finds in the west may reflect the habitat preferences of hominids rather than the route of entry. In this scenario, a route from the east is possible, with few traces in the archaeological record because population density would have remained very low until the favourable habitats of the west were encountered. Rolland (1992) does consider the effect of habitat suitability on density of occupation, in order to explain the lack of sites in Eastern Europe, given his model of colonisation from the Far East.

Rolland (1998b) suggests that population growth could be a cause of hominid dispersal. He argues that the high reproductive success of modern humans has a biological basis, thus it is likely to have resulted in the evolution of a greater propensity to disperse in order to avoid resource stress during the Pleistocene. In evolutionary terms, this argument makes sense, as changes to reproductive biology are likely to be gradual, since this is such a fundamental aspect of biology. However, he makes no suggestions as to why hominid reproductive patterns changed, or what could have supported these developments. He also does not explain how increased population size could lead to adaptation to novel environments. Population pressure may cause expansion into marginal zones, but survival is not guaranteed and a population sink may develop, in which individuals may subsist but cannot reproduce (Hanski and Gilpin 1991). Therefore, population growth alone cannot explain the occupation of Europe; additional changes must have taken place.

Rolland (1998b) argues that carnivory is associated with hominid dispersal success. This is based on the broad environmental tolerances of carnivores, since their food source is ubiquitous; thus, by increasing carnivory, hominids became more generalist. This assertion is ecologically viable, if hominids were able to exploit a range of prey, and were not overly constrained by prey size or behaviours. Generalists are associated with dispersal success as they are more able to find food in unfamiliar habitats than specialists (Williamson 1996). However, some carnivores focus on a specific prey size, or prey with certain behavioural patterns, and therefore are more specialised than Rolland implies. Rolland also suggests that carnivores live at lower population densities than herbivores, since they are higher in the trophic pyramid, and their energy sources are more dispersed. This statement is true, but the degree of hominid carnivory is uncertain. Regular carnivory may have been practiced, but if it remained a low proportion of the diet, the impact on colonisation ability would be minimal.

Rolland asserts that hominid social behaviour, technology and capacity for culture are causes of dispersal. Physical preadaptations to dispersal are denied (Rolland 1992), despite features such as large body size, which correlate with broad environmental tolerances and high dispersal potential, in order to emphasise behavioural aspects of colonisation. This explanation is possible, but other species dispersed during the Pleistocene, without the benefits of technology or culture. Rolland (1992) denies the possibility that Oldowan manufacturing hominids dispersed, Acheulean levels of technology are assumed to be needed for survival beyond Africa. However, he does not expand upon why these traits should be advantageous in the colonisation of new habitats, apart from generally aiding adaptation. Moreover, he presumes that traits present in modern humans were at least partially present in earlier hominids, and were advantageous. Both of these assumptions can be questioned. Modern human traits may have deep time depth, but this is not immediately apparent from the archaeological record. Furthermore, human behavioural and biological traits may have been developing in a piecemeal fashion, and their combinations in pre-modern humans could have resulted in behaviours without modern analogues. Rolland's use of ecological and ethnographic analogies results in difficulties dealing with any behaviours not seen in the present day; thus, modern behaviours are projected into the past. Likewise, modern human behaviour is advantageous to modern humans in contemporary contexts; it would not necessarily provide the same benefits to earlier humans in the Pleistocene. Rolland needs to specify why and how culture and technology would benefit colonising populations, and the mechanisms through which these advantages would be felt. However, emphasis on behavioural flexibility in successful colonisations is ecologically correct (Boudjemadi *et al.* 1999).

Rolland's treatment of behavioural and technological change as being environmentally driven is both plausible and problematic. Environmental changes are likely to be related to behavioural innovations, since novel circumstances demand new behaviours for survival (Potts 1998). However, he seems to suggest that innovation only occurs due to external environmental pressures driving adaptation, as changes in tool manufacturing and other behaviours occur only under climatic forcing (Rolland 1981), leaving no scope for individual agency or other processes of change. He follows a biological, evolutionary view of behaviour, with isolated populations experiencing drift away from the traits of the main population, thus variants appear as hominids expand into diverse environments and become isolated (Rolland 1986). It is true that isolation is associated with unusual behaviours, but other factors may be involved. He also treats technological industries as bounded and uninfluenced by other assemblage forms; for example, the lack of interaction or adoption of elements between the Southern and Northern Acheulean (Rolland 1986), despite interdigitation in France. This lack of change in technology, or interaction with other industries justifies the search for origins in similar industries beyond Europe.

Rolland uses mechanistic economic principles to explain variation in Lower Palaeolithic lithic assemblages. The function and utility of tools explains their presence or absence. Economics of raw materials acquisition, relating to their prevalence, is the main cause of assemblage variation. Rolland portrays Palaeolithic industries as varying in response to resources. Thus, despite his focus on behavioural flexibility, the causes of variation are all external conditions to which the hominids reacted in a mechanistic fashion, the flexibility itself is actually environmentally determined. Rolland is therefore able to determine the sources of populations through their lithic industries because variation from the original assemblage composition can be predicted against environmental conditions and raw material availability, thus despite variance, connections between assemblages can be constructed. This approach is undermined by sources of variance beyond tool function and raw material accessibility. Specifically innovations are not accommodated within Rolland's model, and he does not discuss the problem that behavioural change is expected to occur during a colonisation or dispersal, regardless of environmental conditions, due to processes of isolation, adaptation and founder effects (Yom-Tov *et al.* 1999). Moreover, he contradicts himself by trying to show hominid behaviour as flexible, but then denying any variation beyond environmental adaptations in a mechanistic form.

Rolland argues that handaxe loss in Asia was due to there being little need for these tools in forests. He states that this process could not occur in Europe because European environments were not the same as those in Asia, and therefore could not have the same effect on technology, and climatic cycles in Europe do not correlate with loss or gain of handaxes; thus, European climate had no effect on handaxe possession. However, the function of handaxes appears to have been variable (Dominguez-Rodrigo *et al.* 2001) and may not directly correlate with habitat. Moreover, this argument does not hold if hominids lost handaxes from their repertoire during colonisation. Rolland (2001) specifically argues that adaptation is expected in new environments, but only applies this principle to the tropical areas of Asia. He does not consider that a lag may occur between environmental change and technological adaptation. Also, he assumes that the results of environmental adaptation are generalisable beyond their historical context, which contravenes the principles of adaptation that change occurs by adjusting existing behaviours and is thus strongly contextual. The argument that handaxes loss could not be the result of colonisation processes in Europe justifies the search for an antecedent non-Acheulean industry as the source of European colonisers. However, the impossibility of handaxe loss has not been clearly shown by Rolland, as Germany lacks sites with handaxes while the Acheulean is present in other parts of western Europe; hence, the source population could have been either Acheulean or non-Acheulean bearers.

The route from the Far East to Europe has been proposed from a mutual lack of handaxes. This is contentious because it links the areas by the absence of a tool form, rather than by positive evidence of shared manufacturing techniques, which is dangerous as it can be overturned by subsequent finds. The initial lack of handaxes in Europe is disputed due to dating problems and the uncertain anthropogenic nature of some of the material (Roebroeks 1994). Moreover, if the pre-Acheulean phase in Europe is present it could be the result of the small number of sites creating a sampling effect, as Rolland argues that non-handaxe occurrences are to be expected within the Acheulean. Nevertheless, it seems unlikely that no handaxes at all would be produced in an Acheulean using population (White 2000) or that sampling only detects non-handaxe sites. Also, Rolland rejects typological dating in the Palaeolithic, thus it seems contradictory to support the use of typology to trace populations.

Rolland uses lithic assemblage characteristics to trace the routes of hominid colonisation through manufacturing technology rather than typology to link regions. However, technology and typology were both limited in the Lower Palaeolithic, and subject to convergence, and thus may not reflect population history (Straus and Bar-Yosef 2001). Rolland connects widely separated areas by lithic similarities, without evidence from intervening areas of the nature of the assemblages along the proposed dispersal routes; for example, the linkage of the Victoria West technique in southern Africa to the Middle Palaeolithic in Southwest Europe (Rolland 1986). He acknowledges that independent invention of technologies is possible, especially as there are limited ways in which stone can be knapped, and argues that prepared core technologies probably developed separately on more than one occasion, but does not allow for independent invention or loss of bifaces in the Lower Palaeolithic, with the exception of the Northern Acheulean (Rolland 1986). The reason why prepared core technology is treated as likely to appear several times, but bifacial technology is dealt with as developing only once, is not clear and unfounded.

Rolland argues that once an environmental adaptation developed in one area it should be present throughout hominid populations. For example, hominid presence in temperate China is taken to imply that temperate environments in Europe should not pose a problem to colonisation. This approach is falsely reasoned. Adaptation to temperate environments in the Far East is unrelated to the process in Europe, because the groups involved were not the same, unless the European hominids derived from China. An adaptation in one area cannot be taken to imply its ubiquity when groups were living in relative isolation. Furthermore, conditions in temperate China and Europe were not identical. Rolland does not address how hominids overcame environmental barriers, or what specific aspects of the environment were constraints. Hominids probably diversified in terms of adaptations as groups expanded into new areas, thus over time there is a decreasing chance that behaviours can be generalised between groups. Rolland's extrapolation of skills and abilities between areas reflects his mechanistic biological perspective, as biology assumes that animal behaviour is largely instinctive and is found in all populations of a species, as a result of external stimulants acting on latent capacities. This view stems from the presumed lack of learning and capacity to pass on learnt behaviours among non-human species, and has now been shown to be false, especially among primates (McGrew 1992).

Rolland treats developments in behaviour as a linear process. He denies that the non-handaxe assemblages of the Far East are mode 1 (Clark 1977) because mode 2 industries existed elsewhere. This is based on misunderstanding the nature of the technological modes. The modes are additive stages, when mode 2 appears elements are added, but mode 1 remains an aspect of mode 2 technology. Rolland argues that flexibility in knapping repertoires will result in non-handaxe assemblages appearing within mode 2 making populations, and thus these are also mode 2. However, among populations that were making mode 1 technologies, whether or not their ancestors had possessed mode 2 technology, non-handaxe assemblages remain mode 1 occurrences. Rolland tries to construct grades in behaviours, in terms of environmental adaptation and technology that can be seen throughout the range of hominids at any time, which is unlikely due to the isolation of populations.

Rolland's models are all based on his theoretical framework, of biogeography and tracing routes through similarities in lithic industries. However, significant developments can be seen in the models through time. The initial model (Rolland 1978) considered Europe to be occupied simultaneously with the rest of Eurasia, whereas his recent work has highlighted later entry into Europe compared to Asia. The presence of a pre-Acheulean phase in Europe is at first accepted, and then challenged. The three routes into Europe are supported or denied in turn, except the route from the Levant, which is always dismissed. Rolland's view changes in response to new archaeological finds, dates, environmental reconstructions, and shifts in theoretical perspective. The flaws with each model and the limitations of the supporting data are highlighted. His approach is sufficiently flexible to accommodate new information and theories, within the framework of interpretation that he favours. The ability to respond to new findings is praiseworthy, but the underlying interpretive framework remains constant and inflexible. Rolland's (1998b) approach is also admirable because several potential stories are told, and the implications of each are discussed, in terms of archaeological expectations and possibilities for testing their validity.

Rolland's model has at times included an exploratory stage before establishment. This approach is useful in two respects. Firstly, a phase of exploratory small-scale dispersals, not resulting in colonisation of Europe for a prolonged period fits the predictions of ecological and geographical dispersal models (Shigesada and Kawasaki 1997; Haberkorn 1981). The majority of dispersals fail due to insufficient population, inability to rapidly adapt to new conditions, lack of resources, and isolation resulting in breakdown of mating networks (Williamson 1996). Secondly, this model explains the difference in intensity of occupation and the nature of archaeological assemblages before and after 600-500 Kyr BP. However, the appearance of the Acheulean is not fully explained by this scenario, as its absence in the exploratory stage is not intrinsic to the colonisation process, although technological loss is predicted. The route from the Far East may explain the initial lack of handaxes, and the route from the Maghreb could cause their appearance, but Rolland does not explain what changed to remove the barriers initially preventing the Acheulean spread into Europe.

Rolland attempts to overcome this problem by denying that the pre-Acheulean period existed, and calls for testing its presence by the retrieval of large quantities of well-dated material without handaxes, thus rendering the sampling or functional variant of the Acheulean arguments unlikely (Rolland 1998b). However, the problem remains that assemblages are classified by the absence of one specific tool category, rather than by positive technological attributes. Rolland (1998b) suggests that the initial low-density phase may be seen in repercussions in the faunal community. However, low-density hominid populations may have had little impact on the faunal community, unless they were highly effective competitors and predators, and caused community restructuring. Hominids may have been strong competitors, but this needs to be shown, and the reasons for competitive success determined before it can be used to explain other aspects of the archaeological or palaeontological record.

In summary, Rolland puts forward a context of movement during faunal dispersal events, caused by environmental change and population increase. He predicts movement to proceed through environments in order of their similarity to the habitats already occupied, and to be constrained by high altitudes and oceanic barriers. He also suggests that the routes of movement can be traced through similarities in the lithic industries of Europe and the source regions. These issues will be addressed in the data collection and analysis presented in the following chapters.

Carbonell's Dispersal Narratives.

Aims and agenda.

Carbonell's aims regarding early dispersals into Europe are:

- to establish the date of the first European occupation (Carbonell *et al.* 1995c);
- to refute the "short chronology" for European occupation at 500 Kyr BP, and to support occupation from 1.0 Mya as fits the "Mature Europe" hypothesis (Carbonell *et al.* 1999a);
- to define the technical mode used by hominids at Atapuerca, and across Eurasia in the Lower Pleistocene (Carbonell *et al.* 1999b);

- to research processes of human evolution in the Iberian peninsula and Europe (Rodríguez *et al.* 2001);
- to obtain information about the biology, ecology and technology of *Homo antecessor* (Rodríguez *et al.* 2001).

The underlying agenda is the promotion of Atapuerca, Iberia, and Carbonell's work as a whole, as critically import to issues of European occupation. These concerns affect his treatment of modern human dispersal into Europe, with the aims:

- to investigate why the Middle-Upper Palaeolithic transition and appearance of anatomically modern humans seem to occur very late in Iberia despite its closeness to Africa (Straus *et al.* 1993);
- to look at the chronostratigraphic context of the Middle-Upper Palaeolithic transition (Carbonell and Vaquero 1996);
- to highlight the importance of the Abric Romani in the study of the Middle-Upper Palaeolithic transition (Carbonell and Vaquero 1996).

Theoretical view.

Carbonell's theoretical stance is based on a gradual and linear view of behavioural change. He supports occupation of Europe during the Lower Pleistocene, with a pre-Acheulean or Oldowan phase (Carbonell *et al.* 1995b; Carbonell *et al.* 1999c), allowing time for gradual adaptation necessary to survive in Europe. The earliest traces of hominids in Europe are expected to show "primitive" characteristics in the lithic record (Falgueres *et al.* 1999). However, gradualism leads Carbonell to support the presence of complex behaviours during the Lower Palaeolithic, providing time for their refinement into modern behaviours. This leads to contradictory situations such as at Atapuerca TD6, described as possessing a "primitive" lithic industry but also having woodworking (Carbonell *et al.* 1999b; Falgueres *et al.* 1999). He highlights variability and complexity of hominid behaviour in the Acheulean and subsequent industries, focusing on the ability to respond to environmental factors such as resource quality and availability (Carbonell *et al.* 1995d). He creates a dichotomy in behavioural capacities between Acheulean and Oldowan hominids. Continuity in the archaeological record and gradual progressive change is emphasised after the appearance of the Acheulean. The emphasis on continuity and internal development in Europe is seen in his stance concerning the Middle-Upper Palaeolithic transition, highlighting similarities in lithic manufacturing in the late Mousterian and early Upper Palaeolithic, and the potential role of Neanderthals in Aurignacian development (Carbonell and Vaquero 1998). He is also concerned to promote the origin of modern behaviours in Iberia, rather than in Africa.

Carbonell repeatedly asserts that change is irreversible (Carbonell *et al.* 1999c; Aguirre and Carbonell 2001). He states that hominids possessing mode 2 technology (Clark 1977) would never revert to mode 1. Likewise, groups in possession of mode 1 technology could not gain mode 2 by learning from Acheulean groups (Carbonell *et al.* 1999c). Mode 2 is considered to be a progressive adaptation, which evolved from mode 1 industries, increasing efficiency of resource utilisation and competitive ability compared to groups retaining mode 1. The change resulted in two culturally and technologically distinct groups, but not speciation. Gradual change allows him to identify the origins of dispersing groups, because the industry possessed by dispersing hominids and their descendents will match that of the source population.

Throughout his writing Carbonell emphasises the scientific nature of research into prehistory. For example, he compares changes in accepted dates of the earliest occupation of Europe during the last decade to paradigm shifts in scientific knowledge (Kuhn 1962). He demands hypothetico-deductive methodology rather than "speculation" (Carbonell *et al.* 1995c), and advocates actualistic studies to generate interpretive principles, based on observable processes in the present extrapolated into the past, following Middle Range Theory (Binford 1981). However, Carbonell does not adhere to his own demands to support interpretation with experimentation. For example, the system of lithic analysis forwarded proposes tool function based simply on tool edge geometry (Carbonell *et al.* 1995b). Moreover, he emphasises the need to interpret material in the context of other sites of the same period (Carbonell *et al.* 1995d; Carbonell *et al.* 1999b), thus interpretation is historically contextual. His concern to show variable and complex behaviour since the Acheulean overrides attempts at economic rationalisation and mechanistic argument. Nevertheless, he justifies his arguments using parsimony and sociobiological adaptive fitness. For example, the cut marked Atapuerca TD6 hominid remains result from dietary cannibalism of other groups, because cannibalism within the group is not adaptive (Bermudez de Castro *et al.* 1999). Thus, despite claiming to be strictly scientific Carbonell in practice shows little concern over epistemology.

Models of dispersal.

The Initial Occupation of Europe and the Lower Palaeolithic.

Carbonell forwards a "Mature Europe" model of colonisation dating to the early Middle Pleistocene (Carbonell and Rodriguez 1994; Carbonell *et al.* 1995a; Rodríguez *et al.* 2001; Carbonell *et al.* 1995c). He suggests that occupation began in Iberia at 700-800 Kyr BP, during OIS 21, 19 or 18 (Carbonell and Rodriguez 1994; Falgueres *et al.* 1999), and was continuous from this date (Carbonell *et al.* 1995b). The dates of the earliest occupation increase through Carbonell's writings to 1.0 Mya (Carbonell *et al.* 1995a; Ranov *et al.* 1995) but remain within the Mature Europe model. This date is supported by a single flint flake in E-11 of the Sima del Elefante at Atapuerca (Rosas *et al.* 2001).

The lithic industries during this initial phase are described as Developed Oldowan or mode 1, lacking large flakes and core preparation, and exclusively using local raw materials, to produce morphologically variable small flakes by expedient orthogonal flaking (Carbonell *et al.* 1999b). The Oldowan nature of the industries is at times explained by dispersal from Africa before development of the Acheulean. The route proposed is along the Rift Valley to the Levant, and thence across Eurasia (Bermudez de Castro *et al.* 1999). This event is argued to be seen in the lower non-Acheulean horizons of 'Ubeidiya in the Levant at 1.4 Mya, and spreads to Europe and the Far East between 1.0-0.8 Mya (Carbonell *et al.* 1999b).

Carbonell denies that the non-Acheulean lithic industries could be a modified Acheulean lacking large flakes and handaxes, because environmental adaptation cannot explain the loss of these tools, since the same environments were later occupied by a fully Acheulean producing population (Bermudez de Castro *et al.* 1999). Furthermore, loss of the Acheulean would represent a communicative and cognitive degeneration, without independent supporting evidence (Carbonell *et al.*

1999c). Moreover, he redefines the Acheulean as consisting of longer operative sequences and greater planning, seen through raw material transfers and lithic reduction sequences resulting in more standardised tools, and less expedience and mobility than the Oldowan, due to greater subsistence organisation based around territories (Carbonell *et al.* 1999c). Therefore, the Acheulean is not only the presence of large flakes and handaxes; it is a reorganisation of all behaviour. The absence of these changes is claimed in the pre-Acheulean phase; thus, he contends that these assemblages are genuinely Oldowan. The more restricted range of technology seen in Eurasia is argued to be due to the centre of origin being in Africa between 10° north and 10° south, and is definitely not due to environmental adaptation.

Pre-Acheulean occupation is described as systematic and continuous (Carbonell *et al.* 1995c), but less intensive than the Acheulean, as shown by smaller assemblages (Carbonell *et al.* 1995a). Initially Carbonell favours pre-Acheulean Lower Pleistocene occupation throughout Europe, it is assumed that once hominids reached Europe occupation would be widespread, as hominids possessed all necessary adaptations (Carbonell *et al.* 1995c). The key sites of the pre-Acheulean phase listed are Atapuerca, Kärlich, Korolevo, Fuente Nueva 3 and Monte Poggiolo (Carbonell *et al.* 1995b; Carbonell *et al.* 1999a). Carbonell also treats Eurasia as settled by a single dispersal event, and thus uses Asian data from sites such as Kuldara, 'Ubeidiya, Dmanisi and Nihewan to support the pre-Acheulean of Europe (Carbonell *et al.* 1999b). He does not consider barriers into Europe, with the exception of high sea levels. The presence of well-dated material in the late Lower Pleistocene at Atapuerca is used to support more contentious early claims of hominids in Europe, such as at Le Vallonet (Carbonell *et al.* 1995a). He argues that because there is evidence from one site, Atapuerca Gran Dolina TD6, of intensive occupation, hominids had the capacity to colonise the rest of Europe. No distinction is made between locally successful settlement, and regional or continental-scale patterns. However, his later models place less emphasis on early widespread occupation, allowing settlement of the south and west to precede the rest of the continent (Falgueres *et al.* 1999; Bermudez de Castro *et al.* 1999).

The model proposed to explain Oldowan dispersal significantly preceding the Acheulean centres around competition. Carbonell considers the two industries to be made by behaviourally and technologically distinct populations, especially diverging in subsistence organisation (Carbonell *et al.* 1999c). The Oldowan was highly mobile and expedient and could not survive in the presence of the more efficient and territorially based Acheulean, which monopolised access to critical resources. The Acheulean rapidly spread throughout the Rift System, forcing the Oldowan makers into the Eurasian periphery (Carbonell *et al.* 1999c; Bermudez de Castro *et al.* 1999). The Oldowan reached Europe at 1.0 Mya, coinciding with environmental changes, linked to changes in the duration of the dominant orbital cycle driving climate cycles. This facilitated dispersal associated with faunal turnover in Europe affecting the interglacial fauna (Carbonell *et al.* 1999c). This association with an interglacial dispersal event allows Carbonell to justify occupation of northern and southern Europe simultaneously. The environmental changes at 1.0 Mya are argued to have facilitated Oldowan movement, but competition from the Acheulean remains the primary factor in the dispersal, because Carbonell believes that an environmental cause would favour the spread of the Acheulean, due to its competitive superiority.

The fully developed Acheulean arrived in Europe from Africa, during the mid-late Middle Pleistocene, represented at Notarchirico and Carrière Carpentier, at 600 Kyr BP (Carbonell *et al.* 2001). The Acheulean is considered to be entirely separate from the pre-Acheulean industries; and spread of the African Acheulean by diffusion of ideas, rather than dispersal of a population is dismissed (Carbonell *et al.* 2001). Acheulean dispersal nearly one million years after its appearance in Africa, is explained by gradual population increase. Available territory and resources became saturated to the extent that increased efficiency could no longer maintain the entire population within the Rift Valley (Carbonell *et al.* 1999c). Carbonell argues that Acheulean dispersal does not coincide with environmental opportunities for movement, and is not associated with dispersal of other species, and thus must be due to internal social and economic causes (Bermudez de Castro *et al.* 1999). Mode 1 and mode 2 industries then coexisted in Europe for some time. Carbonell *et al* (1999c) propose a model of techno-cultural selection, analogous to biological selection, supporting Acheulean dispersal from Africa facing resistance from the local population. The increased density of archaeological finds after 500 Kyr BP results from more efficient resource use among the Acheulean population, resulting in higher population density, and greater archaeological visibility (Carbonell *et al.* 1999c).

The fossil record is a central aspect of Carbonell's model. The hominid remains from Atapuerca Gran Dolina TD6 were initially described as either primitive *Homo heidelbergensis* or a new species (Carbonell *et al.* 1995a), but were categorically denied to be *Homo erectus*. Thus, he argues for a greater link to Africa than Asia, despite claiming that Eurasia was occupied in a single event. The "primitive" morphology of the TD6 hominids justifies early European settlement (Carbonell *et al.* 1995a). He initially favours anagenesis in Europe until the arrival of modern humans in the Upper Pleistocene, making the Atapuerca hominids ancestral to *Homo heidelbergensis* and *Homo neanderthalensis* (Bermudez de Castro *et al.* 1999). The Middle Palaeolithic is argued to develop within Europe from the Acheulean, without an associated dispersal (Carbonell *et al.* 2001). However, this cannot accommodate the Acheulean as a second dispersal from Africa, with non-Acheulean makers unable to adopt the new technology, because this requires descent of the late Middle Pleistocene hominids from the Acheulean makers, not the pre-Acheulean hominids at Atapuerca. The TD6 hominids have subsequently been declared a new species, *Homo antecessor* (Bermudez de Castro *et al.* 1997), which was initially placed as ancestral to both *Homo sapiens* and Neanderthals, and closest morphologically to late *Homo ergaster* in East Africa. In order to support the TD6 hominids as ancestral to *Homo sapiens* Carbonell suggests a return dispersal from Europe to Africa.

Carbonell has recently significantly modified his model, proposing several waves of dispersal from Africa into Eurasia during the Lower and Middle Pleistocene (Aguirre and Carbonell 2001). Initial expansion of *Homo erectus* into Asia at 1.9 Mya reached as far as Java, before the evolution of *Homo ergaster* and the Acheulean. At 2.0-1.9 Mya global climate was warm and humid, providing familiar environments beyond Africa, and faunal turnover created a context for movement. Aguirre and Carbonell (2001) put forward a second expansion before Acheulean emergence, by *Homo ergaster*, caused by increasingly open vegetation and aridity in Africa, evidenced at Dmanisi. The nature of the hominid fossils gives a date of 1.7-1.6 Mya for this event. The Acheulean subsequently dispersed to the Levant by 1.4-1.3 Mya, seen at 'Ubeidiya, with African and Eurasian faunal elements, easing transition into Eurasia for an African hominid. Environmental deterioration in Africa, increasing humidity and vegetation in the Near East, and population increase, were the reasons for this dispersal (Aguirre and Carbonell 2001). A further Acheulean dispersal from Africa is proposed to explain the material at Gesher Benot Ya'aqov and Ceprano at 0.8-0.7 Mya.

Colonisation of Europe is proposed from Asia at 1.0-0.8 Mya, linked to favourable environments across Eurasia during the Jaramillo event (Aguirre and Carbonell 2001). Europe was initially occupied after Acheulean appearance in Africa and the Levant, therefore Carbonell denies that these areas could be the source of the pre-Acheulean European population, because this demands loss of technological and subsistence advances; hence, the late Lower and early Middle Pleistocene populations in Eurasia are argued to descend from the Dmanisi or Java hominids. An Asian origin is justified by *Homo antecessor* showing Asiatic traits, and using mode 1 technology. The fossils are reinterpreted as similar to *Homo ergaster* at Ternifine, Zhoukoudian, and Dmanisi; and claimed to be a subspecies of *Homo sapiens*. Aguirre and Carbonell (2001) suggest return migration into Africa occurred, allowing *Homo antecessor* to be ancestral to late Middle Pleistocene African hominids believed to have given rise to modern humans. The former links to Neanderthals are dismissed because they assumed that Neanderthal derived features would appear later in the fossil record.

The Acheulean appearance in Europe during OIS 13 is attributed to dispersal from Africa during OIS 14, when low sea levels allowed movement of pre-Neanderthals or *Homo heidelbergensis*, as seen in the Sima de los Huesos fossils from Atapuerca, with morphology described as closest to Bodo, Ndutu and Kabwe, in the African Middle Pleistocene (Aguirre and Carbonell 2001). Carbonell further proposes that the initial Acheulean in Europe is not as developed as in Africa at the time, reiterating explanation by competition driving out the less competitive, followed by demographic growth and spread of more evolved technology. A route via Gibraltar is considered plausible for the Acheulean but not for the Oldowan, due to the behavioural advances associated with the Acheulean.

The Middle-Upper Palaeolithic Transition.

Carbonell does not advocate a specific model of *Homo sapiens* dispersal, but he does comment on the processes involved. He questions the association of the Aurignacian and anatomically modern humans (Straus *et al.* 1993), because ethnographic studies have revealed the fallacy of assuming that populations correlate with distinct material cultures, and the problems of linking industries and species throughout the Palaeolithic (Vaquero and Carbonell 2000). The Aurignacian is described as an archaeological construct obscuring variation, with little or no reality in the past, as it differs significantly between regions, in timing of appearance and contents. He argues that since Mousterian survival and Aurignacian arrival were late in southern Iberia, the Aurignacian did not disperse from Africa, because hominids could cross the Straits of Gibraltar since the Acheulean, and the colonisation of Australia shows that early modern humans were capable of water crossings. Thus, movement from Africa should appear earliest in Iberia. He states that modern behaviour did not disperse from Africa, as Late Pleistocene complexity is seen in both Africa and Eurasia.

Carbonell argues that the western European “transitional” industries developed from the local Middle Palaeolithic and were manufactured by Neanderthals (Straus *et al.* 1993; Carbonell and Vaquero 1998). However, transitional industries are not found throughout Europe, thus the transition varied with the historical context of each region. He highlights the degree of continuity during the transition, in terms of technology, behaviour, and biology; and demands that connections between processes of biological evolution and cultural change be investigated, rather than assuming explanation of archaeological changes by cognitive differences between Neanderthals and modern humans (Carbonell and Vaquero 1996). He downplays potential differences in cognitive capacities between Neanderthals and modern humans, emphasising similarities between the two groups. Diachronic trends towards greater behavioural flexibility, increased planning depth, and specialism in the Mousterian are forwarded (Vaquero and Carbonell 2000). He also suggests that differences between early modern humans and Neanderthals only warrant a sub-species level distinction (Vaquero and Carbonell 2000). Moreover, differences may have been ecological, as in Northeast Iberia the Mousterian persisted in uplands in the same areas as the Aurignacian was in the lowlands and natural communication corridors.

The Aurignacian is a discontinuity from the Mousterian and transitional industries, as the Late Mousterian and Chatelperronian show no trend towards blade production, and raw material provisioning and settlement patterns changed abruptly (Carbonell and Vaquero 1998; Vaquero and Carbonell 2000). However, Carbonell suggests that the Chatelperronian and Aurignacian are both expressions of technological efflorescence and instability, caused by *Homo sapiens* and Neanderthals meeting. Therefore, a European origin of the Aurignacian does not invalidate either the Out of Africa or multiregional hypotheses. He insists that the Chatelperronian derived independently from the Mousterian, not from Neanderthal acculturation. Moreover, he suggests that archaeological changes at this time reflect technological convergence rather than dispersal of people, or diffusion of ideas, from Africa (Straus *et al.* 1993). The Chatelperronian and Aurignacian are argued to be contemporaneous, but with the Chatelperronian in western Europe, and the Aurignacian in the east (Carbonell and Vaquero 1998). Evidence used to support this is that the Aurignacian always overlies the Chatelperronian, and is the proto-Aurignacian when it first appears in the west.

Narrative analysis.

Carbonell's narrative trope concerning the Lower Palaeolithic is metonymy, similar to Foley and Rolland, equating lithic assemblages with populations (Carbonell *et al.* 1999c). Lithic characteristics are also used to infer the timing of dispersal; for example, Asian long chronology is supported due to the non-Acheulean lithics (Aguirre and Carbonell 2001). Moreover, Oldowan dispersal at 1.0 Mya is predicted from climatic and faunal patterns, despite scant archaeological evidence, thus environmental conditions equal movement (Carbonell *et al.* 1999c). In a further application of metonymy, Carbonell uses one site in Europe, Atapuerca, to represent all hominid behaviour at the time, and to claim occupation across the continent (Carbonell *et al.* 1995c). Carbonell differs from Foley, and is similar to Rolland, by refusing to directly link hominid species to assemblage type. However, he discards metonymy for the Middle-Upper Palaeolithic transition. He rejects equating the Aurignacian with movement of modern humans (Straus *et al.* 1993). The movement is not correlated to any external environmental factor or faunal dispersal. Carbonell argues for integration of evidence regarding subsistence, resource procurement and settlement patterning, which fits a Synecdochic trope, with each piece of information forming part of the greater whole.

Carbonell writes about the Oldowan as a Tragedy. The Oldowan moves only in response to climatic conditions (Aguirre and Carbonell 2001) and competition from the Acheulean (Carbonell *et al.* 1999c). However, movement of the Acheulean at times is a Romance, in which hominids escape from external environmental constraints and spread due to internal social and economic forces, achieving colonisation of any environment without adaptation. Nevertheless, Aguirre and Carbonell (2001) place heavy emphasis on the environmental circumstances in which dispersals took place, implying a Tragedy throughout the Lower Palaeolithic. However, hominids are able to overcome environmental obstacles, conforming to a Comedy, in which partial liberation from the forces of the world is achieved. A Comic plot supports the Synecdoche of the later Palaeolithic, and overcomes some of the confusion created by the Romantic plot.

The Tragedy and Metonymy of Carbonell's writing about the Oldowan should be supported by Mechanistic argumentation. This is seen in the use of environmental factors and faunal dispersals to justify his interpretation of the dates and patterning of hominid movements. Moreover, the model of the Acheulean spreading due to demographic pressure (Carbonell *et al.* 1999c) is Mechanistic, since it is based on an ahistorical principle that all groups undergo demographic increase and respond by spreading spatially. However, he insists that all interpretation should take account of all available comparative material from the period, in order to understand the context in which behaviours were situated. This Contextual approach overrides the desire for Mechanistic argumentation in Carbonell's treatment of the Middle-Upper Palaeolithic transition, in which he calls for a holistic approach to the behaviours of both Neanderthals and modern humans in order to understand how they differed, and thus how the transition and dispersal were achieved (Carbonell and Vaquero 1998; Vaquero and Carbonell 2000). Carbonell's call for the transition to be discussed as a historical event rather than a biological process reinforces the Contextual argumentation of his writings. However, Contextual argumentation does not fit easily with Synecdoche, as more integration is expected.

Carbonell's Tragic emplotment and Mechanistic argumentation of the Oldowan would be expected to correlate with Radical approaches to change. This does seem to be the case, as he creates vast differences in behaviour between the Oldowan and Acheulean, in terms of organisational capacities, subsistence and settlement patterning (Carbonell *et al.* 1999c). However, after the appearance of the Acheulean he describes all changes as extremely gradual, emphasising continuity, especially in the Middle-Upper Palaeolithic transition. He also argues for anagenesis in the fossil record, with no major speciations (Arsuaga *et al.* 1993), supporting a weak Out of Africa or multiregional model of modern human origins, linked to his view of there being little change at the Middle-Upper Palaeolithic transition. Thus, the later Palaeolithic conforms to a Liberal ideology, with change occurring incrementally. This is not Conservatism since change is treated as continuous and advantageous, with a strong emphasis on variation and positive developments.

Carbonell's narrative forms are consistent in his writing about the Oldowan, and form a coherent argument. However, his approach to the Middle-Upper Palaeolithic transition seems confused. The use of Synecdoche should be accompanied by Comedy, Organicism and Conservatism. The plot recently has been rewritten as Comic (Aguirre and Carbonell 2001), but in a substantial amount of Carbonell's work was Romantic. Romantic emplotment does not correspond with any other elements of Carbonell's style. The argumentation is Contextualist, and the ideology Liberal, which reinforce one another but do not fit the trope or the plot. His approach is thus contradictory, and fails to produce a coherent story. This problem extends to his treatment of the Acheulean, which at times is dealt with in the Metonymy of the Oldowan, and elsewhere is described in the partial Synecdoche of the Aurignacian. Carbonell is the only one of the four authors to write about the two events in different tropes.

Strengths and weaknesses of the model.

The Lower Palaeolithic.

Carbonell's view of linear change in Lower Palaeolithic industries is key to his model that the lack of handaxes during early European occupation results from dispersal of Oldowan bearing hominids. This is based on the same false interpretation of Clark's (1977) technological modes as progressive stages, rather than an additive system, as Foley and Rolland. Mode 1 technology is an intrinsic part of the Acheulean. Thus it seems possible for hominids to stop making the Acheulean at times, especially during dispersal, when populations are liable to be small and isolated, and encounter new environmental circumstances, which can promote loss or innovation in technology. Carbonell also does not discuss the effects that isolation may have on small groups. He claims that pre-Acheulean occupation of Europe cannot result from loss of the large tool component of the Acheulean by adaptation to European environments because the Acheulean spreads through these environments later. This is not justifiable, because European habitats and faunal communities were not identical at 1.0 Mya and 0.6 Mya. Also, adaptation is historically contingent and highly variable, so survival of handaxe technology during a Middle Pleistocene dispersal cannot be used to explain adaptations involved in other dispersals. Furthermore, Carbonell explains the restricted range of technology in Eurasia compared to Africa as a product of the distance from the origin of the technologies, but does not discuss the mechanism causing this reduction. Limited technology in the periphery compared to the core, is a loss of elements, even if this simply results from a non-representative sample of behaviours accompanying the dispersers, therefore Carbonell contradicts himself.

Carbonell attempts to redefine the Acheulean in terms of reduction sequence length, distance of raw material transfer, and complex organisation of subsistence and settlement patterning; analogous to Rolland's "non-Acheulean mode 2". This is advantageous because it defines the Oldowan by positive characteristics. However, it requires extensive study of raw material provenancing, reduction sequences, subsistence practices and settlement organisation before identification of either industry can be made, which is impossible in many cases. Furthermore, Carbonell does not quantify how far raw materials should be transported, or how long reduction sequences should be to show significant increases in organisation and planning in the Acheulean. It would be worthwhile to test whether the industries designated by him as Oldowan, especially in the early "pre-Acheulean" phase are significantly more "primitive" in terms of their organisation. Without this quantification, the new definition can be used to prefigure the data by subjectively reassigning assemblages to industries fitting Carbonell's model.

The presence of a pre-Acheulean phase in Europe is central to Carbonell's model. Carbonell's linear view of change supports technological developments only emerging once, thus the Acheulean could only develop in Africa and arrive in Europe as a second wave of dispersal. Thus, there is no reason to assume that the sequence of European industries follows the African pattern, where the Oldowan and Acheulean originated. Furthermore, if the Acheulean does represent a more efficient and competitive adaptation than the Oldowan, it seems odd that the non-Acheulean variant would spread before the Acheulean. Moreover, the co-existence of the two industries, in Africa and later in Europe, implies that the Acheulean was not significantly more adaptive, unless the two groups occupied different niches and were not in competition. Given the limited number of sites from the late Lower and early Middle Pleistocene in Europe it is presumptive to claim clear evidence of a pre-Acheulean phase. Moreover, the large numbers of undated finds, and the highly variable state of both the Acheulean and non-Acheulean industries in Europe, undermine complete dismissal of technological diffusion, an element of allochthenous development, or even a single variable Acheulean industry throughout the occupation of Europe.

Carbonell uses typology to assign industries to the Oldowan or Acheulean, directly contradicting his argument that typology is insufficient to identify an industry. The assemblages attributed to each industry by typological attributes are those that cannot be dated by other means, therefore, these attributions cannot be supported with other lines of evidence as intended in his redefinition of the industries. Those assemblages containing small flakes made by orthogonal flaking techniques, and lacking handaxes and large tools diagnostic of the Acheulean, such as Puig d'en Roca, El Espinar, and Molino del Emperador, are assigned to the early Middle Pleistocene pre-Acheulean (Carbonell and Rodriguez 1994). This substantially boosts the number of sites in this phase, reinforcing his model of significant pre-Acheulean occupation of Europe. This is clearly circular, as finds are dated by typology, which in turn defines the phasing of the model. Furthermore, non-handaxe assemblages occur after Acheulean appearance in Europe, such as Bilzingsleben (Mania 1988) and Venosa-Loreto (Barral and Simone 1983), thus it cannot be assumed that non-Acheulean finds are pre-Acheulean.

Carbonell dismisses the possibility of speciation being linked to technologies. He asserts that the possessors of Oldowan and Acheulean technology were behaviourally isolated groups of the same species. However, the mechanism preventing horizontal transfer of information between the two populations is not made explicit. He implies that cognitive skills would have differed between the two groups, as the Oldowan hominids are deemed incapable of adopting the Acheulean, despite its advantages. The two groups are totally isolated, and thus speciation is likely to result, as gene flow would have been prevented (Barton 1988). Moreover, cognitive differences large enough to prevent communication would likely be associated with species level differences between the populations. Carbonell presumably does not want to advocate speciation to explain the cultural division, since fossil remains of *Homo antecessor* from the "pre-Acheulean" level TD6 at Atapuerca have been claimed to be ancestral to Neanderthals, as well as modern humans, and hence must be the same chronospecies that produced the Acheulean, and gave rise to the Middle Palaeolithic. Thus, his argument only holds if the pre-Acheulean hominids of Europe were replaced by the same species using Acheulean technology. In his recent model, *Homo antecessor* is removed from the Neanderthal lineage, placing it as ancestral to modern humans, and most closely related to Asian Lower Pleistocene hominids (Aguirre and Carbonell 2001). This removes the problem of a lack of evidence for population replacement during Acheulean replacement of the Oldowan, and reinforces his view that any Oldowan dispersal from Africa into Asia should reach Europe, explaining the non-Acheulean lithics. Therefore, it justifies use of Asian data to support his model of European colonisation. The fossils are radically reinterpreted, motivated by the desire to make Atapuerca central in the evolution of modern humans, and to create a coherent model, which demanded abandonment of the Neanderthal ancestry claim. It remains to be seen how well accepted this rearrangement of hominid phylogeny will be, especially in view of the attribution of the Ceprano skull to *Homo erectus* (Clarke 2000), implying that Asian hominids did not resemble *Homo antecessor*, and reached Europe independently of the Atapuerca hominids.

Retaining *Homo antecessor* as ancestral to African Late Pleistocene hominids and modern humans requires a dispersal into Africa from Europe. Theoretically, this is possible, as return migrations do occur (Kearney 1986). However, it seems unlikely that European hominids would return to Africa and replace the African Acheulean populations, given Carbonell's model of Acheulean competitive superiority. Furthermore, this phylogeny gives European *Homo heidelbergensis* an African

Middle Pleistocene origin, and Late Pleistocene African fossils a European origin, thus the European and African hominids replaced one another, swapping continents. Carbonell denies that pre-Acheulean hominids could cross the Straits of Gibraltar; hence, all these movements must have gone between Iberia and Africa via the Levant. No explanation is given of how or why such a high level of movement occurred.

The competition model of centrifugal dispersal followed by Carbonell is contentious. Centrifugal dispersal has been proposed to explain historical biogeographical species distributions (Briggs 2000). However, centripetal dispersal has also been forwarded (Barton 1988). Highly competitive individuals receive a larger proportion of resources than the less competitive during infancy; and will be larger, stronger and leave parental care earlier; therefore, highly competitive individuals have a greater choice of locations to occupy, since they disperse early (Gese *et al.* 1996). It is not clear why these competitively strong individuals would choose conditions of high population density and competition at the core, or poor resource quality at the periphery, and both models are supported by ecological observations (Belichon *et al.* 1996). Thus, if the Acheulean is more efficient and competitive compared to the Oldowan, then there is no theoretical reason why this should not have led to Acheulean dispersal. Moreover, Carbonell does not explain how a mobile hunter-gatherer population could exclude another group through territoriality, given the low population density of both groups. Raw material transfers are local throughout the Lower Palaeolithic, thus there is no evidence for increased territoriality in the Acheulean. Furthermore, Oldowan spread occurs around 500 000 years after Acheulean appearance; Carbonell does not explain the causes of such a long time lag before competition drove out the Oldowan population.

A further problem with centrifugal dispersal is adaptation at the periphery. Carbonell's model stipulates that less competitive Oldowan hominids were forced into the periphery, without behavioural changes or speciation. However, the less competitive individuals in a population are least likely to innovate or adapt, thus it is unexpected for a successful and widespread dispersal of the least flexible part of a population to occur, because behavioural changes are likely to be necessary to survive the marginal conditions at the periphery (Suarez *et al.* 1999). The dispersing population is also liable to become isolated; thus, the chances of speciation are high because of founder effects and novel selection pressures (Barton 1988). The postulated lack of behavioural change may be supported if the dispersers were the least capable of innovation in the population, but biological adaptations are expected.

Carbonell uses the palaeoenvironmental record to identify periods when dispersal would be facilitated by low sea levels. He assumes that any dispersal occurring outside of such ecological windows of opportunity must be caused by internal social and economic factors. This is untrue because external pressure may cause the dispersal of a single species (Williamson 1996). Moreover, his construction of likely dispersal periods is based on gross climatic change, rather than local conditions liable to affect population dispersion. Furthermore, faunal turnover events often involve independent movements of species at ecological time scales, which appear to be simultaneous in the geological record, thus it is incorrect to argue that species always move together in a community or guild (Myers and Giller 1988a). Therefore, movements of species in a faunal turnover event may not be causally linked to one another, or any single environmental episode. Carbonell uses the timing of opportunities for dispersal to argue for European occupation in the late Lower Pleistocene from 1.0 Mya. However, the earliest hominid presence in Europe dates to 0.85 Mya at Atapuerca TD6, or possibly 1.2 Mya at Fuente Nueva 3. A date of 1.2 Mya correlates with spread of glacial fauna, whereas arrival at 1.0 Mya involves turnover of interglacial fauna. It seems unlikely that hominids would move in a cold stage event, since they originated in the tropics. Therefore, Carbonell questions the date of Fuente Nueva 3, and utilises a single stone tool at Atapuerca TD4 dated to 1.0 Mya to support his claims (Rosas *et al.* 2001), prefiguring the data to fit his model.

Carbonell assumes that hominids possessing mode 1 or Oldowan technology would disperse only in response to environmental triggers, especially low sea level and faunal turnover events, whereas the Acheulean is free of these constraints. These factors are argued to assist but not cause dispersal, since beneficial environmental change is deemed more likely to cause Acheulean spread due to its competitive advantages. This does not hold because the Acheulean and Oldowan could disperse in response to different environmental factors, given the economic differences suggested by Carbonell. Moreover, he argues that low sea level provided routes for dispersal, but that hominids should disperse into Europe during warm and wet phases following a model of environmental matching between source and destination areas, thus the proposed environmental opportunities are contradictory. He also does not consider community interactions or niche dynamics in his treatment of environmental factors associated with dispersal.

Carbonell does not consider physical barriers within Europe, such as mountains; or ecological constraints of temperature, growing season, and daylight length variance across the continent. He assumes that hominids were capable of occupying any environment encountered, and that dispersal is caused by push forces at the origin, not processes at the destination. This is unjustified, as survival in the destination is key to successful establishment (Watts 1971). Carbonell extrapolates the ability to occupy the rest of Europe from the evidence of intensive occupation of Atapuerca. This cannot be upheld because intense settlement in a favourable area does not imply that the population was behaviourally adapted for survival elsewhere. Iberia is ecologically more similar to African environments than the rest of Europe, and is liable to have been easier to colonise for an African hominid. It cannot be assumed that hominids always possessed the behaviours necessary to survive throughout Europe. Carbonell does not address behavioural developments allowing European colonisation; therefore, origins of behaviours allowing colonisation are all exogenous. In later models, he does admit that Mediterranean Europe may have been occupied before the north. This is far more plausible, as hominids colonise areas most similar to their habitat of origin before adapting to unfamiliar conditions, following an environmental matching model (Williamson 1996), and better fits the current state of knowledge of the distribution of the earliest sites in Europe.

Carbonell proposes continuous occupation of Europe since the Lower Pleistocene, founded on evidence of hominid activity from many levels of the Atapuerca sequence. However, at no point does he consider the population size necessary to maintain itself in isolation from Africa and Asia, whilst being widely spread. There are few pre-Acheulean sites in Europe, and therefore it seems that the population was small and liable to become extinct (Marshall 1988). Carbonell counters this by claiming that high mobility and expedience in the pre-Acheulean would result in low archaeological visibility, thus the population was larger than it appears in the archaeological record. However, expedience could also be associated with high discard rates and high archaeological visibility. The Atapuerca sequence does not contain lithic artefacts in every level, thus even in Iberia it is possible that occupation was not continuous.

The recent model of multiple hominid dispersals in the Lower and Middle Pleistocene (Aguirre and Carbonell 2001) attempts to fit hominid fossil data into a framework of global climate change. This removes the need for controversial centripetal dispersal, in favour of more accepted environmental matching to explain the patterning of movement. Hominids moved within familiar habitats and therefore establishment was achieved with relative ease, without requiring major adaptations. Thus, the Oldowan dispersed without the push of competition from the Acheulean, and the long chronology can be justified, providing a more parsimonious explanation of the lack of the Acheulean in Asia. However, population growth as a cause of the spread of the Acheulean is retained, and suffers from a lack of supporting data.

Carbonell suggests that Dmanisi represents a second dispersal involving *Homo ergaster*, after *Homo erectus* spread to Java. However, the D2700 skull from Dmanisi is closest in morphology to *Homo habilis* (Vekua *et al.* 2002) therefore, these hominids were more primitive than those in Java, and are not good evidence of a separate later dispersal event. Carbonell shows a splitting tendency in hominid phylogeny, creating several species in Eurasia, each explained by dispersal. However, these hominids could be a single variable population, resulting from only one dispersal. The phylogenetic patterning of African hominids between 2.0-1.6 Mya is unclear, and has been majorly revised on several occasions. It is dangerous to base models of dispersal on current phylogenetic attributions, as these are liable to change. Furthermore, very early dates of hominid occupation of Java have been contested (Langbroek and Roebroeks 2000). Therefore, the Dmanisi hominids may be the earliest representatives of hominid colonisation of Eurasia. Given their great variability, it is plausible that all or most Lower Pleistocene Eurasian fossils descend from this group.

Carbonell suggests that the Atapuerca *Homo antecessor* fossils are closely related to Asian hominids, descended from the non-Acheulean dispersals. This explains the initial lack of the Acheulean in Europe. However, dispersal from Asia at 1.0 Mya would invalidate the link to a turnover event in the European interglacial fauna, as the species moving from Asia were predominantly cold adapted (Arribas and Palmqvist 1999). Nevertheless, given the long period proposed by Carbonell for the hominid occupation of Asia before spread to Europe, it is possible that adaptation to cold conditions had occurred before the dispersal.

Acheulean appearance in Europe at 0.5 Mya is argued to result from dispersal of African *Homo heidelbergensis*, leading to the Neanderthals. Aguirre and Carbonell (2001) fall back to the centripetal model to explain this event, as it does not correlate with faunal dispersal or environmental change. It is stated that the initial Acheulean in Europe is not as fully developed as in Africa at the time, but there is no sign of indigenous development in Europe, therefore less advanced Acheulean populations were pushed out of Africa by more developed populations. However, it is possible that the seemingly less advanced nature of the initial European Acheulean is due to effects of colonisation, such as initially limited exploratory activities undertaken by a sub-group of the parent population, for example hunting expeditions. Furthermore, differences between the African and European Acheulean are questionable.

The spread of the Acheulean into Europe is proposed to have occurred during OIS 14, which induced low sea levels and opened routes through the Near East and the Straits of Gibraltar. However, Carbonell does not address the problem of why hominids should move north from Africa during a glacial, into habitats to which they were probably very poorly adapted. He does not specify whether occupation was restricted to Iberia, and other Mediterranean regions, and thus buffered from the glacial. Even if this were so, Iberia, Italy and the Balkans would have been refugia for the existing European population, and any immigrants would have had to compete strongly, with locally adapted populations, to establish settlement. Furthermore, this contradicts the environmental matching seen in the rest of the model.

The Middle-Upper Palaeolithic Transition.

Carbonell's questioning of the link between the Aurignacian and dispersal of *Homo sapiens* is praiseworthy because it does not assume that archaeological assemblages correlate to specific populations or ethnic groups, which has been shown to be unwarranted (Jones 1997). However, his approach to the species responsible for the archaeological industries is contradictory. Carbonell accepts that Neanderthals were solely responsible for the Chatelperronian. He also recognises that the Aurignacian is intrusive in western Europe, and implies this is due to movement of people, not diffusion of ideas, as the Aurignacian is ecologically, technologically and economically distinct from the preceding industries, and is found earliest along natural corridors. Thus, if the Aurignacian does not represent movement of *Homo sapiens*, then the question remains over who these migrants were.

Carbonell's approach to the Aurignacian is admirable for questioning Aurignacian unity throughout Europe and the Near East, and for challenging its assumed origin beyond Europe. He correctly states that the Aurignacian may not be identical across Europe, as it is defined by regional research traditions (Clark 2001). However, he makes the mistake of using the Aurignacian to stand for behavioural modernity. The transitional phase towards greater complexity and "modernity" does appear to have occurred earlier in the Near East and eastern Africa, at sites such as Enkapune Ya Muto in Kenya and Ksar Akil in Lebanon, without becoming Aurignacian. He dismisses evidence from Africa for early modernity, for example at Blombos Cave in South Africa, as insignificant due to similar occurrences in Europe, such as blade industries at Seclin. However, the changes seem more directed and permanent in Africa than elsewhere during the Upper Pleistocene (McBrearty and Brooks 2000). Thus, it is not apparent that changes leading to the Upper Palaeolithic were confined to Europe.

Carbonell's suggestion that the Aurignacian developed in Europe is useful. It is true that the fully developed Aurignacian appears later in the Levant than in Europe, and not at all in Africa (Banesz 1998). He advocates that interaction between *Homo sapiens* and Neanderthal groups caused technological instability and innovation, followed by Aurignacian fixation. This seems plausible, as interaction between two previously isolated groups may result in novelties appearing (Castles and Miller 1993). However, this suffers from a lack of evidence for transitional pre-Aurignacian Upper Palaeolithic material in areas where Neanderthals resided, except for the proto-Aurignacian of northern Spain, southern France and northern Italy (Arrizabalaga *et al.* 2003). Thus, evidence for this process is limited to a small area of Europe. The interaction model also assumes movement of people into Europe, contradicting

Carbonell's claim of little or no evidence for migration from Africa. He again fails to consider the potential effects of migration on behaviour; changes may simply be a product of movement, making interaction with Neanderthals superfluous to explanation of Aurignacian origins.

The interaction model explains the "transitional" industries, such as the Chatelperronian, as the outcome of local Mousterian Neanderthal industries, during the period of interaction. However, Carbonell aims to show that the transitional industries were not the product of acculturation, and hence focuses on the lack of early Upper Palaeolithic industries preceding the Chatelperronian. Thus, he is left with no interaction, and the transitional industries become independent inventions showing technological convergence with the Aurignacian. He does not consider how these parallel developments took place. Moreover, if the transitional industries developed in isolation, no room is left for the Aurignacian to result from interaction, as he has removed the evidence for population contact. In this scenario, the Aurignacian is the response of *Homo sapiens* to meeting the Neanderthals, but Neanderthals remain unchanged in areas of contact, and innovate in isolation.

Carbonell represents the Neanderthals as similar in behaviour to early modern humans, and focuses on continuities from the late Middle to the Upper Palaeolithic. This is reinforced by suggesting that Neanderthals were a sub-species of *Homo sapiens*, implying support for interbreeding between the two groups, and accommodating a multiregional or moderate Out of Africa model of human origins. However, these views hinge on continuity during the transition, and the presence of temporal trends towards the transition during the late Middle Palaeolithic. The high level of continuity constructed by Carbonell allows him to suggest that the origins of modern behaviours were in Iberia rather than Africa, as fits his agenda. Nevertheless, he does admit that the appearance of the Aurignacian is a discontinuity in Europe, which suggests that some aspects of it developed elsewhere, unrelated to Neanderthal technologies, contradicting the interaction or indigenous development models.

The assumption that any movement from Africa crosses the Straits of Gibraltar is false. Carbonell presumes that movement should follow the shortest route to Europe. However, genetic evidence for the origins of modern human suggests a restricted ancestral group in sub-Saharan Africa (Stringer 2002), thus it seems that the North African Aterian producing population was unconnected to *Homo sapiens* origins. Carbonell claims that humans should have crossed the straits of Gibraltar, because Australian colonisation implies that humans had water-crossing abilities. This is unfounded because European and Australian groups were isolated from one another after leaving Africa, and watercraft may have developed since their common ancestor. He also does not discuss how easy it would have been to cross between North Africa and Iberia at 40 Kyr BP, in terms of distance to cross and current strength. Moreover, there are no regional idiosyncrasies of technology shared between Iberia and the Maghreb, providing no evidence of a specific connection between these regions at the time of the transition (Garcea 2004).

The only specific model that Carbonell advocates to explain the transition concerns ecological differences between the groups. He claims that in Catalonia the late Mousterian is found in the uplands at Ermitons, whereas the proto-Aurignacian is in the lowlands at Arbreda, Abric Romani and Reclau Viver. Ecologically this is plausible, as the two groups could avoid direct competition and therefore could have coexisted for a long period. However, competition models reveal that species most similar and strongly competing are likely to coexist for longest before one is eliminated (Marshall 1988). Moreover, direct competition between highly similar species is liable to result in extinction of one, as neither is sufficiently different to be able to reduce competition by niche shifts. Therefore, it is possible that Neanderthals and modern humans were as similar as Carbonell portrays, and that similarity was a major factor in Neanderthal extinction. Also, he does not make it clear whether the late Mousterian was a highland industry before the Upper Palaeolithic arrived, or whether it was forced from the lowlands. The presence of the initial modern human groups in Iberia in the valley systems is credible because restriction to major natural corridors can occur in the early stages of a colonisation (Kelly 2003).

In summary, the key point raised by Carbonell concerning the Lower Palaeolithic events is that competition drove hominid movement, resulting in a pre-Acheulean phase in Europe between 1.0-0.6 Mya. He suggests that differences should be apparent between the pre-Acheulean and Acheulean phases, in terms of subsistence and raw material transfers, and that the pre-Acheulean arrival should coincide with environmental and ecological opportunities but the Acheulean should arrive without such external facilitation. Regarding the Aurignacian, Carbonell proposes that early modern human groups were confined to lowlands and natural communication corridors. He also strongly supports a European origin of the Aurignacian as an outcome of the meeting of the two populations. These issues will be explored in the following chapters.

Comparison of the models and narratives.

The narrative construction.

Each of the authors has constructed a model using the same data, but with significantly different outcomes. The narrative trope underlying the writing of each model influences the argument and construction of change and hominid abilities, but in turn reflects the aims and agenda of the author. The narrative elements used by each author are presented in Table 3.3.

Author	Plot	Argument	Ideology	Trope
Gamble	Comedy	Organist	Liberal	Synecdoche
Foley	Tragedy	Mechanistic	Liberal	Metonymy
Rolland	Tragedy	Mechanistic	Radical	Metonymy
Carbonell (Lower Palaeolithic)	Tragedy	Mechanistic	Radical	Metonymy
Carbonell (Aurignacian)	Comedy	Contextual	Liberal	Synecdoche

Table 3.3. The narrative elements used in the models of each of the four authors.

Foley, Rolland and Carbonell use similar styles, with Tragic plot, Mechanistic arguments and Metonymic trope. Hominids are treated by all three authors as simply reacting to external environmental forces, and gradually developing new behaviours. Linear change, with no possibility of reversals is a shared feature of these models, and an aspect of the Mechanistic reasoning and Tragic emplotment, which allows flexibility only in response to external environmental factors, and denies other causes of variation. The extrapolation of behaviours beyond their context in time and space to justify the models predictions is also a shared Metonymic feature of these authors' models. Metonymy encourages the use of lithic assemblages as proxies for the populations that made them, and thus routes and timing of dispersals can be determined from the archaeological record. Foley takes the most extreme Metonymic stance by treating tools as equating with entire species, not just populations, fitting his agenda of evolution being paramount, and determining all behaviour. Carbonell's view is similar to Foley, in that assemblages correlate with populations, and communication between groups and indigenous innovation is impossible. Rolland's view is the least extreme, as he allows indigenous developments in technology, and a greater degree of behavioural flexibility than the other authors.

Foley differs from Rolland and Carbonell by considering change Liberally as positive and continually ongoing, as selection constantly refines traits. Rolland and Carbonell share a Radical ideology, with static behaviour until external circumstances force a major and abrupt change. Thus, their narratives follow the same structures, but create substantially different models and predictions. Carbonell follows an agenda of promoting Iberia and Atapuerca, and a medium chronology of European occupation with a pre-Acheulean phase, but is flexible in his models of dispersal, as long as his own fieldwork remains central to the arguments. Rolland's agenda is to promote his theoretical model of hominids conforming to his interpretation of historical biogeographical principles, of change happening gradually by environmental adaptation, and of technological details reflecting population origins. Rolland is flexible in his interpretation of data, and changes the timing and routes of the movements, but retains a fixed interpretive model throughout his work. Foley, like Rolland, is more concerned with promoting his evolutionary and socioecological framework of interpretation, than the details of the data he uses to support his models.

In contrast, Gamble constructs his model in an entirely different manner to the other three authors. His emplotment is Comic, his arguments are Organicist, and his trope is Synecdochic. This construction reflects his social agenda, which contrasts with the other authors concern with ecology and biogeography. Gamble's Liberal ideology is similar to Foley, but reflects a belief in human ability to gradually develop behaviours through social activities, rather than biological adaptation to the environment. Thus, hominids are only partially constrained by the environment, and develop socially to overcome these restrictions, hence all change is internally driven and has no environmental triggers. Gamble's focus on individuals and purposive behaviour is an aspect of this Comic emplotment, and Organicist rejection of laws of causation. Gamble is also concerned to show how modern human behaviour is substantially more complex and flexible than that of archaic hominids. This interest in modern humanity results in Gamble's social focus, contrasting with the other authors, who are more interested in the Lower Palaeolithic and non-modern humans, and therefore follow a more evolutionary and ecological approach, advocated by the research traditions of each period.

Carbonell's use of Synecdoche, Liberalism and Comedy in his treatment of the Upper Palaeolithic is the closest to Gamble's writings, likewise reflecting an interest in sociality and human abilities, and a disregard for environmental constraints. However, Carbonell's argument is Contextual, and he fails to integrate his material into a coherent model. Carbonell uses Contextualism to break down the assumption of the "Out of Africa" hypothesis that the Aurignacian is the product of modern humans, and developed without input from the Neanderthals, fitting his agenda of promoting the Iberian Mousterian as central to the development of modern behaviour. Contextualism reinforces an Ironic stance, and is usually employed to deliberately undermine existing models by denying the validity of their integration of material into an argument.

None of the authors utilise a Metaphoric or Ironic trope. Metaphor is usually applied in the earliest stages of knowledge building in an academic discipline, as this trope is associated with the naming of entities and defining of terms, without the integration of elements into a general model, which occurs at a later stage, using Metonymy or Synecdoche (White 1973). Therefore, it would be difficult to construct a general model of hominid movement using Metaphor. In archaeology Metaphoric models were used during the Culture-History phase of interpretation, which defined cultural groups and explained changes simply by the movement of these entities. Likewise, Irony would not allow the construction of models of movement as this trope is used to negate the pre-existing state of knowledge, and usually follows the construction of models in Metonymic or Synecdochic tropes (White 1973). Thus, in archaeological writings Irony, and its associated Contextualism and Satire, has been used by Post-Processualists to deconstruct Processual arguments that were built using Organicist or Mechanistic argumentation. The only use of Contextualism in the four models analysed is seen in Carbonell's treatment of the Upper Palaeolithic, which is simply a comment on the potential means of interpreting the data and does not form a model for the movement. The lack of Conservative or Anarchistic ideology in any of the archaeological writings studied can be explained by the shared belief in beneficial changes during the Pleistocene, which eventually resulted in modern humans.

Differences between the narratives of the Lower and Upper Palaeolithic movements.

The movement of the Upper Palaeolithic is treated entirely differently to the Lower Palaeolithic by Gamble and Carbonell, but not by Rolland or Foley. Gamble constructs a major behavioural change coinciding with the appearance of modern humans and the Upper Palaeolithic. Carbonell creates a behavioural break at the origin of the Acheulean, and changes his argument to Contextualism from this point. Foley treats modern humans in the same manner as all other hominids, and has no abrupt changes in behaviour in his model, because he believes that the same socioecological principles underlie the behaviours of all species. Thus, the behaviours of modern humans are different to previous hominid species, but are subject to the same economic constraints. Rolland also does not create a single moment of radical behavioural change coinciding with the emergence of modern humans. However, Rolland does not discuss the spread of the Aurignacian, or the origins of the Upper Palaeolithic in detail, therefore it is unclear whether these developments are treated in the same manner as the Lower Palaeolithic. Rolland projects modern behaviour into the Lower Palaeolithic, thus his revolutionary change towards humanity occurs before the Pleistocene dispersals discussed. Carbonell shares this projection of modernity into the Lower Palaeolithic, but excludes the Oldowan from any of its aspects, building revolutionary change. Therefore, there is no consensus among the authors over whether the spread of modern humans was a tangibly different process to the movements in the Lower Palaeolithic. Nevertheless, a bias towards a more social approach to the movement of the Aurignacian is seen, as even Foley suggests that modern humans have evolved to become more social. The Lower Palaeolithic events likewise are treated more ecologically, with Foley, Rolland and Carbonell showing a strong environmental concern, and Gamble giving less ability to overcome habitat constraints to non-modern humans.

Strengths and weaknesses of the models.

Each of the authors has strengths and weaknesses in their models. Ecologically, Rolland and Foley propose plausible models, including elements of environmental matching, corridors and barriers, and faunal turnover. Foley focuses on the relationship between climate change, resource redistribution and subsequent faunal and hominid movements; and includes ecological concepts of biotic release, and physical pre-adaptations contributing to hominid dispersal success. Rolland takes his model from historical biogeography, but has an incomplete picture of the biological processes involved in movement. However, Rolland's concern with human impacts on the ecological community in Europe is apt. Carbonell's postulated scenario of competition driving centrifugal movement is less well supported, and he makes little mention of other ecological processes, with the exception of faunal turnover providing a context for movement. Gamble considers the environment only in terms of the habitat grain scale that could be coped with socially by hominids, and does not make use of biogeographical theory, or ecological observations on dispersal processes. Gamble also denies that physical adaptation could have any affect on hominid colonisation abilities. None of the authors consider models from human geography or sociology, based on human movements in the present. However, some aspects of the proposed models do fit the expectations of human migrations, such as Gamble's focus on social networks and information exchange, and Rolland's expectation of exploration preceding large-scale movement and establishment.

In terms of archaeological plausibility, Foley's model is the least well supported, and obscures variation in lithic assemblages that contradict his predictions. Foley does not believe in human ability to innovate, or to overcome the ecological constraints affecting other species, therefore the archaeological record is only able to illustrate hominid evolution, and has no other possible meanings. Foley does not consider how to detect aspects of his models, such as group size and social organisation in the archaeological record. Rolland is interested in technological details, and incorporates an understanding of the processes of lithic manufacturing into his models, unlike Foley. However, Rolland's linear approach to archaeological developments, and disregard for innovation except when driven by environmental circumstances, undermines his archaeological approach. Carbonell has a strong agenda regarding archaeological data, which is inflexible, and undermines the plausibility of his model. Carbonell disregards the lack of clear archaeological evidence for aspects of his model; for example, the impossibility of horizontal transfer of knowledge, the direct equation of lithic assemblages with populations, and the increase in territoriality and complexity in the Acheulean. Carbonell's approach to the Upper Palaeolithic is likewise limited by his agenda of promoting Iberia, leading him to attempt to show Iberian Neanderthal influence over the development of the Aurignacian, reflecting a compromise between a desire for multiregional human evolution, and acknowledgement that modern humans evolved in Africa. Gamble's model aims to use the features of the Upper Palaeolithic to reveal why modern humans were more successful colonisers than previous hominids. Gamble therefore uses large volumes of archaeological data to support his model, and to reinforce his division between the Upper Palaeolithic and earlier periods. His model therefore appears to be well supported by the archaeological record. However, the interpretation of the Aurignacian reflecting larger social networks, supported by complex social cognitive abilities is not directly apparent from the archaeological record.

Several common themes emerge from the models, with respect to the factors that influenced hominid movement and how these may be detected. The sources of data suggested by the authors include:

- the palaeoenvironmental record,
- the palaeogeographical record,
- the faunal record,
- the hominid fossil record,
- the nature of the lithic assemblages,
- the dating of the first European archaeological sites,
- the nature of raw material transfers,

- the spatial distribution of the early sites in Europe,
- the volume of material recovered from the early sites,
- the presence or absence of regional behaviours and symbolic activities.

The means by which these sources of data can be investigated to test the validity of the models proposed by the four authors, and to reveal the presence of processes suggested in the ecological and sociological models of movement will be discussed in the following chapter.

Chapter 4 : Materials and Methods.

This chapter concerns the methods of collection of data pertinent to the testing of the models of hominid movements into Europe during the Pleistocene discussed in the previous chapter, and the interpretive framework developed in Chapter 2. The key issues raised by the archaeological, biological, geographical and sociological models of population movement will be outlined, and the reasoning connecting the potential data sources of the archaeological, palaeontological and environmental records of the Pleistocene with these critical aspects of the models will be considered, with the intention of highlighting the means by which the models can be tested in the Pleistocene record. The sources of data relevant to the examination of these models during the initial peopling of Europe and the spread of the Upper Palaeolithic will then be discussed, and a description of the methods used to collect the data will complete the chapter.

Methods of examining Pleistocene population movements.

Scope of the study.

This study aims to examine the strength of the archaeological record with respect to the evidence of movement processes. In order to fulfil this aim the models of hominid movement were tested with regard to the initial population of Europe and the spread of the Upper Palaeolithic. These periods were chosen because they were extensively discussed in the archaeological literature, and therefore allowed the justification of the treatment of movement in the archaeological models to be tested. These periods are widely accepted to represent movement, and thus provide the best sample of data with which to examine the potential for the archaeological record to reveal the processes that occur during movement, and to examine whether the interpretive framework of movement developed in Chapter 2 can be usefully applied to the Pleistocene events. The use of both periods of movement into Europe also allows the aim of determining whether the nature of movements changed during the course of the Pleistocene to be addressed.

The potential movement associated with the origin of Levallois technology, suggested by Foley, has not been widely accepted because the origins of the Middle Palaeolithic are considered by many archaeologists to be indigenous to Europe and therefore to not require explanation by dispersal. Therefore, the origins of prepared core technologies were not included in this study, as it is uncertain that movement was involved, and hence this period would not provide a good test of the archaeological models or the interpretive framework. However, once a means of examining the processes of movement from the archaeological record has been generated by the testing of the interpretive framework and the archaeological models, it may be possible to resolve the issue of whether movement was involved in the emergence of prepared core technologies in Europe in a future study. Likewise, the potential movements associated with the origins of Upper Palaeolithic techno-complexes, such as the Gravettian, could then be investigated.

Key issues.

The key issues concerning movement, highlighted in the archaeological, geographical, sociological and biological models, which may be seen during hominid dispersals into Europe, are:

- spatial patterning,
- temporal patterning,
- environmental context,
- faunal community context,
- behavioural context,
- exploration,
- knowledge.

The means of detecting each of these factors in the Pleistocene archaeological, palaeoenvironmental and palaeontological records will be examined in the following section.

Dispersal processes and Pleistocene data.

This section will discuss how the expectations regarding the processes of movement, described in the preceding two chapters, may be detected in the available data sources for the European Pleistocene.

Spatial patterning.

Spatial patterning has been highlighted in the geographical, ecological and archaeological models as being a major source of data concerning movement processes. The issues of exploration, establishment, and networks are all seen through patterns in the location of dispersers. Chain migration models predict that a network of major destination nodes should develop after a period of small-scale exploration (Tilly 1978). The exploration stage is predicted to consist of long distance movements of small groups, resulting in ephemeral but far ranging occupation. At a later stage occupation is expected to disperse into a denser network of secondary nodes in the hinterland surrounding the original primary nodes. Ecological models also predict that colonisers will be clustered in areas of suitable habitat before adapting to conditions in the surrounding areas (Williamson 1996). Archaeological models have suggested a sequence of regions of Europe to be occupied, and have considered early sites to be restricted to easily accessible areas. Therefore, patterning in the locations of archaeological sites can reveal important processes that occurred during movement.

Temporal patterning.

Temporal patterning in evidence of occupation has been linked to dispersal processes in ecological models, which predict the form of the increase in population size over time. Initially, dispersal is expected to involve a small population, and often will fail to establish, resulting in hiatuses before continuous occupation is seen (Williamson 1996). Once a population is established the area occupied is predicted to increase linearly or exponentially over time, depending on the nature of movement, before growth slows and the final range is fully occupied (Shigesada and Kawasaki 1997). Sociological and geographical models also predict initially low numbers of individuals moving during exploration, followed by an exponential increase in numbers as a migration flow develops in a chain migration (Rogerson 1984). These models may be tested by data concerning population size over time, and therefore require the collection of proxy data sources of population size for the sites within the study period. The potential proxies of population size used in this study were the number of sites and the volume of archaeological finds at each site.

Archaeological models have not specifically addressed the temporal patterning of the volume of population movements, and have instead focused upon the chronology of arrival in Europe, which has been connected to the behavioural and ecological circumstances that allowed movement, and to the species of hominid that undertook the movement. It has also been suggested that evidence of occupation should ebb and flow with changes in the Pleistocene environments in Europe. In order to address these key issues it is critical to establish a clear chronology of the evidence for hominid occupation of Europe, as well as to collect environmental, behavioural and hominid fossil data.

Environmental context.

Ecological models suggest that environmental matching between the source and destination can be a key factor in the success of a dispersal (Samways *et al.* 1999). Foley, Rolland and Gamble also put forward models of hominid colonisation in the Lower Palaeolithic, which are linked to a sequence of environmental adaptations, allowing spread through Europe in a fixed order of habitats. Thus, the ecological conditions encountered, and the ecological niche occupied by hominids, during the movements are central aspects of the processes affecting dispersal. However, within major biomes, patches of habitat may have been preferred, which were not representative of the overall conditions. For example, in a steppic region, areas of woodland may exist in sheltered valleys, and if the evidence for hominid presence is only found in the woodland patches then this is the critical environmental factor allowing occupation, not the presence of steppe. Thus, the habitat in the immediate surroundings may be of greater importance in the nature of population movements than gross measurements of regional palaeoecology. Therefore, the palaeoenvironmental data concerning the immediate surroundings of a site can reveal more about the habitats occupied than the regional conditions, allowing the ecological factors that formed barriers to occupation to be delimited.

Landscapes physiognomies, such as mountainous regions, have been claimed to form barriers to occupation in Rolland's models. Models of the spread of the Aurignacian have also suggested a movement through the major river valleys and around the coast of Europe (Mellars 1996). Furthermore, the ecological and geographical models suggest that initial exploration of a region may be restricted to easily accessible communication corridors, in a nodal network. Therefore, the landscape characteristics of the sites of hominid occupation can reveal important information concerning movement processes and hominid behavioural capacities.

Faunal community context.

The ecological community into which hominids arrived has been predicted to be low in competition and experiencing faunal turnover by Rolland and Foley, or possessing a poor ability to resist the incursion of new species in ecological models (Case 1991). Faunal turnover results in low competition levels and poor ability to resist biological invaders as ecological communities undergo restructuring. Hominid appearance in Europe has been suggested to coincide with, or immediately post-date, a period of turnover that reduced competition, providing easier conditions for establishment. Periods of faunal turnover can be detected through a high level of first and last appearance dates of species in Europe. Ecological models also suggest that extinctions often follow the arrival of a species in a new community (Simberloff and Von Holle 1999), thus data concerning the last appearance dates of species in Europe can also highlight any repercussions of hominid arrival on the faunal community.

In archaeological models hominid movement has been considered to take place as part of the movement of guilds of species, which share a geographical origin and a dietary niche, in large-scale dispersal events. The palaeontological record of Pleistocene Europe, particularly the assemblages of fauna recovered from archaeological sites, can address the question of whether hominids moved as part of a faunal dispersal event, within a community or guild, or moved alone. The appearance of species from particular geographical regions or with certain dietary requirements, coinciding with hominid arrival, could access these issues of hominid participation in faunal dispersal events.

Behavioural context.

The archaeological record has been suggested by Rolland, Carbonell and Foley to show linkages between the regions of origin and destination, through shared technologies and tool forms, particularly handaxes in the Lower Palaeolithic, and end scrapers and burins in the Upper Palaeolithic. The geographical extent of the production of tool forms and the use of different technologies can reveal whether such linkages between regions existed.

The ecological, geographical and archaeological models all predict behavioural changes, adaptation and innovation to be associated with movement, either as a process of overcoming the barriers to movement, or as a result of the isolation of the populations at the destination. These processes have been linked to speciation by Foley (Foley 1987a; Foley and Lahr 1997), and may be assessed through the association of artefact types and hominid species over time. The geographical and temporal placement of the appearance of novel forms of behaviour seen in lithic assemblage characteristics could identify these predicted behavioural changes. Behavioural changes have also been linked to environmental causes driving adaptation (Foley 1984b, 1987b), and particularly the development of strongly stylistic forms as a means of communication and social network reinforcement in harsh environments (Gamble 1980, 1984, 1986). The timing and location of the appearance of novelties in the archaeological record can establish whether these events do correlate with environmental conditions. Behavioural innovation has been suggested to be the cause, as well as a result, of movements. Therefore, the study of movements into Pleistocene Europe needs to include assemblage characteristics in the regions surrounding Europe, in order to detect any innovations that preceded movement, at the origin of the colonisers.

Exploration.

The proposition that movements feature an exploratory stage before major population flows and establishment occur, suggested by geographical and ecological models, can be linked to features in the archaeological record. The exploratory stage should theoretically involve small populations, with a restricted range of behaviours, spread widely over Europe, and with short duration of occupation at any single locality. The established phase would be expected to show evidence of larger populations, with a broad range of activities occurring, and a greater knowledge of the landscapes in which hominids resided, reflecting a more permanent presence.

The size of archaeological assemblages and the number of sites over time could act as a proxy of the relative size of the population involved in movement and settlement. However, the size of the lithic assemblage may also reflect the duration of occupation at Lower Palaeolithic sites. Nevertheless, large populations or long duration of occupation are both aspects of an established settlement phase. In the Upper Palaeolithic the number of hearths and the presence of structures at a site could act as an additional reflection of occupation duration or intensity. The range of species utilised at each site might also provide a proxy for the duration of occupation or size of population, by assuming that increasing numbers of subsistence expeditions, as a result of increased time or group size, would result in more species being encountered and used.

Knowledge.

Poor knowledge of the surrounding area would be expected in an exploratory phase. Raw material transfer distances may be used as a means of accessing knowledge of the region. A group with poor knowledge of the location of resources would be expected to curate existing tools, and to transfer materials long distances from the few known sources, in which scenario the average distance of raw material transfers would be expected to decrease over time, and the number of sources of material would increase as groups become more familiar with local resources. Raw material movements could also address the issue of territoriality raised by Foley and Carbonell, by revealing the extent of movements undertaken by individuals, if it is assumed that raw materials were always directly transported and were not exchanged between groups.

The number of species utilised at a site could also provide a measurement of familiarity with the local area, as specialism on a single species would only be possible when the movements of the species in the surroundings were known. Alternatively, subsistence breadth may be initially limited to resources familiar from the home region, becoming broader as knowledge about local resources increased. Therefore, a trend either for more species, or for less species, to appear in sites over time could reveal processes linked to movement. However, ecological models predict that a wide variety of species should be utilised throughout the colonisation events because a broad diet is a marker of a flexible, generalist species capable of successful dispersal. Thus, dietary breadth may be an important factor in the processes of movement.

The Lower Palaeolithic data collection.

Data sources.

To test the models concerning hominid movement in the Lower Palaeolithic data was collected from sites throughout Europe, the Near East and North Africa, in order to provide a picture of the level of similarities and differences between sites in Europe and those in the potential source areas of European settlers. The study involved sites dating to OIS 11 or earlier, with the intention of comprising all the early phases of potential settlement in Europe, and also to include a period of clearly established occupation, in order to compare between patterns in a possible exploratory stage, and in an established occupation phase. Faunal sites, with no evidence of human occupation, within the temporal and spatial range covered, were included in order to establish the environmental and faunal community context in Europe during the arrival of hominids. Data was collected by literary review, with the aim of covering as many sites within the study area and time span as possible, and thus producing a database that was representative of the archaeological, palaeontological and palaeoenvironmental records throughout Europe during the study period. A relational database was constructed, containing the categories of data listed below.

Lower Palaeolithic data collection.

Archaeological sites were catalogued by individual level or context as displayed in Figure 4.1. This section will describe the classes of data collected for each site context, with the classifications used in the database highlighted in bold.

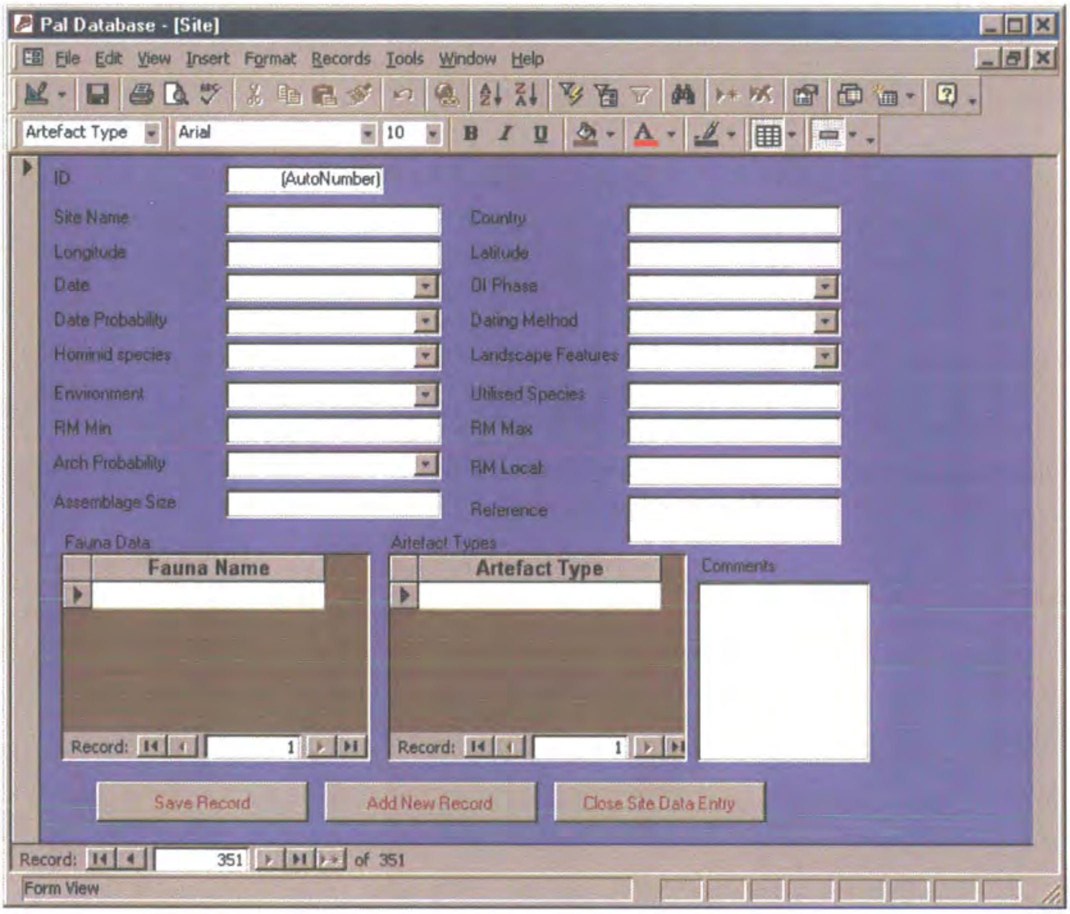


Figure 4.1. Data entry form for the Lower Palaeolithic sites.

Latitude and **Longitude**: recorded to four decimal places, was used to provide a consist means of plotting the locations and thus exploring the spatial patterning associated with movement. Sites described by local map grid values in the literature were converted into longitudes and latitudes. However, the majority of the literature consulted did not give a precise location of the site, in either a map grid or longitude and latitude. The locations of these sites were determined as accurately as possible from descriptions of the physical location of the site given in the literature, with the use of The Times Atlas of the World (Lewis and Geelan 1993), and internet map resources. Nevertheless, some sites were impossible to locate, and have been excluded from the analysis of spatial patterning.

Date: recorded as an oxygen isotope stage, in order to provide a comparable date for all sites in the study area, rather than placing sites within a regional dating sequence. However, uncertainties existed over the placing of many sites in the oxygen isotope stage scale; therefore, a **date probability** was also used, which was categorised as:

- Definite: no doubts raised over the placement of the context into a single isotope stage.
- Probable: doubts over the dating existed, but the material could be confidently dated to a range of two consecutive glacials or interglacials.

Records for sites with probable dates were duplicated and assigned to both probable date values. When greater uncertainties existed over the dating of the material the site was rejected as too poorly dated for analysis.

However, as data collection proceeded it became clear that this process rejected a great number of sites, which contained otherwise useful information. The exclusion of so many sites was considered to be liable to bias the final analysis and possibly destroy potential evidence relevant to the models of colonisation. Therefore, additional broader date categories were added to allow poorly dated sites with otherwise good archaeological evidence to be analysed. These date categories were based on the faunal and palaeomagnetic sequences, as these dating methods were applicable to the majority of sites. The six date categories constructed were:

- "Later Middle Pleistocene", defined as post-Cromerian or Biharian in fauna, and coinciding with late OIS 12 and the whole of OIS 11.
- "Mid Middle Pleistocene", included sites with fauna from the second half of the Cromerian complex, corresponding to OIS 15-12.
- "Early Middle Pleistocene", containing fauna from the first half of the Cromerian complex, equivalent to OIS 19-16.
- "Late Early Pleistocene", defined as falling between the Jaramillo and Brunhes-Matayama palaeomagnetic boundary.
- "Mid Early Pleistocene", containing sites within the Jaramillo palaeomagnetic event.

- "Early Early Pleistocene", consisting of sites within the Pleistocene before the Jaramillo event.

Each site context was recorded as falling within these broad categories, and whenever possible was also assigned to an oxygen isotope stage. The qualification of date probability was retained. Sites that could not be dated to this level of accuracy, such as surface finds, were rejected from the analysis. This procedure resulted in each site context being duplicated for each probable date. Analysis was then performed at both levels of dating accuracy and certainty.

Oxygen isotope stage phase (OI Phase): recorded with the intention of providing dates at a finer scale than the oxygen isotope stage scale allows. The assignment of each site to a phase within an oxygen isotope stage was based on the palaeoenvironmental evidence present in each context. The phases of glacials and interglacials used were:

- Early: sites that were clearly at the transition from cold and open glacial conditions to warm and closed interglacial environments, or vice versa.
- Middle: sites showing the presence of full interglacial conditions of closed forests, or fully glacial conditions of tundra and steppe.
- Late: sites displaying a transition towards glacial conditions and more open vegetation, or containing evidence of a succession from open glacial environments to more vegetated conditions.
- Early/Late: sites containing evidence of the absence of closed forest and warm interglacial faunas, or open habitats and glacial faunas, without clear evidence of the direction of the transition.
- Early-Middle: sites showing conditions approaching full interglacial flora and fauna, or containing evidence of a decline in temperature towards fully glacial conditions.
- Middle-Late: sites with evidence of a cooling of conditions from warm and closed forest to cool and open environments at the end of an interglacial, or a rise in temperature and the return of sparse vegetation during a glacial.
- Early-Middle-Late: sites that could not be attributed to any of these phases of an interglacial or glacial, or sites that showed the full range of conditions within one archaeological level.

Dating method: recorded to allow the dating techniques to be compared and inconsistencies highlighted. The dating methods included in the database were faunal correlation, potassium-argon series, uranium series, palaeomagnetism, amino-acid racemization, thermoluminescence, electron-spin resonance, argon-argon series, optically stimulated luminescence, geological correlation, and lithic typology.

Hominid species: collected in order to test hypotheses regarding the linkage between species and technology, and species and timing of the dispersals. Species were recorded as:

- *Homo erectus*
- *Homo ergaster*
- *Homo heidelbergensis*
- *Homo antecessor*
- *Homo sp.*: in the case of controversy over assigning hominid fossils to a species.
- Archaeological: sites that contained archaeological material without any hominid fossils.
- Non hominid: faunal sites, lacking any evidence of hominid presence.

Landscape features: assigned to categories designed to describe all general landscape formations, in order to examine whether landscape physiognomy affected the ability of hominids to occupy an area. The classifications of the landscapes in which the sites were situated were:

- coastal,
- riverine,
- lacustrine,
- mountainous,
- high plateau,
- hilly,
- plains.

Sites were attributed to one of these categories by the landscape physiognomy deemed to be the most important in allowing hominid presence. For example, sites situated in a major river valley within a mountainous region were recorded as riverine, because valleys were considered to be corridors encouraging hominid presence. Therefore, sites within valleys were designated riverine, whether or not they were situated directly bordering the river. Likewise, coasts were treated as natural corridors through the landscape, facilitating hominid movement and occupation. Therefore, sites were described as coastal if they were situated on the coastal plain, close to, but not necessarily adjacent to the coastline.

Environment: recorded following standard ecological biome categories (Whittaker 1975), with the aim of avoiding the problem of pre-determining the important aspects of the environment through the construction of categories to fit the expectations of the archaeological models. Biomes are zonal plant formations and their associated animals (Schultz 1995), of which there are six major physiognomic types on land: forest, woodland, shrubland, grassland, semidesert scrub, and desert. Whittaker's system was chosen because it provides a universal classificatory system, which applies to all ecological communities, regardless of regionally occurring species, and can therefore be applied to Pleistocene communities that lack a direct analogue in the present day. The physiognomic classes are divided on the basis of the plant cover, and these plant formations are sub-divided by climate into the following relevant classifications:

1. Temperate rain forest: found in cool and maritime climates, with abundant winter rainfall, and much summer cloudiness and fog. The trees are tall but have low species diversity.
2. Temperate deciduous forest: located in moderately humid continental climates, with summer rainfall and severe winters. Broad-leaved deciduous trees dominate, and typical species are oak (*Quercus*), beech (*Fagus*), maple (*Acer*), ash (*Fraxinus*), chestnut (*Castanea*), alder (*Alnus*), elm (*Ulnus*), hornbeam (*Carpinus*), lime (*Tilia*) and birch (*Betula*). Modern mammals found in this biome are primarily ground dwelling, and include red deer (*Cervus*), bear (*Ursus*), badger (*Meles*), hedgehog (*Erinaceus*), dormouse (*Muscardinus*) and squirrel (*Sciurus*).
3. Temperate evergreen forest: seen in varied climates and displays varied structures. Mediterranean, or summer-dry and low humidity, and maritime climate forest has sclerophyll leafed trees, which are tough, evergreen, small,

and broad leaves, such as olive (*Olea*), evergreen/holly oak (*Quercus ilex*) and Aleppo pine (*Pinus halepensis*). Other typical plants are box (*Buxus*), cranberry (*Viburnum*), mock-privet (*Phillyrea*), Pistachio (*Pistacia*), buckthorn (*Rhamnus*), rose (*Rosa*), butcher's-broom (*Ruscus*), madder (*Rubia*), asparagus (*Asparagus*), ferns (*Asplenium*), and sedges (*Carex*). Needle-leaved evergreen forest, with more open structure than deciduous forest, is found in continental climates.

4. Taiga or subarctic-subalpine needle-leaved forest: differentiated from temperate evergreen forests by lying at the cold edge of the climatic range of forests. Taiga is dominated by coniferous spruce (*Picea*), fir (*Abies*) or pine (*Pinus*), and can include deciduous larch (*Larix*), especially in extremely continental areas. Taiga is characterised by low species diversity of trees. Deciduous trees present include: birch (*Betula*), poplar (*Populus*), willow (*Salix*), alder (*Alnus*) and ash (*Fraxinus*). Shrubs producing berries are also found in taiga, including rowan (*Sorbus*), cranberry (*Viburnum*), blueberry (*Vaccinium*), crowberry (*Empetrum*), wild strawberry (*Fragaria*) and cloudberry (*Rubus*). Undergrowth species are varied, including lichens and mosses. Sub-alpine zones contain open pine woodland, whereas humid sub-arctic areas are covered by extensive bog. Taiga opens northwards to woodland of scattered trees with tundra undergrowth. High elevation margins have woodland or wind-sheared shrub communities. Animals found in these biomes consist of elk (*Alces*), red deer (*Cervus*), bear (*Ursus*), beaver (*Castor*), wolverine (*Gulo*), wolf (*Canis*), fox (*Vulpes*), hare (*Lepus*), lynx (*Lynx*) and reindeer (*Rangifer*). Reptiles and amphibians are rare.
5. Temperate woodlands: communities of small trees, ranging from nearly full canopy cover to open woodlands with scattered trees, grading into treeless shrublands and grasslands. Dominant trees are either needle-leaved, sclerophylls or deciduous broad-leaved trees. Woodlands exist in areas too dry for full forest, such as the Mediterranean. Increasing dryness results in grasslands, shrubland and semidesert.
6. Temperate shrublands: sclerophyll shrublands in Mediterranean type moderately dry and warm temperate maritime climates with little or no summer rain. Sclerophyll leaves dominate, creating low canopy open conditions. Mediterranean maquis is typical, as is South African fynbos.

Frequent fires characterise these biomes. Temperate shrublands also include deciduous shrublands of inland mountains, aromatic shrublands of dry Mediterranean climates, and heaths of cool maritime climates. Box (*Buxus*), cranberry (*Viburnum*), mock-privet (*Phillyrea*), pistachio (*Pistacia*), buckthorn (*Rhamnus*), rose (*Rosa*), butcher's-broom (*Ruscus*), madder (*Rubia*), asparagus (*Asparagus*), ferns (*Asplenium*), and sedge (*Carex*) form the typical flora.

7. Savannah: consists of tropical grassland, with or without scattered trees or shrubs. Savannah forms in areas too dry for forest, with poor soil conditions, or a frequent fire regime. C-4 grasses are the dominant plants. The fauna is extremely rich in grazers; typical species are: antelopes (*Hippotragus*), gazelles (*Gazella*), elephant (*Loxodonta*), giraffe (*Giraffa*), hippopotamus (*Hippopotamus*), rhinoceros (*Ceratotherium*), warthog (*Phacochoerus*), ostrich (*Struthio*), lion (*Panthera leo*), leopard (*Panthera pardus*) and hyena (*Crocuta*).
8. Temperate grasslands/steppes: found in areas of moderately dry, continental climate. The vegetation is single stratum, but has high plant diversity compared to most forests. Mammals are characterised by small burrowers such as rabbits (*Lagomorpha*) and rodents (*Rodenta*); and larger running herbivores, such as bison (*Bison*), saiga-antelope (*Saiga*) and horse (*Equus*). Plants are grasses and sedges.
9. Alpine shrublands: seen in mountainous areas above the timberline. The height of the shrubs decreases towards drier and higher areas on the mountains.
10. Alpine grasslands: form the principle communities above the timberline. These are dominated by sedges (*Carex*), and miniature shrub communities of dwarf willow (*Salix*), heaths (*Ericaceae*) and other woody plants. Characteristic animals are pica (*Ochotona*), marmot (*Marmota*), mountain goat (*Capra*), sheep (*Ovis*) and bear (*Ursus*). Summers are brief, resulting in many animals migrating to lower elevations, or hibernating for winter.
11. Tundras: are treeless arctic plains, with varied and complex patterns of dominance by dwarf-shrubs, dwarf birches and willows, sedges and grasses, mosses and lichens. Common genera among the herbaceous plants and dwarf shrubs are: blueberry (*Vaccinium*), bearberry (*Arctostaphylos*), crowberry (*Empetrum*), mountain aven (*Dryas octopetala*), bog/dwarf birch (*Betula nana*), cloudberry (*Rubus chamaemorus*), wood horsetail (*Equisetum*

silvaticum), cotton grass (*Eriophorum*), Labrador tea (*Ledum*), willow (*Salix*), sedges (*Carex*), saxifrage (*Saxifraga*) and heathers (*Cassiope*). Lichens (*Cetraria* and *Cladonia*), and mosses (*Plytrichum* and *Dicranum*) are common. Dwarf-shrubs disappear in colder areas of the tundra. Herbivores include musk ox (*Ovibos*), reindeer (*Rangifer*), arctic hare (*Lepus*), wolf (*Canis*), arctic fox (*Alopex*), wolverine (*Gulo*) and lemming (*Synaptomys*). On the coast fauna include seal (*Phoca*), walrus (*Odobenus*) and polar bear (*Ursus maritimus*). Reptiles and amphibians, molluscs and insects are few or absent.

12. Warm semidesert scrub: seen in dry warm-temperate and sub-tropical climates. This biome forms rich and diverse shrub communities on the margins of deserts. Succulents are the dominant plant group. Plants are dispersed, not clustered as in forested steppe.
13. Cool semideserts or Desert steppe: widespread communities dominated by sagebrush (*Artemisia*) with perennial grasses. Desert steppe ranges from dry grassland with sagebrush to sparse cover of shrubs, and from dominance of sagebrush to dominance of shadscale (*Atriplex*). Some desert steppes are formed from a mixture of several species. Animals include antelopes (*Hippotragus*), and jumping rodents such as pocket mice (*Chaetodipus*) and kangaroo rats (*Dipodomys*).
14. Arctic-alpine semideserts: found in arid climates above the timberline. These biomes are dominated by spiny cushion plants, such as members of the genus *Astragalus*, and succulents. Small sagebrushes (*Artemisia*) are the dominant plants. Semiarid areas of the arctic are often treated as part of the tundra, but in characteristics they are desert-like.
15. Deserts: located primarily in the subtropics. Deserts are continuous with areas of warm semidesert scrub, but are found in more arid climates. Precipitation is less than, or equal to 5cm annually, resulting in sparse or absent plant cover. Deserts are dominated by bare ground surfaces. Plants are low desert shrubs, and lichens in areas with fog. Some semideserts are floristically rich, but true deserts are poor in plants and animals.
16. Arctic-alpine deserts: found in extremely cold climates. Plant cover is very low, and these areas are dominated by ice, rock or snow. Some algae occur on ice surfaces, lichens grow on rocks, and scattered vascular plants grow in less extreme environments.

17. Cool temperate bog: forms in cool, humid and maritime climates. These communities are poor in flora, and are mostly formed of sedges, with few species of mosses, grasses and dwarf shrubs. Cool temperate bogs are similar to dwarf shrub tundras.
18. Temperate fresh water swamp: forms in cool, waterlogged conditions.
19. Saltmarshes: formed along temperate coasts, and consist of salt resistant plants.

Each site context was assigned to one of these categories using the faunal and palaeoenvironmental record, such as microfauna and pollen evidence from the site itself, rather than the regional palaeoenvironmental record. In the case of conflicting environmental indicators, the site was attributed to the category supported by the majority of the evidence. The environmental data was intended to allow the testing of the environmental matching models of biogeography, adhered to by Foley, Rolland and Gamble, and also to provide a means of determining the habitats that acted as corridors, filters and barriers to hominid movement.

Assemblage size: recorded numerically, rather than in categories, in order to allow several ranges of category sizes to be used in the analysis. Large assemblages were often described in the literature as having a number of tools greater than a fixed value, in which case the assemblage was recorded in the same manner. This data was intended to form a proxy for the size of the population present, and to provide insights into exploration before established occupation. Therefore, the assemblage size included all the artefacts present in a site, as sites containing small numbers of tools and large volumes of debitage were considered to show more substantial evidence of occupation than those that only contained few completed tools, because tool production on site could reflect established settlement rather than exploration and the use of curated tools transported from regions of pre-existing occupation.

Raw material minimum and maximum transport distance: recorded in kilometres. However, it was found that precise raw material transfer distances were described in very few cases. Therefore, the database was modified to include a second category of raw material transport, termed **Local Raw Materials**, which classed sites as:

- Local: all material in the assemblage originated within 40 Km of the site.

- Non-local: assemblages including materials transported more than 40 Km.

The 40 Km distance was used because this corresponds to the boundary of a local hominid network defined by Gamble (1998). Sites were described as containing non-local raw materials when any amount of material was found to have been transported over distances greater than 40 kilometres, even if the majority of raw materials were derived from local sources. The raw material transfer distances were collected as a proxy for the level of knowledge of the landscape, and thus of the process of landscape learning during exploration.

Utilised species: recorded the number of faunal species described as showing evidence of utilisation, which was defined by the presence of butchery marks or use of bones as tools. The numbers of cut-marked bones or individuals were not recorded, as such detailed information was only presented in a small minority of reports concerning Lower Palaeolithic European sites, whereas a greater number of reports described the species showing evidence of use. The number of identified specimens or the minimum number of individuals were not used, because this level of detailed information was not available from the majority of sites. Therefore, the number of utilised species was intended to act as a substitute for the number of utilised individuals in each archaeological context, and was collected with the aim of providing insights into the potential exploratory phase of movement and the process of knowledge acquisition.

Artefact types: recorded the types of artefacts recovered in each assemblage, using the categories of:

- bone or antler tools,
- choppers,
- cleavers,
- debitage,
- flake tools,
- handaxes,
- prepared cores,
- wooden tools.

These categories were considered to be broad enough to include all material described in the literature, without having to re-examine assemblages personally. The categories were also designed to include the full range of variation seen in the Lower Palaeolithic in Europe. However, the presence of any unusual features seen in an assemblage, not covered in these tool categories, were recorded in the **Comments** on the site. The artefact data was collected with the aim of establishing whether the pre-Acheulean phase of European occupation did occur, and to determine whether there is any evidence of the route of movement, and behavioural changes and innovations accompanying the spread into Europe.

Archaeological probability: classified the likelihood of each site context genuinely representing hominid presence, rather than containing pseudo-artefacts. Assemblages were divided into three categories of

- Definite: assemblages that are accepted as archaeological in all reports, and contain artefacts that are clearly of human manufacture, such as handaxes, or included unquestionably hominid fossils.
- Probable: assemblages accepted as archaeological in the majority of reports, but some doubts over their human origin were expressed in the literature.
- Unlikely: assemblages consisting of uncertainly humanly manufactured tools, which were widely questioned in the literature, and those that contained fossils not generally accepted as hominids.

This approach aimed to include all material in the database, rather than rejecting sites that potentially revealed patterns of hominid dispersal. The classification of probability of hominid presence allowed analysis of patterning to be undertaken at each level of confidence in the archaeological record.

Faunal data: recorded the macrofauna present in each site context by genus and species. Microfauna were excluded because the study of the fauna intended to reveal the ecological community and competitive environment faced by colonising hominids, and microfauna were believed not to contribute to these factors. The microfauna were included in the assessment of the environmental type surrounding each site. Additional information included in the fauna database, shown in Figure 4.2, consisted of:

- **Dietary type**: classed as herbivorous, carnivorous or omnivorous. This data was collected in order to test whether hominids moved as part of a faunal guild.
- **First Appearance Date** (FAD) and **Last Appearance Date** (LAD): recorded at the level of accuracy of the six major palaeomagnetic and faunal divisions of the Lower and Middle Pleistocene described above. The FADs and LADs applied to the appearance of the species in Europe, in order to highlight potential correlations with the timing of hominid movements. For example, a species that originated in Asia was recorded as having a later FAD than its evolutionary origin. Species that had appeared in Europe prior to the Pleistocene were classed as having a FAD in the early Early Pleistocene. Likewise, LADs were given for presence in Europe only, and those species still in existence at the end of the study period were assigned a LAD in the late Middle Pleistocene. The FADs and LADs were calculated from the presence of each species in the database. This data was used to determine whether a context of faunal turnover coincided with hominid movements.
- **Geographical Origin**: classified by continent where possible, or major faunal zone if the precise origin could not be discerned. Species that had arrived in Europe before the beginning of the Pleistocene were classed as European. The geographical origin of each species was generated from a review of the literature concerning Pleistocene fauna (Savage and Russell 1983). This data was used to examine whether hominids were associated with species from a particular region, and whether hominid arrival coincided with that of other species from any distinct region.

The faunal data was checked for duplications due to renaming of species, with the assistance of Dr. Danielle Shreeve; for example, the replacement of *Dicerorhinus* by *Stephanorhinus*, and all duplicates were removed.

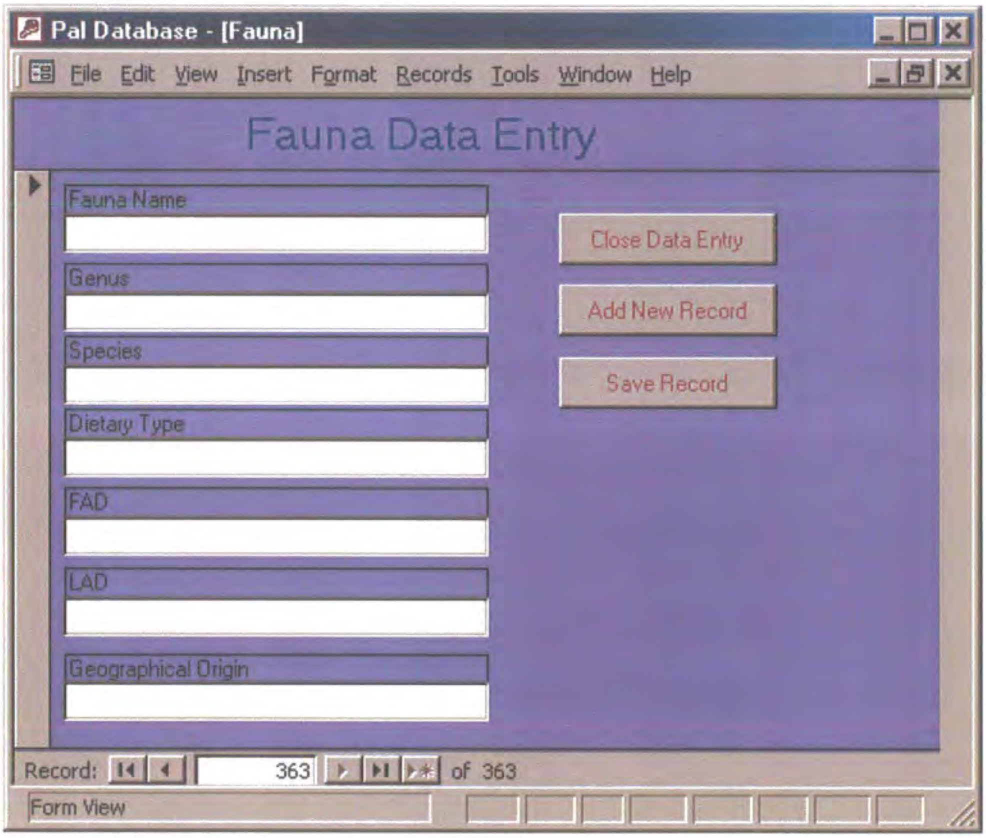


Figure 4.2. Data entry form for the faunal data.

The Upper Palaeolithic data collection.

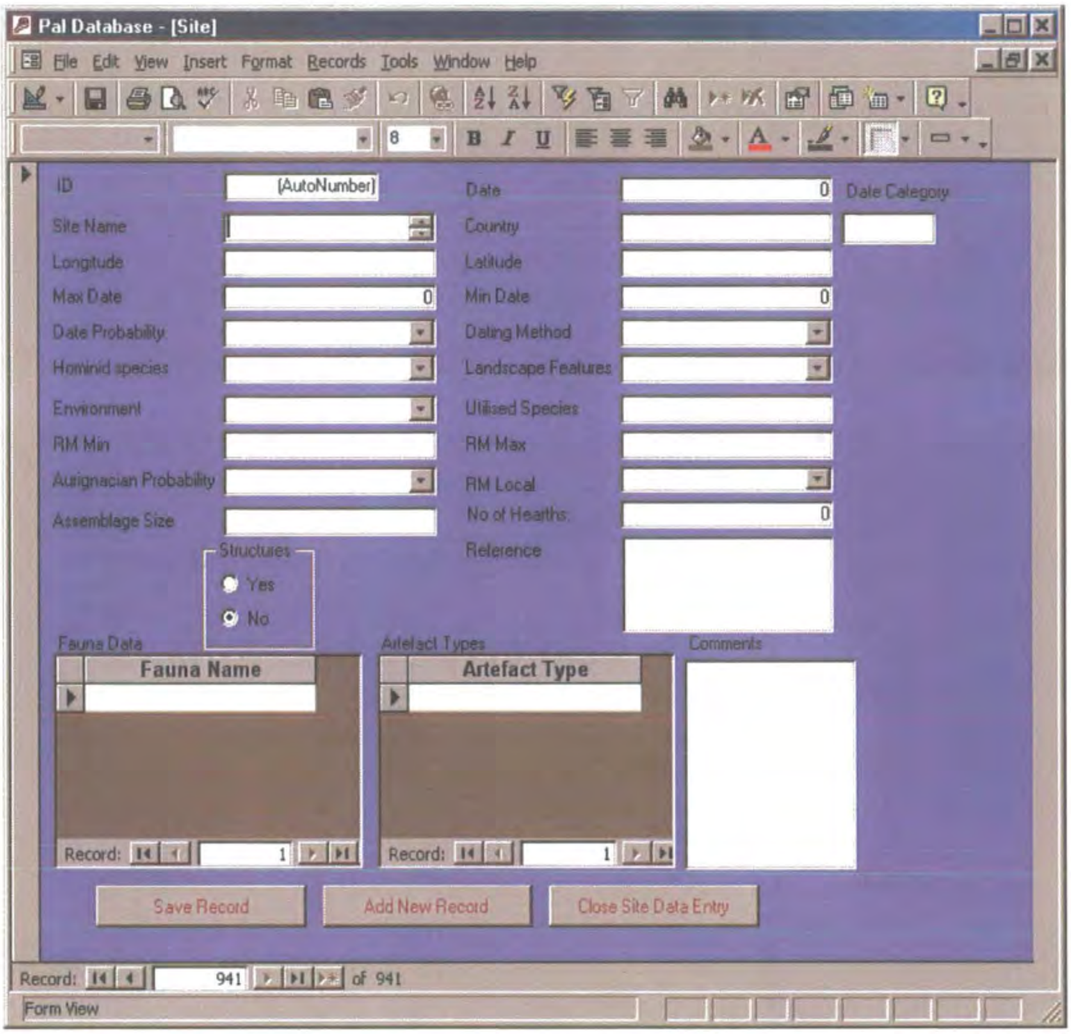
Data sources.

It was decided to use the Aurignacian industry only, in the examination of the process of movement in the Upper Palaeolithic. The transitional industries, such as the Chatelperronian and the Uluzzian, were excluded because of the possibility that these are not the product of modern human immigrants to Europe, and are instead representative of final Neanderthal industries. The potential interaction between the modern humans and the Neanderthals during the influx of *Homo sapiens* to Europe was considered to be beyond the scope of this study, since the examination of the processes of movement in the Upper Palaeolithic was intended to test the models of colonisation, not acculturation and interaction. Human geography and sociology do provide models of interaction that could be applied to these industries; however, it was decided to restrict the testing of the models strictly to the processes of movement.

The Aurignacian does not appear to be an indigenous development in Europe, and has been strongly argued to be a proxy for the colonisation of Europe by modern humans (Davies 2001), and therefore was considered to provide the best archaeological opportunity to study migration in the Upper Palaeolithic. The temporal and spatial range of the data collected corresponds to the occurrence of the Aurignacian; thus, excluding North Africa and the majority of the Levant. The data used in this study was derived from the Stage Three Project (van Andel and Davies 2003; Davies 1999). This provided a large database of dated sites in Europe during the existence of the Aurignacian. The Stage Three Project data was modified to add information considered pertinent to the processes of colonisation, by referring back to the original site reports listed in the database. Every entry in the Stage Three Project database that corresponded to an Aurignacian, probably Aurignacian, early Upper Palaeolithic or faunal site was investigated.

Upper Palaeolithic data collection.

The data collected was intended to be as similar as possible to the Lower Palaeolithic data, with the aim of providing a directly comparable sample, and hence to allow similarities and differences in the movements of the Lower and Upper Palaeolithic to be detected. The Stage Three Project database was used to generate the list of potentially Aurignacian sites, with absolute dates, and the longitude and latitude of each site. The absolute dates replaced the use of oxygen isotope stages and phases, and major divisions of the Pleistocene. The remaining classes of data were collected by referring to the original literature listed in the Stage Three Project database. The data was entered into a relational database constructed in the same manner as the Lower Palaeolithic database, with the exception of the following modifications, shown in Figure 4.3:



ID (AutoNumber)

Date 0

Date Category

Site Name

Country

Longitude

Latitude

Max Date 0

Min Date 0

Date Probability

Dating Method

Hominid species

Landscape Features

Environment

Utilised Species

RM Min

RM Max

Aurignacian Probability

RM Local

Assemblage Size

No of Hearths 0

Structures ○ Yes ● No

Reference

Fauna Data

Record: 1

Artefact Types

Record: 1

Comments

Record: 941 of 941

Figure 4.3. Data entry form for the Upper Palaeolithic sites.

Date: consisted of a calibrated absolute date, expressed as the numerical centre-point. The Stage Three Project used the CALPAL calibration of radiocarbon dates with the default calibration curve (van Andel *et al.* 2003b).

Minimum date: recorded the minimum value of the calibrated radiocarbon date at two standard deviations.

Maximum date: recorded the maximum value of the calibrated radiocarbon date at two standard deviations.

Date probability: recorded the qualification of the probability of the dates as:

- Definite: dates that were not questioned in the Stage Three Project database or in the original literature.
- Probable: dates listed as questionable in the Stage Three Project database due to being clear outliers producing dates far outside the range of Aurignacian existence, or as being measured on poor samples, or infinite dates (van Andel *et al.* 2003b), and dates questioned in the original literature for the same reasons.

The dates that were not definite were excluded from further analysis.

Date category: recorded all the periods within the existence of the Aurignacian that the site was dated to, using the following categories:

- >40 Kyr BP,
- 40-36.5 Kyr BP,
- 36.5-33 Kyr BP,
- 33-29.5 Kyr BP,
- 29.5-26 Kyr BP,
- <26 Kyr BP.

These divisions of 3500 years were designed to allow sites to be placed in a minimum of categories, by considering the size of the standard deviations of radiocarbon dates during the early Upper Palaeolithic, following the recommendations of Pettitt (1999). A division earlier than 40 Kyr BP was not used as no Aurignacian sites could be placed earlier than 43.5 Kyr BP. Radiocarbon dates represent the distribution of possible dates of a sample; therefore, the actual date may fall anywhere within the distribution given by the standard deviation, and thus all dates within this range are equally likely and must be included in all analyses (Pettitt 1999, 2000; Pettitt *et al.* 2003). Therefore, each site was placed in every category covered within the range of its minimum and maximum definite dates at two standard deviations. In the situation of a site having been dated using several samples, the overall minimum and maximum of all the unquestioned dates were used to assign the site to the date categories. This resulted in some entries in the database being duplicated to place each site context into every applicable category. In order to ensure that each site context was assigned to each applicable date category only once, the sites with many dated samples were checked for duplicated date categories, and the superfluous entries in the database were removed from the analysis, preventing the over-representation of sites that had been extensively dated. The probable dates were discarded because they were too imprecise to allow sites to be placed within the date categories, and often resulted in a single context being dated to all six categories. The date categories, rather than numerical dates, were then used throughout the analysis of the Upper Palaeolithic data.

Aurignacian probability: measurement of the probability of a site representing the Aurignacian, which replaced the probability of a site representing human presence. Sites were classed as:

- Definite: sites that undoubtedly contain Aurignacian assemblages, as represented by typical Aurignacian artefacts.
- Probable: sites that were listed as "?Aurignacian" or "EUP" (early Upper Palaeolithic) in the Stage Three Project database, and were found to be early Upper Palaeolithic, but containing few typically Aurignacian tool forms.
- Unlikely: sites described as "?EUP" in the Stage Three project data, and found to be formed of early Upper Palaeolithic assemblages lacking diagnostic Aurignacian tools.

Hominid species: recorded as:

- *Homo sapiens*
- *Homo neanderthalensis*
- Archaeological: Upper Palaeolithic assemblages lacking human fossils
- Non hominid: faunal sites.

Sites found to contain *Homo neanderthalensis* fossils were excluded from further analysis, in order to avoid including material that was unrelated to the movement of *Homo sapiens* into Europe.

Two categories of data not present in the Lower Palaeolithic database were added as potential proxies for the intensity and duration of occupation of the site, and therefore for the presence of an exploratory stage before major occupation:

Number of hearths: recorded the number of hearths reported from each site context.

Structures: recorded the presence or absence of structures in each context.

Artefact types: recorded the presence in each assemblage of the following categories of artefact: Aurignacian blades, backed bladelets, beads, bevelled bone points, biconical points, burins on truncations, busqué burins, carinated scrapers, chamfered blades, Chatelperronian knives, crested blades, debitage, dihedral burins, Dufour bladelets, flake tools, flattened lozengic points, Font-Yves bladelets, grattoirs, leaf points, Levallois cores, marine shell, mobilary art, nosed scrapers, oval lozengic points, parietal art, perforated teeth, prismatic cores, split pebble cores, split based bone points, strangulated blades, Uluzzian crescents and Vachons burins.

These classes of artefact were designed to describe the full range of temporal and spatial variation within Aurignacian assemblages (Davies 1999, 2001). The presence of other unusual and potentially significant behaviours, such as the use of ochre, was also noted.

Fauna: recorded by species present, and FADs and LADs, dietary type and geographical origin as in the Lower Palaeolithic study. However, the FADs and LADs were given as oxygen isotope stages if the species appeared or disappeared in Europe after the time range of the Lower Palaeolithic study.

The results of the analysis of this data, with respect to the predictions of the archaeological models and the strength of the interpretive framework developed from the biological, sociological and geographical models, will be presented in the following chapters.

Chapter 5 : Temporal and spatial patterning in the Lower Palaeolithic data.

This chapter will present the methods, results and interpretation of the data analysis of the temporal and spatial patterns of the Lower Palaeolithic case study, beginning with a general description of the analysis methods and statistics used throughout the study. The analysis will explore the causes of the patterning seen in the data, and the effects that this has on the results. The discussion will address the issues of whether the data supports aspects of the ecological, geographical and sociological models of movement described in Chapter 2, and which aspects of the data support or refute the archaeological models presented in Chapter 3. The temporal data will be presented and discussed, followed by the spatial data.

The timing of hominid arrival in Europe, and the spatial extent of occupation underlie many of the key issues raised in the models of movement; for example, these factors are related to the issues of the environment and faunal community encountered by the groups entering Europe, and also the presence or absence of exploration and social networks facilitating movement. Moreover, the archaeological models have focused on the question of the chronology and area of occupation as issues in their own right. Therefore, these sources of data are fundamental to the resolution of the questions raised in both the archaeological and ecological, geographical and sociological models of movement, and are critical to the remainder of the data, presented in the following chapters.

Data analysis.

Statistics.

The statistics and charts used in the analysis were calculated using the SPSS 11.0 software package. Statistical significance was considered at the 0.05 significance level (α) throughout the analysis. The statistical tests used in the analysis consisted of chi-squared, Goodman and Kruskal's lambda, Kendall's tau-C and Spearman's rank correlation (Shennan 1988; Fletcher and Lock 1991). The chi-squared test ascertains whether there is a significant association between two categorical variables. The Goodman and Kruskal's lambda test is similar to a chi-squared test, but produces robust results despite a high level of empty cells in the cross tabulation of the variables. The value of lambda is also a direct reflection of the strength of the relationship. Tau-C is also a test of association that can be applied to data measured on an ordinal scale, and is not affected by large amounts of low or zero values in the cross tabulation. Spearman's rank correlation measures the association between two ordinal variables that are not necessarily normally distributed. The value of the correlation coefficient produced reflects the strength of the relationship between the variables.

Maps.

The maps were produced using the ESRI ArcMap 8.3 GIS package. The sites were projected over the 2003 edition of the "World Continents" map of continental outlines produced by ESRI, and the 2003 edition of the "World Digital Elevation Model (MrSID Image)" map, produced by the U.S. Geological Survey, EROS Data Center Distributed Active Archive Center (EDC DAAC) and ESRI. These maps were clipped to produce an elevation and continental outline map of the area of study. The final output maps are projected using the GCS WGS 1984 co-ordinate system.

Analysis.

Data analysis was undertaken at all three levels of certainty of the presence of hominids, and at both probable and definite levels of precision of dating, for both the major date categories and oxygen isotope stages, throughout the analysis of the Lower Palaeolithic data, unless otherwise stated. This was intended to allow an exploration of the effect of dating and archaeological certainty on the patterns of hominid colonisation.

When did hominids move into Europe?

Temporal patterns in the Lower Palaeolithic sites.

Figures 5.1-5.12 present the numbers of sites in Europe during each period. Figures 5.1-5.6 relate to the major date categories, as defined in Chapter 4, and Figures 5.7-5.12 show the oxygen isotope stages. The data is displayed by the level of certainty that it does represent hominid presence and the level of confidence in the dating.

Hominid presence in Europe is seen from the early Early Pleistocene in the major date category data, at all levels of resolution of the dates and archaeological evidence. A significant increase in site numbers in Europe is seen during the middle Middle Pleistocene in all datasets. The late Early Pleistocene and early Middle Pleistocene show greater numbers of sites than the earlier periods, especially the middle Early Pleistocene, and a trend towards increasing numbers of sites over time since this period can be seen.

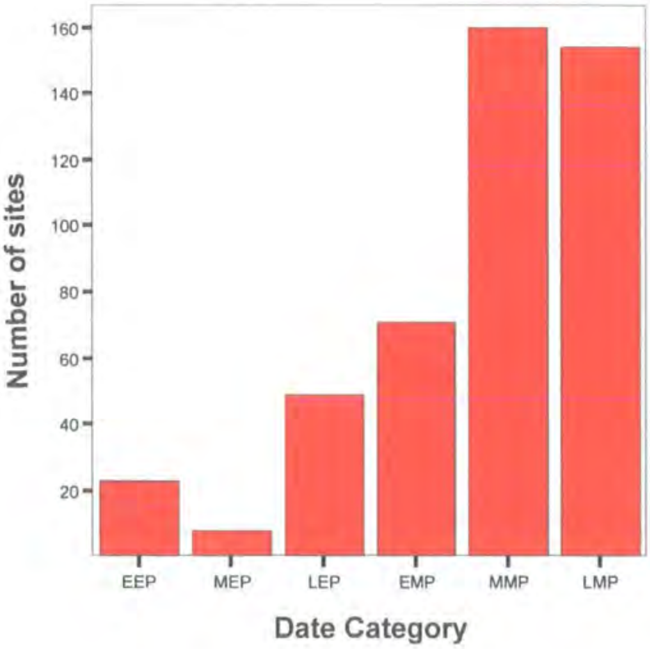


Figure 5.1 Chart showing all the possible hominid sites in Europe, probably or definitely dated to each major date category. N=465.

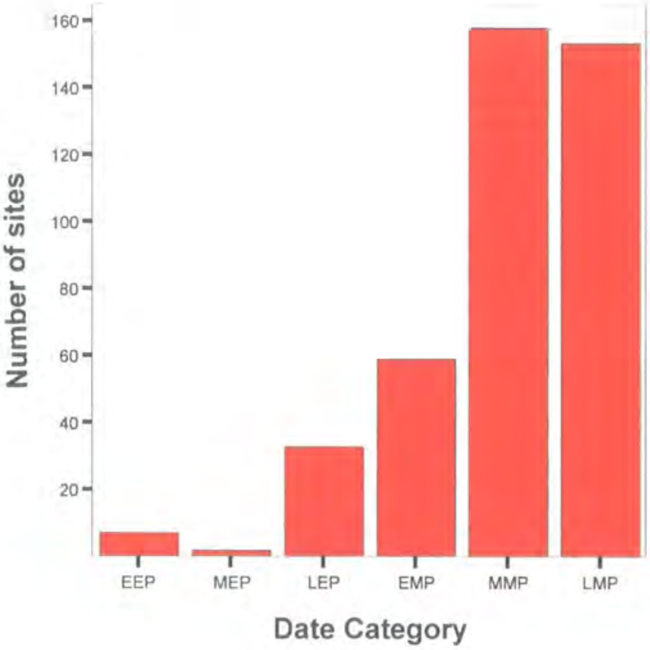


Figure 5.2. Chart showing the number of probable and definite hominid sites in Europe, probably or definitely dated to each major date category. N=412.

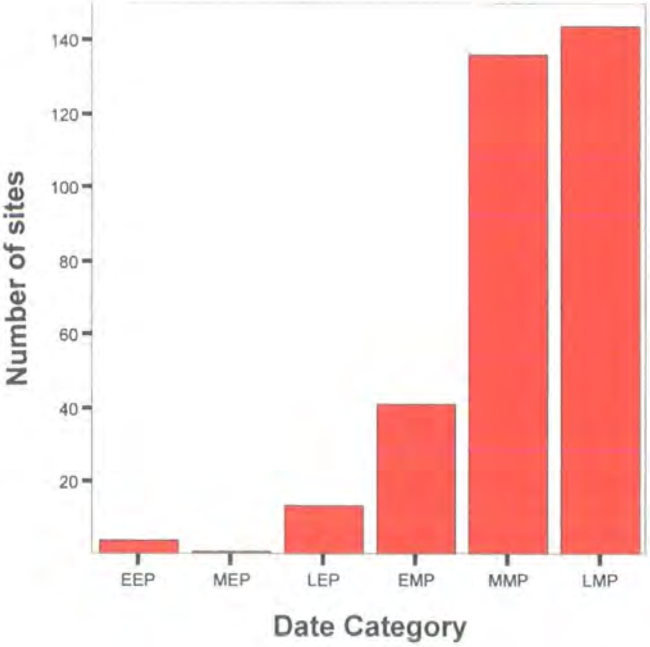


Figure 5.3. Chart showing the number of definite hominid sites in Europe, probably or definitely dated to each major date category. N=339.

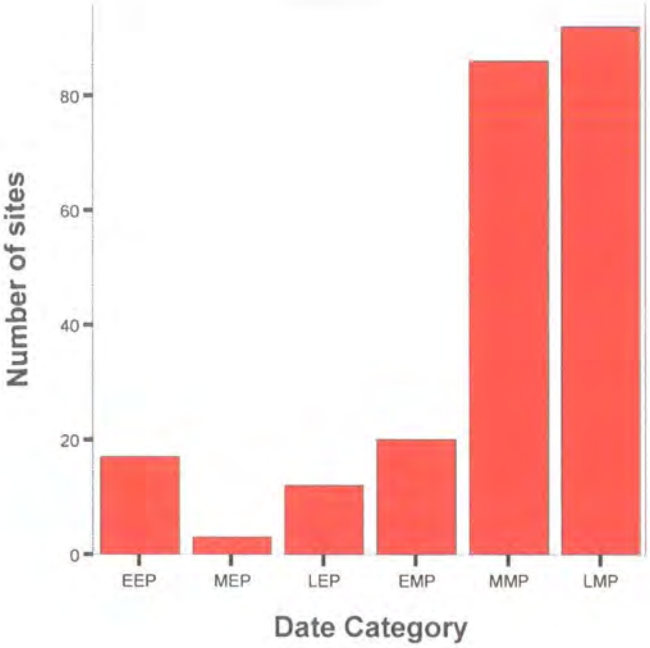


Figure 5.4. Chart showing the number of all possible hominid sites in Europe, definitely dated to each major date category. N=230.

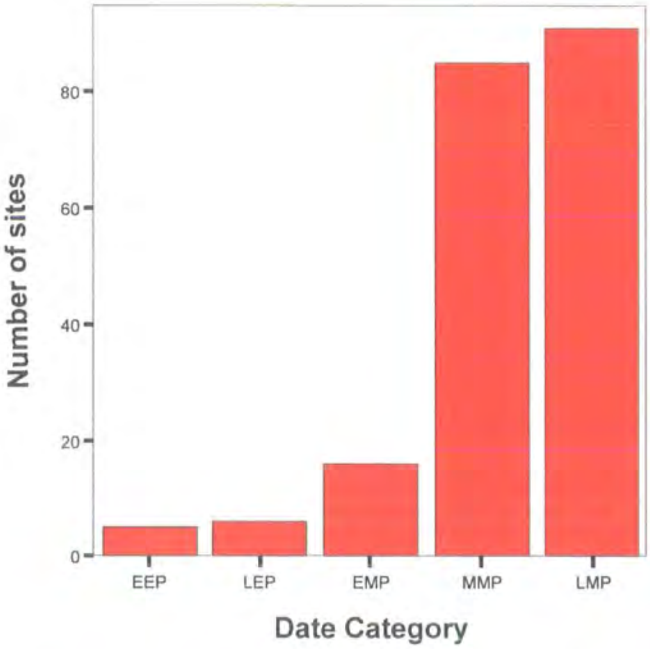


Figure 5.5. Chart showing the number of probable and definite hominid sites in Europe, definitely dated to each major date category. N=203.

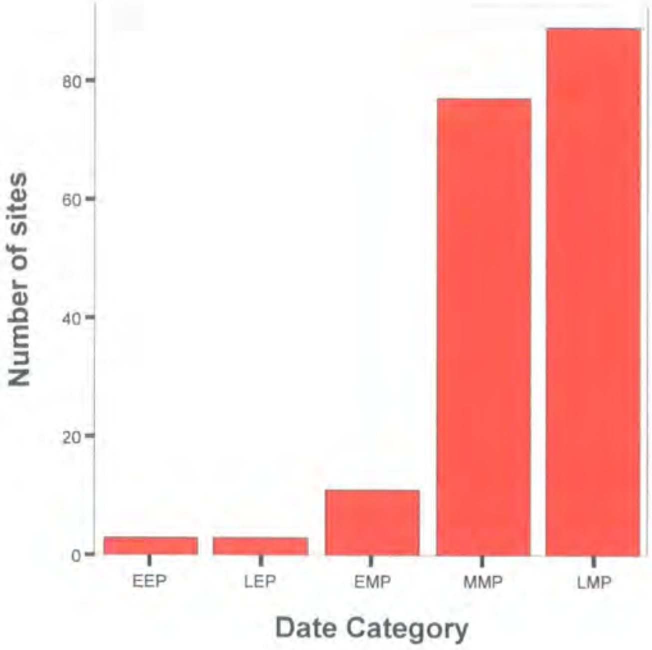


Figure 5.6. Chart showing the number of definite hominid sites in Europe, definitely dated to each major date category. N=183.

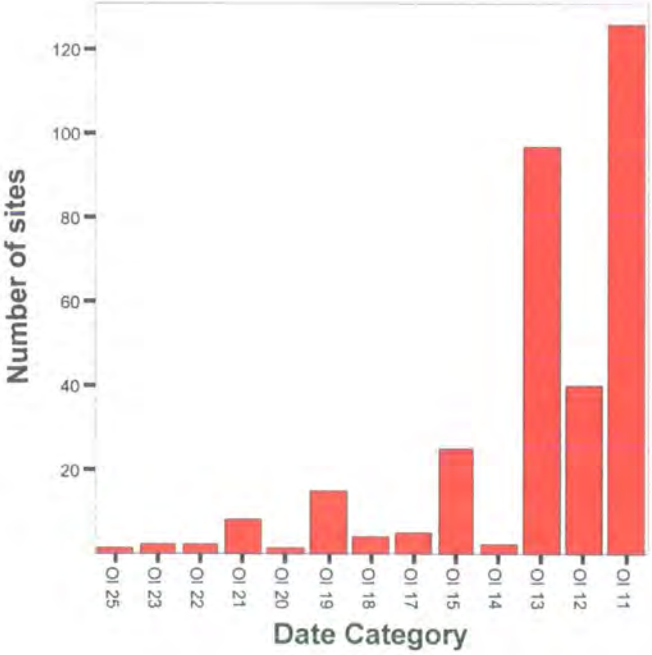


Figure 5.7. Chart showing the number of all possible hominid sites in Europe, probably or definitely dated to each oxygen isotope stage. N=328.

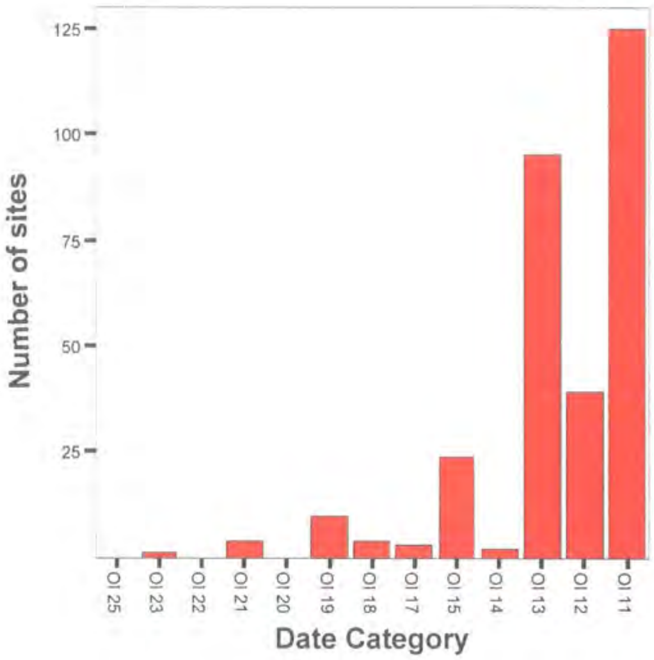


Figure 5.8. Chart showing the number of probable and definite hominid sites in Europe, probably or definitely dated to each oxygen isotope stage. N=307.

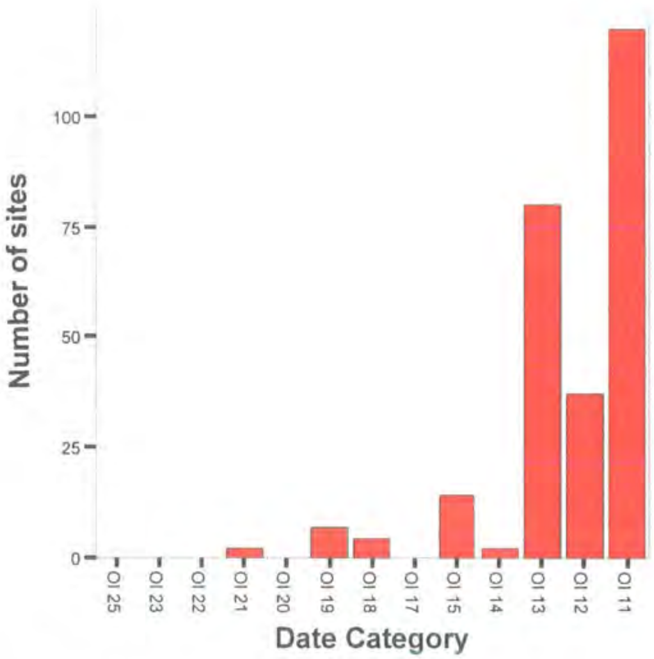


Figure 5.9. Chart showing the number of definite hominid sites in Europe, probably or definitely dated to each oxygen isotope stage. N=266.

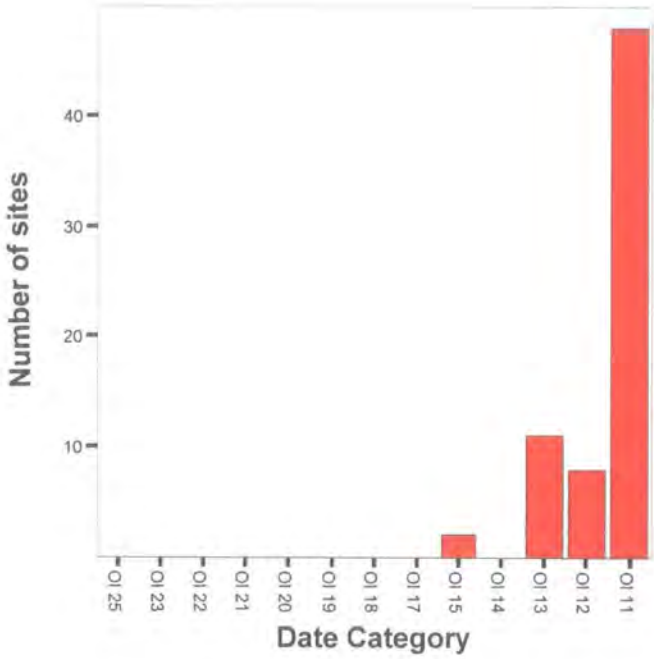


Figure 5.10. Chart showing the number of all possible hominid sites in Europe, definitely dated to each oxygen isotope stage. N=69.

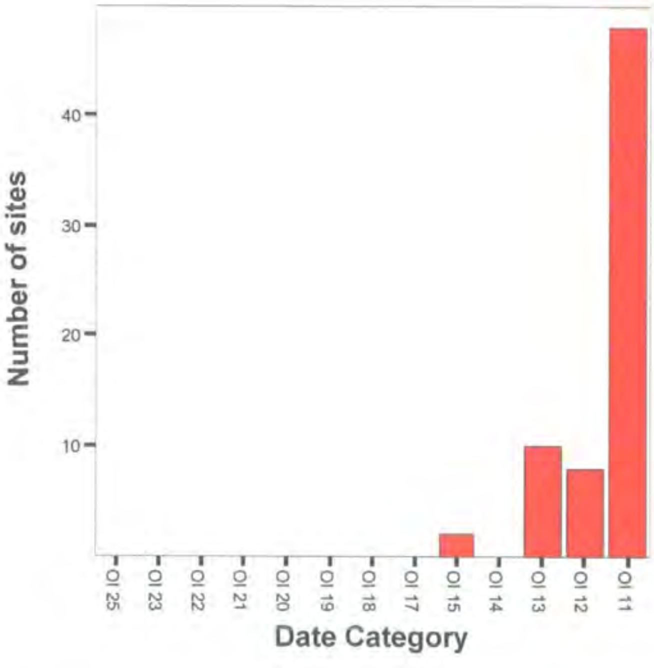


Figure 5.11. Chart showing the number of probable and definite hominid sites in Europe, definitely dated to each oxygen isotope stage. N=68.

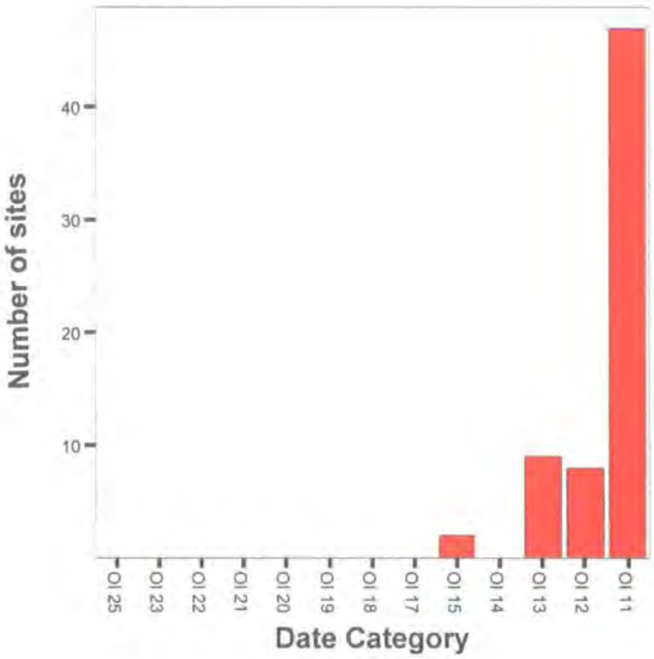


Figure 5.12. Chart showing the number of definite hominid sites in Europe, definitely dated to each oxygen isotope stage. N=66.

The date of the earliest presence of hominids in Europe becomes later as the dating and archaeological resolution is increased. There are no sites in Europe that can be definitely dated to earlier than OIS 15, whereas the less certain dates suggest entrance during OIS 25, 23 or 21. A substantial increase in site numbers is seen during OIS 13 and 11. However, a continuous trend towards greater site numbers over time can be seen in the probably dated sites. Site numbers are significantly lower in glacials than interglacials.

Patterning in the distribution of hominid occurrence during the phases of the oxygen isotope stages, defined in Chapter 4, was investigated by cross tabulating the date of each site by the phase within the oxygen isotope stage. The sites assigned to the "early/middle/late" category were removed from the analysis because this class included the sites that could not be assigned to a phase, as well as those that spanned the whole glacial or interglacial. The remaining data were subjected to chi-squared, lambda, and tau-C tests, with the null hypothesis that there is no significant relationship between the oxygen isotope stage of a site and its placement in a phase within the oxygen isotope stage. Figures 5.13-5.15 display the number of sites dated to each OIS phase for each dataset with a significant relationship between the date of a site and its placement within a subdivision of an interglacial or glacial. These significant relationships are:

All possible hominid sites with probable or definite dates: lambda=0.155 (α=0.044) and tau-C=0.088 (α=0.037)

Definite hominid sites with probable and definite dates: lambda insignificant, tau-C=0.092 (α=0.024).

All possible hominid sites with definite dates: lambda=0.226 (α=0.043), tau-C=.0.141 (α=0.015)

Chi-squared tests were invalid due to empty cells in the cross tabulation. The datasets not shown do not have significant relationships between the oxygen isotope stage of a site and the phase of the oxygen isotope stage. The significant relationships listed are all weak, indicating a slight trend towards an increase in sites early in the glacial or interglacial over time.

Hominid presence is seen in the mid interglacial throughout the sample, although at lower levels than during the early or late phases. Occupation also took place throughout the OIS 12 glacial, but not OIS 14. The appearance of hominids during interglacials became earlier over time. Increasing the resolution of the dating removed the earlier sites from the sample.

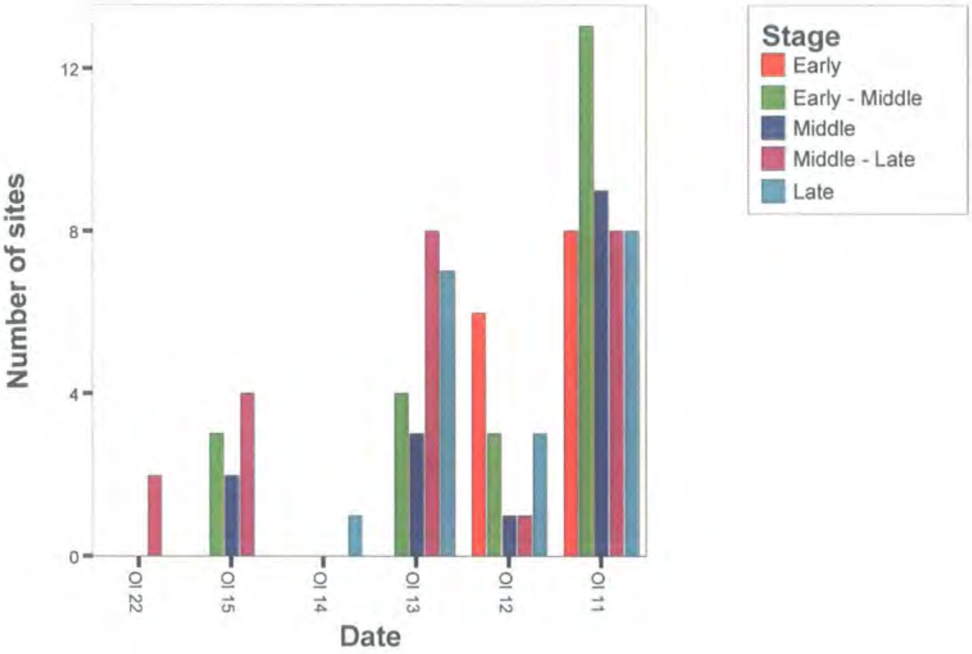


Figure 5.13. Chart showing the number of all possible hominid sites, probably or definitely dated to each oxygen isotope stage phase. N=94.

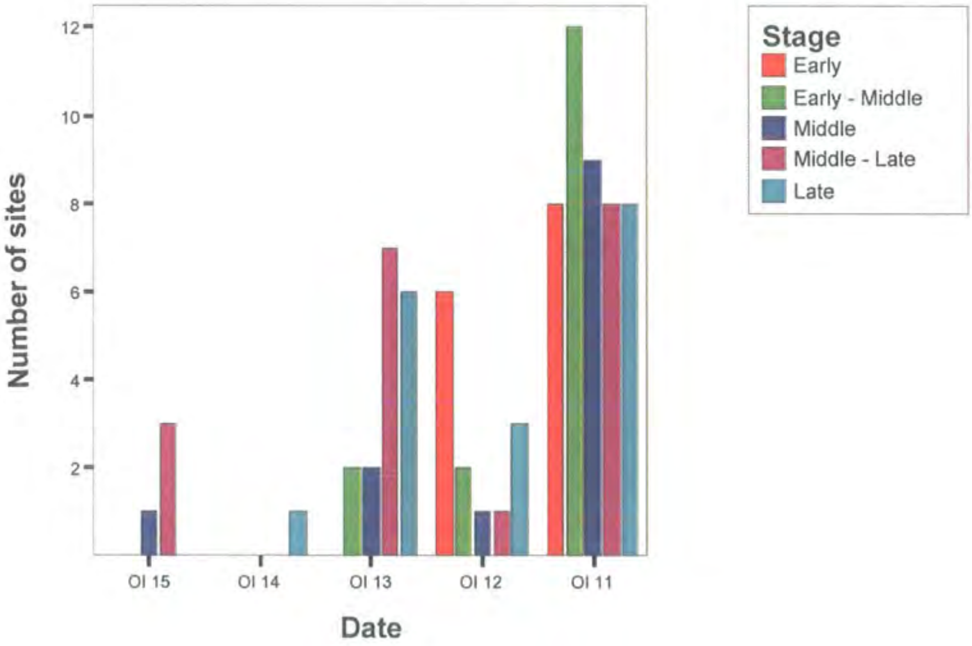


Figure 5.14. Chart showing the number of definite hominid sites, probably or definitely dated to each oxygen isotope stage phase. N=80.

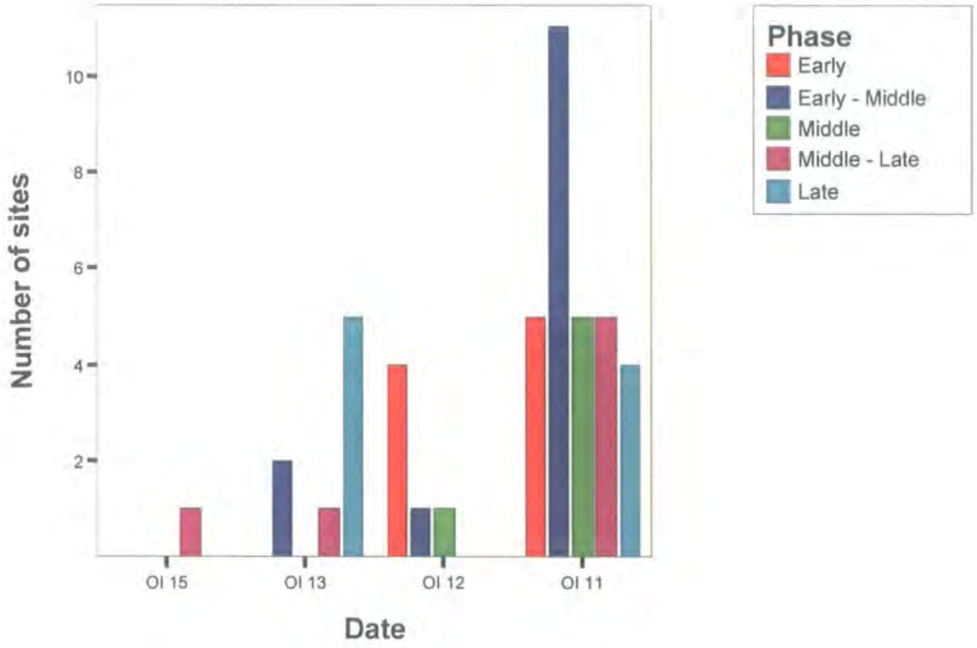


Figure 5.15. Chart showing the number of all possible hominid sites, definitely dated to each oxygen isotope stage phase. N=45.

Interpretation of the temporal patterns.

The most basic inclusion criterion in the data collection was the date of the sites. Those sites that could not be dated with a reasonable level of accuracy were excluded from the analysis, thus all sites in the database have a date and the problems presented by small and unrepresentative samples due to missing data do not apply to the dating. Nevertheless, two major problems were detected in the analysis of the dates. Firstly, increasing dating accuracy removed a higher proportion of the earlier sites, resulting in an impression of occupation of Europe being restricted to the Middle Pleistocene. Secondly, a regional bias in the quality of dating was found, with accurate dates applying to the sites in the north of Europe, and less accurate dates for the southern European, Levantine and North African material, shown in the spatial data below.

The major divisions of the Pleistocene.

The bar charts of the number of sites during each period presented in Figures 5.1-5.6 reveal that low levels of occupation of Europe began in the Early Pleistocene, and expanded considerably in the middle Middle Pleistocene. The effect of increasing dating resolution disproportionately removes sites from the earlier periods, but some remain in the early Early Pleistocene, implying that hominids have been correctly identified as present in Europe in low numbers during this period. The possibility of dating a site to a single period, without uncertainties, reduces as the age of the site increases; therefore, it is expected that the earliest periods should show a small number of well-dated sites. An increase in the certainty of hominid presence also removes more early than late sites. The earlier sites have come under closer scrutiny than later sites because hominid presence in Europe in the early Pleistocene has been challenged as a whole (Roebroeks *et al.* 1992; Roebroeks 1994). Therefore, very few early sites have been entirely accepted as archaeological, since this contradicts the "short chronology" paradigm that dominated the European Palaeolithic in the mid 1990s.

The low levels of sites in the middle Early Pleistocene can be explained by the short duration of this period compared to the early and late Early Pleistocene. The middle Early Pleistocene was defined using the palaeomagnetic Jaramillo event because this was clearly seen in Pleistocene sequences across Europe, providing a means of dating sites without dependence on faunal correlations, as is the case in the majority of the rest of the Early Pleistocene, producing a study-wide unit of time. It is possible that the low site numbers during this period reflect genuine depopulation; however, as the sample of sites is expected to be smaller than in the preceding and following periods, it is not possible to see the lack of sites in the middle Early Pleistocene as abandonment of Europe. The increase in site numbers in Europe in the late Early Pleistocene can therefore be interpreted either as a second episode of population movement into the continent from elsewhere, or simply as an effect of the increased duration of the late Early Pleistocene compared to the middle Early Pleistocene in a situation of population continuity since the time of the first arrival of hominids, or as indigenous population growth.

The issue of unequal duration of the major date categories does not affect the data after the middle Early Pleistocene. The increase in the number of sites in the late Early and early Middle Pleistocene could result from better preservation of sites after the Jaramillo event. However, it seems unlikely that taphonomic effects related to the age of sites could fully explain the level of increase in hominid sites after 1 Mya, as sites formed during the Middle Pleistocene would also have been subject to the effects of glaciations on preservation; hence, it seems valid to use the number of sites as a reflection of the size of the overall population of hominids in Europe. Regional research history may affect the quantity of sites present in different areas of Europe but by looking at the continent as a whole these problems may be minimised. Therefore, the rise in the number of sites in the early Middle Pleistocene can be interpreted as a genuine increase in the quantity of evidence for hominid occupation of Europe, due to either an increase in the indigenous population or because of movement into Europe of new groups.

The substantial increase in the number of sites in the middle Middle Pleistocene can be interpreted as legitimate evidence of an expansion in the population present in Europe because the assemblage size data, presented in Chapter 7 (Figures 7.1-7.3, pages 329-331), shows a weak trend towards increasing site size over time in the poor resolution data, and no trend over time in the good resolution data. This suggests that the increase in the number of sites during the Middle Pleistocene represents population increase, rather than greater dispersal of a population of the same size in smaller groups. This argument requires assemblage size to act as a reliable proxy for the group size present at the site, thus an increase in both site numbers and assemblage size would indicate a growth in group size and number of groups, resulting in overall population growth. However, assemblage size is not a straightforward proxy of group size, as it is related to factors such as the duration of occupation and the level of curation of tools. There is a weak trend over time for the distance of raw material transfers to decrease during the study period, discussed in Chapter 7 (Figure 7.47, page 364), which could imply that tool curation also decreased, and thus the increased size of the assemblages may be accounted for by an increased rate of discard. However, this trend is extremely weak, and therefore could potentially account for the slight increase in assemblage sizes, but is unlikely to explain the substantial increases in site numbers. Thus, the weak trend for an increase in site size could be accounted for by increased duration of occupation of sites, which itself is linked to possession of a greater knowledge of the region to allow longer survival before resource depletion. Thus, the population in the Middle Pleistocene probably became larger, and possibly more established and knowledgeable in each region, which implies that the increase was related to growth of the indigenous population rather than an influx of new groups into Europe. Therefore, the data concerning the number of sites over time cannot be used to determine whether this population increase was caused by indigenous population growth or an influx of groups from areas beyond Europe, but in conjunction with other aspects of the archaeological record these questions may be approached.

In summary, three periods of potential hominid movement into Europe are suggested by the numbers of sites: the early Early Pleistocene, the late Early Pleistocene and the middle Middle Pleistocene. The first event can only be explained by a population movement, but the subsequent increases in site numbers may represent indigenous increase rather than new episodes of movement. However, given the small size of the population during the Early Pleistocene, it is possible that the first groups to inhabit Europe became extinct, and thus the late Early Pleistocene episode could represent renewed movement into Europe. The episodes of movement may have taken place as a single event or an ongoing process of spread. Furthermore, the later population increases could reflect groups moving as a continuation of earlier exploration, or as isolated episodes of movement without knowledge of the areas to be occupied or contact with the preceding inhabitants. The questions of whether the patterning of the site numbers represents movement or population increase, and the potential processes of the movements will be explored through the findings from the other data, as site numbers alone cannot address these issues.

The oxygen isotope stage data.

The oxygen isotope stage data, shown in Figures 5.7-5.12, reveal very small numbers of sites before OIS 19, and no sites definitely dated to earlier than OIS 15. Thus, the increase in dating resolution can be seen to decrease the information available about the earliest phases of European occupation. Although there are no well-dated sites earlier than OIS 15, there is good evidence of hominid presence in Europe before the middle Middle Pleistocene in the broader date categories. Therefore, by excluding the less well-dated sample of sites, the possibility of addressing the earlier stages of movement into Europe is denied, and actual patterns of occupation can be obscured. This trend is seen to a greater extent in the data relating to the sub-divisions of the oxygen isotope stages, where the data is limited to a very small sample of sites, almost all of which are dated to the end of the study period.

Nevertheless, the oxygen isotope stage dates do allow a better understanding of hominid reactions to environmental change during glacial-interglacial cycles. Throughout the range of the oxygen isotope stage dates it can be seen that significantly more sites are present during the interglacials than the glacials. Sites are found throughout the interglacials, including the mid-interglacial in Figure 5.13 and Figure 5.14, contra the suggestion of Gamble (1995c) that these climatic conditions would have led to the formation of dense forests that would be uninhabitable to Lower Palaeolithic hominids.

The possibility of abandonment of Europe, or withdrawal to refugia, during glacials is raised by the lack of sites dated to OIS 16, 20 and 22, and the very low number of sites present in OIS 14 and 18. OIS 16 in particular reflects population contraction, because hominids had been present in moderate, rather than very low, numbers in the preceding stages. It is possible that the presence of hominids during OIS 14 in Europe affected the substantial number of sites during OIS 13, as recolonisation distances would have been reduced compared to previous interglacials. The same processes may have been in operation during OIS 12 and 11, partly explaining the increase in number of sites at the end of the study period.

The issues of abandonment and recolonisation can be addressed in more detail through the sites dated to sub-divisions of the climatic cycles. However, very few sites could be dated to this level of accuracy, and thus this data could be unrepresentative of the behaviours of hominids, especially as a strong geographical bias exists in the areas dated at this level of precision. Nevertheless, the patterning of the timing of hominid presence within climatic cycles corresponds with the suggested explanations of the site numbers within each oxygen isotope stage. There is a weak trend for a greater proportion of sites to be found in the early part of interglacials at the end of the study period. The lack of early sites in OIS 15 may be linked to the absence of any sites dated to OIS 16, implying that hominids may have entirely abandoned Europe during this glacial, and therefore recolonisation would have taken a substantial length of time. The presence of sites in late OIS 14 would explain the early dates of sites in OIS 13, as recolonisation had begun during the late glacial, possibly from within Europe. The presence of hominids in the mid-glacial of OIS 12 may be explained by sites in the refugia in the south of Europe, which could contribute to the high number of sites in early OIS 11. This suggests that the distance of withdrawal from glacial conditions decreased over time, possibly as hominids increased their skills for survival in Europe.

Where were hominids present in Europe?

The spatial data suffers from the problem of some sites being un-locatable, due to a lack of a published description of the whereabouts of the sites. 5% of the sites in the database could not be located. All the British sites had published grid references, whereas the majority of the publications of sites in other countries did not contain grid reference data and varied considerably in the quality of descriptions of the site locations. However, the quality of publication of sites in continental Europe varied from site to site, rather than regionally, and thus the spatial patterning can be considered to be representative, although it is not complete.

Spatial patterns in the Lower Palaeolithic sites during the major divisions of the Pleistocene.

Figures 5.16-5.49 display maps of Europe illustrating the sites with presence of hominids during each major division of the Pleistocene, as defined in Chapter 4, divided by the level of confidence in the identification of hominid presence, and the accuracy of the dating. The maps are shown in order by date and then by precision of dating and hominid attribution, beginning with the early Early Pleistocene, including all possibly hominid sites, and both probable and certain dates. The level of confidence in hominid presence is then increased, followed by the accuracy of the dating. In the middle Early Pleistocene no sites with definite dates and either probable or definite evidence of hominid habitation appeared in the database, and therefore the maps corresponding to these conditions have been omitted. The maps are presented with the aim of revealing the areas of Europe that were occupied during each period, and therefore the discussion will focus on the regions showing evidence of hominid presence, and the reasons for these regional patterns, such as the route of entry into Europe and the environmental conditions across Europe. The full list of sites dated to each period, at each level of confidence in the dating and presence of hominids is presented in Appendix 2.

Figures 5.16-5.21 present the spatial distribution of hominid sites during the early Early Pleistocene. These maps demonstrate that hominid presence in Europe appears widespread in the low-resolution datasets, but is more geographically restricted as the dating and archaeological resolution is increased. Occupation of Europe during this period was probably restricted to the south, and appears to be mainly seen in the southwest. This trend becomes stronger as the resolution of the dates and archaeological certainty of hominid presence increases. The lack of definitely dated sites with definite hominid presence in Europe, during the early Early Pleistocene, shown in Figure 5.21, is a result of the problems of locating all the sites in the database, as sites were present, shown in Figure 5.6. The only site that possessed definite evidence of hominid presence during the early Early Pleistocene, which could be located, was Fuente Nueva 3 in Spain (Agustí *et al.* 2000), shown in Figure 5.18.

Figure 5.16. Map showing all the possible hominid sites, probably or definitely dated to the early Early Pleistocene.

Figure 5.17. Map showing the probable and definite hominid sites, probably or definitely dated to the early Early Pleistocene.

Figure 5.18. Map showing the definite hominid sites, probably or definitely dated to the early Early Pleistocene.

Figure 5.19. Map showing all the possible hominid sites, definitely dated to the early Early Pleistocene.

Figure 5.20. Map showing the probable and definite hominid sites, definitely dated to the early Early Pleistocene.

Figure 5.21. Map showing the definite hominid sites, definitely dated to the early Early Pleistocene.

Figures 5.22-5.25 represent the hominid sites during the middle Early Pleistocene. These maps reveal that hominid presence in Europe focused on the south and west of the continent, and was only definite in Iberia at Fuente Nueva 3 (Agustí *et al.* 2000), shown in Figure 5.23 and Figure 5.24. Moreover, only three sites were definitely dated to the middle Early Pleistocene: Sima del Elefante E-11 at Atapuerca, Spain, and Le Vallonnet (Bonifay 1991) and Saint-Prest (Bourdier 1969) in France. None of these well-dated sites possessed probable or definite evidence of hominids. However, these sites show that increasing the dating resolution removed the sites further to the east, reinforcing the focus of occupation in the southwest. All the other sites dated to this period were deemed to contain unlikely evidence of hominid presence. Therefore, the trend seen during the early Early Pleistocene, of the strength of evidence of hominid presence decreasing to the north and east of Iberia, continued during the middle Early Pleistocene.

Figure 5.22. Map showing all the possible hominid sites, probably or definitely dated to the middle Early Pleistocene.

Figure 5.23. Map showing the probable and definite hominid sites, probably or definitely dated to the middle Early Pleistocene.

Figure 5.24. Map showing the definite hominid sites, probably or definitely dated to the middle Early Pleistocene.

Figure 5.25. Map showing all the possible hominid sites definitely dated to the middle Early Pleistocene.

Figures 5.26-5.31 present the hominid sites dated to the late Early Pleistocene. The number of sites in Europe can be seen to have greatly increased compared to the preceding periods. These maps show that hominids may have spread into northern and central Europe, but remained focused on the south, particularly in Iberia and Italy, although there is good evidence of hominid presence at Staré Mesto 1 in the Czech Republic (Chlachula 1993, 1994), shown in Figure 5.31. The sites containing material that was definitely indicative of hominid presence were generally located further to the south than the less certainly archaeological sites, indicating that the pattern of geographical restriction to southerly areas as resolution increases, seen in the previous periods, continued during the late Early Pleistocene. The maps of the sites definitely dated to this period reveal a lack of material in Iberia, contrary to the patterns seen in the early and middle Early Pleistocene. However, Italy shows strong evidence of hominid presence during the late Early Pleistocene at Monte Poggiolo (Mussi 1995; Villa 2001) and Castro dei Volsci (Segre and Biddittu 1981; Ascenzi and Segre 1997), shown in Figure 5.31.

Figure 5.26. Map showing all the possible hominid sites, probably or definitely dated to the late Early Pleistocene.

Figure 5.27. Map showing the probable and definite hominid sites, probably or definitely dated to the late Early Pleistocene.

Figure 5.28. Map showing the definite hominid sites, probably or definitely dated to the late Early Pleistocene.

Figure 5.29. Map showing all the possible hominid sites definitely dated to the late Early Pleistocene.

Figure 5.30. Map showing the probable and definite hominid sites, definitely dated to the late Early Pleistocene.

Figure 5.31. Map showing the definite hominid sites, definitely dated to the late Early Pleistocene.

Figures 5.32-5.37 illustrate the sites with hominid presence during the early Middle Pleistocene. An increase in the number of sites in Europe compared to previous periods is seen during the early Middle Pleistocene. These maps demonstrate that hominid presence in Europe remained predominantly in the south, with Iberia and Italy again the most heavily occupied. However, a spread further north may have begun during the early Middle Pleistocene, with greater numbers of sites and more convincing evidence of hominid presence than during the late Early Pleistocene. Nevertheless, there are no well-dated sites with definite evidence of hominid presence to the north of the Alps, shown in Figure 5.37. The only well-dated material to the north of the Alps is found at Montières, Ferme de Grâce in France (Bourdier 1976a, 1976b; Tuffreau and Antoine 1995) shown in Figure 5.35, and Mladeč in the Czech Republic (Bucha *et al.* 1975; Valoch 1995), shown in Figure 5.36, both of which contain questionable artefacts. Therefore, the sites in the north of Europe, shown in Figures 5.32-5.34 could be the result of poor dating of material from later periods. Thus, the pattern seen throughout the Early Pleistocene, of the higher resolution evidence of hominid presence being restricted to Southern Europe, can be seen to continue into the early Middle Pleistocene.

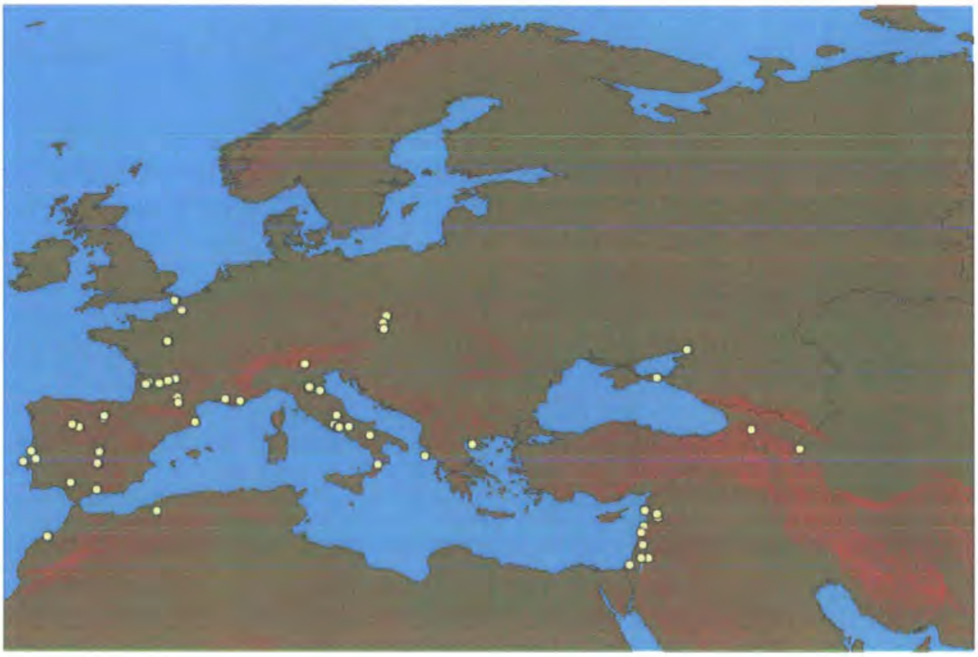


Figure 5.32. Map showing all the possible hominid sites, probably or definitely dated to the early Middle Pleistocene.

Figure 5.33. Map showing the probable and definite hominid sites, probably or definitely dated to the early Middle Pleistocene.

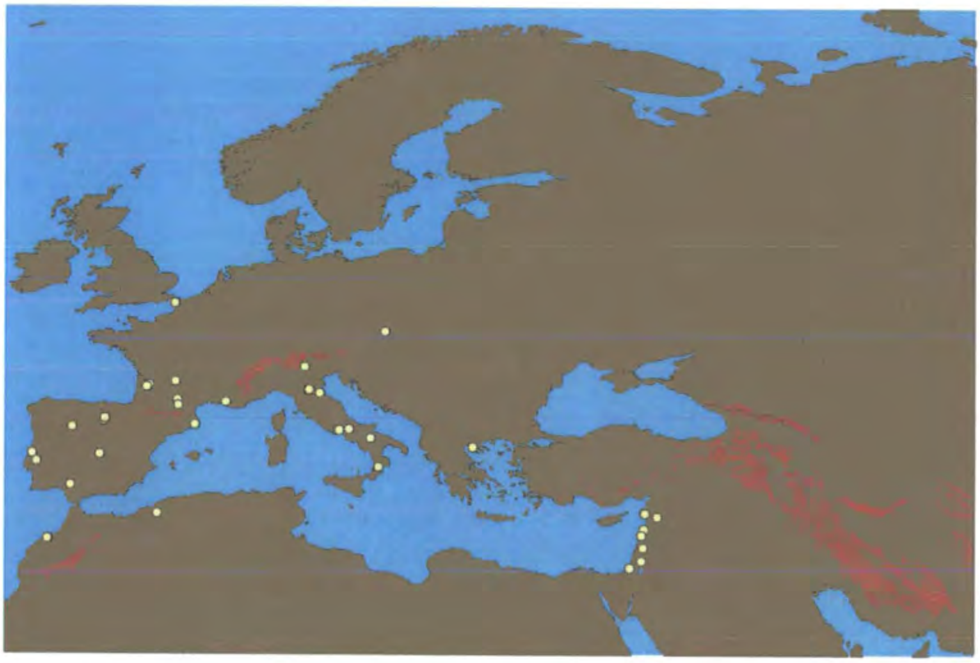


Figure 5.34. Map showing the definite hominid sites, probably or definitely dated to the early Middle Pleistocene.

Figure 5.35. Map showing all the possible hominid sites, definitely dated to the early Middle Pleistocene.

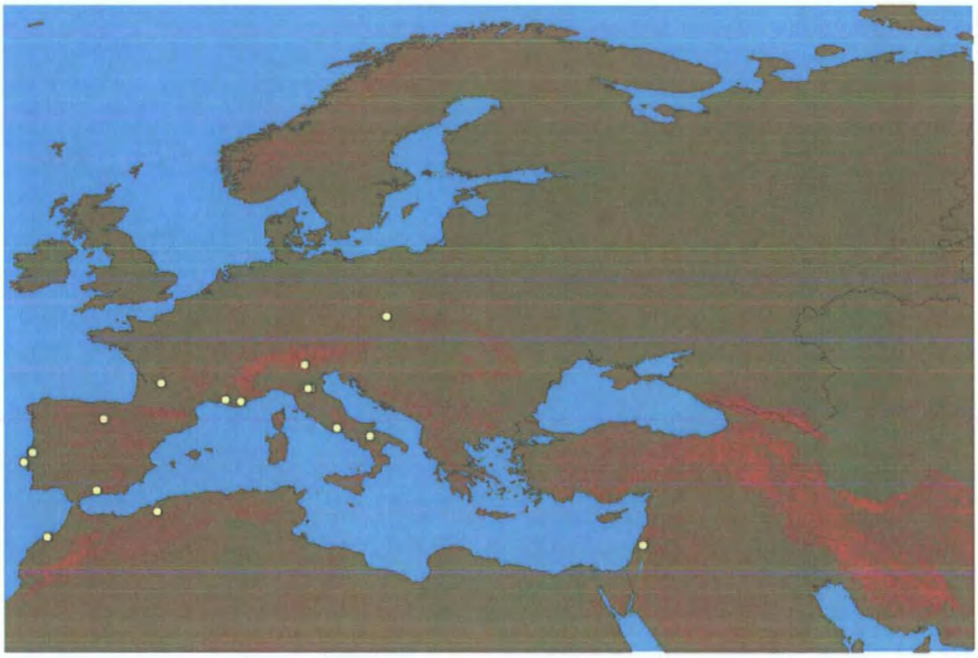


Figure 5.36. Map showing the probable and definite hominid sites, definitely dated to the early Middle Pleistocene.

Figure 5.37. Map showing the definite hominid sites, definitely dated to the early Middle Pleistocene.

Figures 5.38-5.43 present the hominid sites during the middle Middle Pleistocene. These maps exhibit definite occupation of northern and central Europe during the middle Middle Pleistocene, with a large number of well-dated sites with strong evidence of hominid presence being located in Britain and continental Northwest Europe. In this period fewer differences are seen between the maps of each level of confidence in the archaeological validity of the sites, as hominid presence in Europe is accepted by proponents of the "short chronology" (Roebroeks 1994; Dennell and Roebroeks 1996) and hence fewer questions are raised over the artefactual nature of the sites, but the quality of the dates greatly affects the number and distribution of the sites. The maps of the sites with good dating evidence show a lack of material in Iberia, with the exception of Cúllar de Baza 1 (Ruis Bustos and Michaux 1976; Raposo and Santonja 1995; Agustí *et al.* 2000), shown in Figures 5.41-5.43, as was the case during the late Early and early Middle Pleistocene. Furthermore, the sites in the whole of Southern Europe are more reduced in numbers in the well-dated maps, than the Northern European sites. Therefore, the middle Middle Pleistocene is the first period to show more evidence of hominid occupation of Northern Europe than the south.

Figure 5.38. Map showing all the possible hominid sites, probably or definitely dated to the middle Middle Pleistocene.

Figure 5.39. Map showing the probable and definite hominid sites, probably or definitely dated to the middle Middle Pleistocene.

Figure 5.40. Map showing the definite hominid sites, probably or definitely dated to the middle Middle Pleistocene.

Figure 5.41. Map showing all the possible hominid sites definitely dated to the middle Middle Pleistocene.

Figure 5.42. Map showing the probable and definite hominid sites, definitely dated to the middle Middle Pleistocene.

Figure 5.43. Map showing the definite hominid sites definitely dated to the middle Middle Pleistocene.

Figures 5.44-5.49 show the sites with hominid presence during the late Middle Pleistocene. During this period large numbers of sites are located throughout Europe, particularly in the northwest, and definitely archaeological sites appear in the northeast, at Vértesszöllös in Hungary (Kretzoi and Vertes 1965; Kretzoi and Dobosi 1990; Valoch 1995), Korolevo VI in the Ukraine (Adamenko and Gladiline 1989; Gladilin 1989; Anikovich 1992), and Dubossary in Moldavia (Anisssutkine 1987; Praslov 1995), although with poor dates, shown in Figure 5.46. The well-dated sites are heavily concentrated in the northwest, continuing the trend seen in the middle Middle Pleistocene, of the strongest evidence of hominid presence being focused in Northern Europe, particularly Britain and France. The late Middle Pleistocene maps show that the Southern European sites suffer from poor dating compared to the northern European material, as was the case since the late Early Pleistocene, with only one well-dated site in Iberia at Mealhada in Portugal (Raposo and Carreira 1986; Penalva 1987; Antunes *et al.* 1988), shown in Figure 5.49.

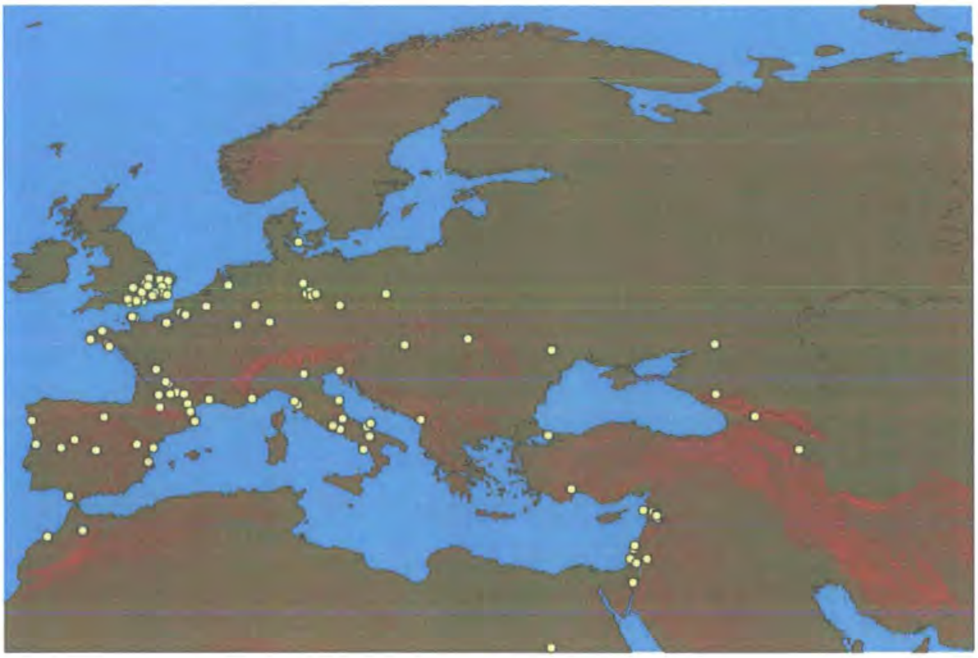


Figure 5.44. Map showing all the possible hominid sites, probably or definitely dated to the late Middle Pleistocene.

Figure 5.45. Map showing the probable and definite hominid sites, probably or definitely dated to the late Middle Pleistocene.

Figure 5.46. Map showing the definite hominid sites, probably or definitely dated to the late Middle Pleistocene.

Figure 5.47. Map showing all the possible hominid sites, definitely dated to the late Middle Pleistocene.

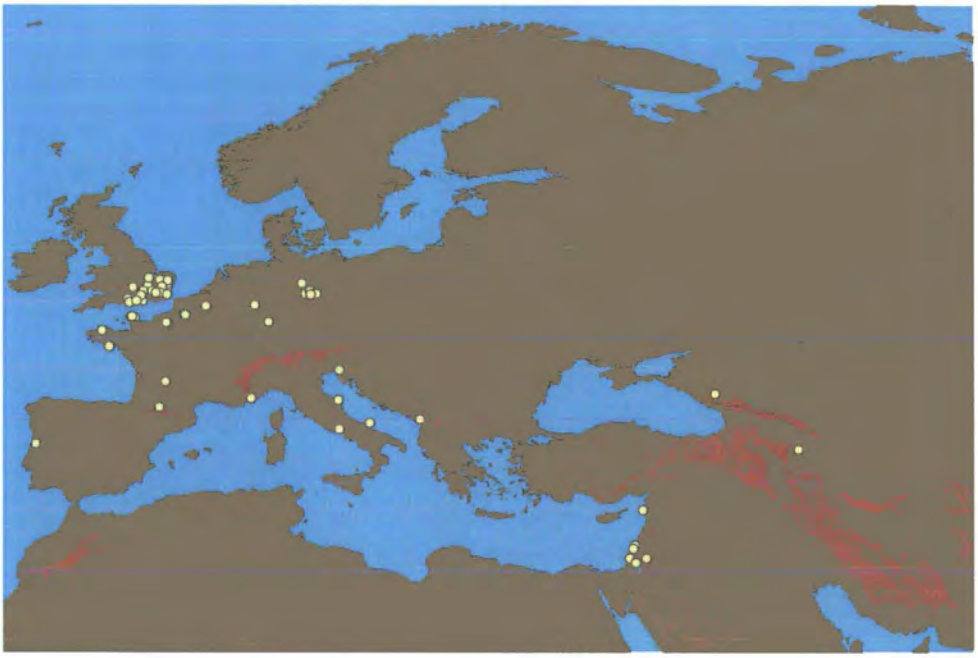


Figure 5.48. Map showing the probable and definite hominid sites, definitely dated to the late Middle Pleistocene.

Figure 5.49. Map showing the definite hominid sites definitely dated to the late Middle Pleistocene.

Interpretation of the spatial patterning in the major divisions of the Pleistocene.

Early Pleistocene patterning.

Figures 5.16-5.31 show that hominid presence is better attested in the south and west of Europe, particularly in Iberia, than further to the north and east, during the Early Pleistocene. Areas of southern Europe suffer problems of poor dating resolution, due to the lack of dramatic physical traces of the climatic cycles, and the relatively stable ecological communities (Turner 1995), undermining the strength of biostratigraphical methods. Palaeomagnetism, and other relatively imprecise dating methods, tend to be used in dating southern European sites, whereas northern European sites can be dated to individual climatic cycles. These dating problems result in the false picture of a lack of sites in Iberia in the definitely dated samples, whereas the probably dated sites show clear evidence of occupation of the southwest of Europe. The number of poorly dated sites in Iberia during the Early Pleistocene implies that hominids were present in the region despite individual sites having dating problems.

There are several potential explanations of the patterning of sites focused on the southwest of Europe. Firstly, the route into Europe could have been from the Maghreb, via the Straits of Gibraltar, to Iberia; if so, the patterning would reflect the route into Europe and the duration of occupation since arrival of the first inhabitants. However, there are no sites in Morocco until the late Early Pleistocene, providing little evidence of a source population in the Maghreb at the time of entry to Europe. Nevertheless, definite hominid presence in Eastern Europe or Anatolia begins at the late Early Pleistocene at Dursunlu in Turkey; earlier material is limited to a single site deemed to be unlikely evidence of hominid manufacture at Tetoiu/Bugiulesti in Romania; thus, there are no indisputable sites between the traces of hominid occupation in Europe and in Asia. Therefore, site locations alone do not provide clear evidence in support of the route taken into Europe.

The spatial distribution of different size sites, presented in Chapter 7 shows that the Levant was very substantially occupied in the Early Pleistocene, especially towards its end, shown in Figures 7.4-7.9 (pages 333-336), which could imply that it formed a major population centre and provided a source of the groups moving into Europe through the mechanism of population pressure. There are fewer sites in North Africa during the Early Pleistocene, but those present are large; however, the Maghreb does not show as much evidence for a large population in a potential source area as does the Levant. Nonetheless, the differences in the number and sizes of sites in the Levant and the Maghreb could be the result of different intensities of research in these areas, rather than differences in the intensity of hominid occupation. As the quality of the dates and certainty of hominid presence is varied the patterning of population centres varies, which creates the impression that the route of entry into Europe changes. In the late Early Pleistocene the removal of uncertainly dated sites results in Iberia containing no sites, implying that movement occurred via the eastern route, rather than across the Straits of Gibraltar, as suggested from the poorer dates.

The second argument explaining early traces of hominids in Iberia and the Mediterranean is that these areas had ecological conditions that allowed successful establishment of a population large enough to be detected archaeologically. This argument is supported by the similarities between Mediterranean shrubland in seasonally dry conditions, and the plant communities located in the Levant and North Africa (Naveh and Vernet 1991). The biomes surrounding the Mediterranean are structurally similar, and share a common climatic regime, which could allow hominid entry to Europe without the need for adaptation to new environmental conditions, following the environmental matching model of biogeography, and Foley's (1987b) suggestion that hominid dispersal followed a sequence of environmental adaptations. The environments occupied by hominid groups will be discussed in the following chapter.

A model of site numbers reflecting environmentally advantageous regions, rather than route of entry and duration of occupation has been suggested to explain colonisation patterns in the late Pleistocene Americas (Steele *et al.* 1998; Hazelwood and Steele 2004). In this scenario, groups would move rapidly across hostile environments, and population size would remain small, until suitable habitat is reached, settlement occurs and population size increases. This model is supported by the suggestion of ecological biogeography that rapid and long distance movement is possible (Shigesada and Kawasaki 1997), and that species can move through unsuitable habitats if the habitat grain scale is small enough to allow movement to reach suitable conditions before starvation occurs, or if the conditions are not hostile enough to result in death (Stenseth and Lidicker 1992a). Chain migration models also suggest that nodes will form in regions of opportunity, without settlement in areas between the source and the destination, because exploration will result in movement becoming focused towards the areas with known advantages (Tilly 1978; Anthony 1997). Therefore, rapid movement of small groups across Eastern Europe could have taken place before establishment and population growth occurred in the west. The ephemeral traces of small mobile groups are unlikely to be detected, or if recovered to meet the criteria of validation used by most archaeologists.

Thirdly, there may be a regional research tradition that focuses on identifying ancient hominid remains in Iberia and the Mediterranean, resulting in a tendency for older dates to be supported, and more tenuous evidence of hominid presence to be accepted than elsewhere in Europe. There is a tradition in Iberia and France for the acceptance of sites dating to the Early Pleistocene e.g. de Lumley (1976), whereas in Britain and northern continental Europe there has been a tendency for a higher level of scepticism regarding early occupation of Europe e.g. Roebroeks and van Kolfschoten (1995). The relative abundance of unlikely archaeological sites in Southwest Europe reflects this tradition of credulity. However, concerns over the validity of the dating and archaeological or fossil evidence in southern European sites have been raised, and were taken into account in the qualification of sites as definite, probable or unlikely traces of hominid presence. Therefore, variations in the quality of the data between regions were controlled in the data collection methodology, and should not have affected the patterning of the definite archaeological sites.

Fourthly, there may be a greater chance of the preservation of ancient archaeological remains in the south of Europe due to the impact of glaciation on deposits that occurred across the north. However, as good evidence of hominid occupation at well-preserved sites does exist in the Middle Pleistocene of northern Europe, it seems unlikely that such taphonomic arguments could explain the focus of occupation in the south and west of Europe during the Early Pleistocene, especially considering that climatic cycles had smaller amplitudes at this time (Agusti *et al.* 2001).

Middle Pleistocene patterning.

In the early-middle Middle Pleistocene hominid presence can be seen to spread into the northwest of Europe and potentially into the northeast by the late Middle Pleistocene. This range expansion could either be the result of indigenous expansion or an influx of population from outside Europe. The occupation of these new regions by groups originating beyond the borders of Europe implies that these hominids possessed greater survival skills than previously existing groups in Europe, which has implications for the behavioural and possibly cognitive capacities of the potential migrants. The reasons for a spread of the indigenous population into northern Europe include adaptation to new environments, environmental change and population growth. These will be discussed in the following two chapters with respect to the environmental and behavioural evidence. A movement of new groups of hominids into Europe is difficult to prove or disprove from the spatial distribution of the sites because the potential source areas in the Levant and the Maghreb contain few sites in the middle Pleistocene, and Eastern Europe remains sparsely populated compared to the west, as was the case in the Early Pleistocene.

However, the size of assemblages in the Levant and the Maghreb are large, shown in Figure 7.18-7.27 (pages 342-346), suggesting that either area could form a source of new movement into Europe. The maps show that substantial occupation of Iberia occurred at this time, which supports the use of a route of entry to Europe via Gibraltar, especially as large sites are also located in North Africa. The Italian peninsula likewise is relatively densely occupied, providing some support for the suggested route through Sicily. Nevertheless, in the poorly dated sample the Levant is densely occupied, and some sites exist in central and eastern Europe, providing limited evidence for a route from the Near East. However, the well-dated samples remove many of the sites in the Levant, reinforcing the impression that occupation was focused in the west of Europe, and that the likely route of entry was from the Maghreb to Iberia. However, the possibility of rapid undetected movement through Eastern Europe remains in the Middle Pleistocene.

The focus of occupation appears to shift into the northwest during the middle Middle Pleistocene. The possible explanations for this pattern are the presence of more suitable environmental conditions for hominids in the northwest, a regional bias in the quality of dating sites, regional research traditions and preservation biases. The northwest of Europe has a maritime climate, with reduced seasonal stresses and continentality compared to the east. The semi-open conditions of these environments may have provided optimal conditions for food procurement, without the problems of severe winters (Gamble 1984, 1986). Therefore, it is plausible that the hominid population in the Middle Pleistocene was heavily skewed towards the northwest.

However, it seems unlikely that the Mediterranean would be as under-populated compared to the north as the maps in Figures 5.38-5.49 suggest. Mediterranean regions had been populated since the Early Pleistocene and possessed a scrubland and open woodland environment (García Antón 1995) that hominids had occupied since their evolution in Africa (Brugal *et al.* 2003; Wynn 2004), hence these areas should have been habitable. A bias in the quality of dating between the Mediterranean and the northwest could explain the discrepancy in the number of sites in each region, especially in the definitely dated samples. The effects of glacial-interglacial cycles were more pronounced, and are thus more easily identified in the northwest, resulting in a greater ease of placing sites within a regional dating framework, which can be correlated to the divisions of the Pleistocene. This results in the over-representation of the northern sites in the definitely dated sample, and has some affect on their representation in the probably dated sample.

Preservation biases between the north and south are a less likely explanation of the site distribution, because the north was more heavily affected by glacial and peri-glacial processes that would destroy sites. Moreover, in the Early Pleistocene the distribution was focused on the south; therefore, site preservation in this region must be possible. A regional tradition biasing the placement of sites in the north towards the middle and late Middle Pleistocene is possible, given the history of scepticism towards early sites in this region. However, considering the better resolution of dating possible in the north, the dating of the sites is more likely to be correct than in the south, and the placement of so many sites in the Middle Pleistocene is probably genuine.

The sites in the late Middle Pleistocene of northeast Europe are all uncertainly dated, suggesting that hominid occupation of this region may have occurred after the study period, and the sites present should be dated to the subsequent interglacial, OIS 9. However, ecological, sociological and geographical models all suggest that an exploratory stage usually precedes major movement into a new area; therefore, the few sites in the Northeast could represent such an exploration. This interpretation is tentatively supported by the widely distributed spacing of the sites in the Northeast, which potentially reflects ephemeral and highly mobile occupation expected during a pioneering phase. The late expansion into the northeast supports the model proposed by Gamble (1984; 1986) that continentality restricted the range of early hominids. Moreover, environmental differences between the northeast and the rest of Europe allow this patterning to be interpreted as movement following an environmental matching and gradual adaptation model, as proposed by Foley (1987b).

Spatial patterns in the Lower Palaeolithic sites during the oxygen isotope stages.

Figures 5.50-5.79 display maps showing the location of sites with evidence of hominid presence in each oxygen isotope stage. The map sequence begins at OIS 25, as the earliest date available at this level of resolution. The maps are shown in order of decreasing age, and by certainty of dating and strength of evidence for hominid presence within each oxygen isotope stage. The maps highlight how few sites can be dated to a single stage, especially before OIS 15. A geographical bias in dating at this level of precision can also be seen, with very few sites in Iberia and Italy included in the OIS data compared to the broader date categories shown above. Moreover, the low numbers of sites dated to this level of precision removes many of the spatial patterns seen in the maps of the major divisions of the Pleistocene, such as the early focus of occupation in the southwest of Europe.

There are no sites definitely dated to OIS 25, and no sites with probable or definite evidence of hominids during this period. The only site dated to OIS 25 is Monte Peglia in Italy (van der Meulen 1973; Radmilli 1976), shown in Figure 5.50, which is poorly dated and contains questionable artefacts. Nevertheless, the pattern of occupation being restricted to Southern Europe is expected, given the spatial patterning of the sites dated to the major divisions of the Pleistocene.

Figure 5.50. Map showing all possible hominid sites, probably dated to oxygen isotope stage 25.

No sites are assigned to OIS 24, which could indicate that Europe was abandoned during this glacial, although given the small number of sites dated to this resolution at this time depth it is possible that hominids were present and have not been identified during this period.

The sites in the OIS 23 interglacial are limited to questionable evidence of hominids with uncertain dates at Kärlich A in Germany (Bosinski 1995a, 1995b) and Dursunlu in Turkey (Güleç *et al.* 1999), shown in Figure 5.51, providing little evidence of the spatial distribution of hominids across Europe during this interglacial.

Likewise, the only site dated to OIS 22 is Atapuerca TD4 in Spain (Carbonell and Rodriguez 1994), shown in Figure 5.52, which is uncertainly dated and contains poor evidence of hominid presence. Thus, there is some limited evidence to support hominid withdrawal to a southerly refugium during the OIS 22 glacial.

Figure 5.51. Map showing all the possible hominid sites probably dated to oxygen isotope stage 23.

Figure 5.52. Map showing all the possible hominid sites probably dated to oxygen isotope stage 22.

The sites assigned to OIS 21 lack definite dates, but there is good evidence of hominid presence at Atapuerca TD6 in Spain (Carbonell *et al.* 1995a; Carbonell *et al.* 1999b; Bermudez de Castro *et al.* 1999; Falgueres *et al.* 1999) and Staré Mesto 1 in the Czech Republic (Chlachula 1993, 1994), shown in Figure 5.55. The date of the first definite presence of hominids in Europe at OIS 21 is far later than the definite appearance of hominids in the major divisions of the Pleistocene, during the early Early Pleistocene, which demonstrates that increasing the dating resolution removes the majority of the evidence of hominid occupation of Europe in the earliest periods of the study. Nevertheless, this period coincides with the increase in the number of sites in Europe seen during the late Early Pleistocene, and therefore probably reflects a genuine trend of increased evidence of hominids in Europe, despite the small sample size of well-dated sites.

Figure 5.53. Map showing all the possible hominid sites probably dated to oxygen isotope stage 21.

Figure 5.54. Map showing probable and definite hominid sites, probably dated to oxygen isotope stage 21.

Figure 5.55. Map showing the definite hominid sites, probably dated to oxygen isotope stage 21.

There is only one site dated to OIS 20, Achalkalaki in Georgia (Ljubin and Bosinski 1995), shown in Figure 5.56, which possesses unconvincing traces of hominid presence without good dates. Therefore, Europe appears to have been abandoned by hominids during the OIS 20 glacial.

Figure 5.56. Map showing all the possible hominid sites probably dated to oxygen isotope stage 20.

OIS 19 contains many more sites than the earlier periods, however, none of these sites is well dated. Nevertheless, there is strong evidence of hominid presence in southern Europe during OIS 19, shown in Figures 5.57-5.59, which corresponds to the rise in the number of sites present in Europe during the late Early and early Middle Pleistocene, shown in Figures 5.26-5.37. Therefore, the oxygen isotope stage dates show a pattern of occupation that matches that displayed by the major divisions of the Pleistocene, but with a substantially reduced sample of sites. Moreover, these maps show widespread occupation of Europe during an interglacial, following the potential depopulation shown in Figure 5.56, indicating that a process of abandonment and recolonisation took place during the OIS 20 glacial and OIS 19 interglacial.

Figure 5.57. Map showing all the possible hominid sites probably dated to oxygen isotope stage 19.

Figure 5.58. Map showing the probable and definite hominid sites, probably dated to oxygen isotope stage 19.

Figure 5.59. Map showing the definite hominid sites probably dated to oxygen isotope stage 19.

The only site assigned to OIS 18 is Isernia La Pineta I t.3a in Italy (Sevink *et al.* 1981; Cremaschi and Peretto 1988b; Anconetani *et al.* 1995a), shown in Figure 5.60, which has an uncertain date, but shows definite traces of hominid presence. This map could again indicate hominid contraction into Southern European refugia during the glacial.

Figure 5.60. Map showing the definite hominid sites probably dated to oxygen isotope stage 18.

There are few sites that potentially date to OIS 17, shown in Figure 5.61 and Figure 5.62, and none in Europe that can definitely be assigned to this period, shown in Figure 5.63. Furthermore, there are no sites with definite evidence of hominid presence in Europe at any level of confidence in their placement within OIS 17. Therefore, the evidence of recolonisation of Europe following the OIS 18 glacial is tenuous. However, the low levels of occupation of Europe indicated by these maps does not correspond to the patterns of occupation seen during the early Middle Pleistocene, in Figures 5.32-5.37, and thus the sample of sites dated to OIS 17 may be unrepresentative of the actual presence of hominids in Europe, due to the high numbers of sites that cannot be dated to this level of precision.

Figure 5.61. Map showing all the possible hominid sites probably dated to oxygen isotope stage 17.

Figure 5.62. Map showing the probable or definite hominid sites, probably dated to oxygen isotope stage 17.

Figure 5.63. Map showing the definite hominid sites probably dated to oxygen isotope stage 17.

There are no sites dated to OIS 16 in Europe or its surroundings, implying that this glacial caused a complete abandonment of Europe.

The sites probably dated to OIS 15 include possible, probable and definite hominid sites, widely spread across Central and Western Europe, shown in Figures 5.64-5.66. These maps show that the areas occupied during OIS 15 are similar to those inhabited during OIS 17; however, sites are more numerous within the occupied regions during this period. The sites definitely dated to OIS 15, shown in Figure 5.67, all contain definite traces of hominids. These sites are Treugol'naja Cave layer 7a in Russia (Doronichev 2000b; Lioubine 2000, 2002; Hoffecker *et al.* 2003) and Carrière Carpentier in France (Bourdier 1974; Tuffreau and Antoine 1995). By comparison with the uncertainly dated sites in Figures 5.64-5.66 and the sites dated to the equivalent major division of the Pleistocene, the middle Middle Pleistocene, shown in Figures 5.38-5.43, Figure 5.67 reveals the extent to which the sample of sites is reduced as the dating resolution is improved. Moreover, at this level of resolution of the dates the possibility of detecting patterns in the spatial distribution of the sites across Europe is denied, due to the small number of sites in the dataset.

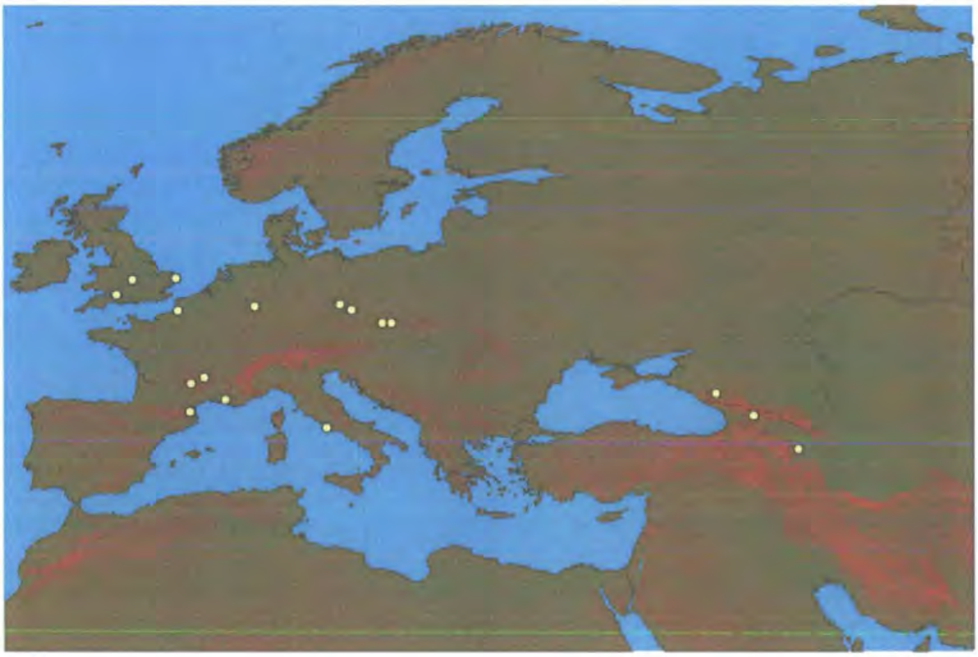


Figure 5.64. Map showing all the possible hominid sites probably or definitely dated to oxygen isotope stage 15.

Figure 5.65. Map showing the probable and definite hominid sites, probably or definitely dated to oxygen isotope stage 15.

Figure 5.66. Map showing the definite hominid sites, probably or definitely dated to oxygen isotope stage 15.

Figure 5.67. Map showing the definite hominid sites definitely dated to oxygen isotope stage 15.

The only sites attributed to OIS 14 lack definite dates, but contain definite signs of hominid presence, shown in Figure 5.68. These sites are Kärlich G in Germany (Bosinski 1995a; Gaudzinski and Vollbrecht 1995) and Kudaro III level 8 in Georgia (Doronichev 2000a; Lioubine 2000, 2002). This map shows that OIS 14 is the first glacial to show evidence of hominid presence in Northern Europe, although the dating is uncertain. Nevertheless, the potential presence of hominids in Germany during a glacial is significant. However, Figure 5.68 shows that the number of sites in Europe during OIS 14 was substantially lower than during the preceding interglacial, implying that a degree of abandonment took place.

Figure 5.68. Map showing the definite hominid sites, probably dated to oxygen isotope stage 14.

There are sites with possible, probable and definite evidence of hominids uncertainly dated to OIS 13; however, all the sites with definite dates are probably or definitely archaeological. The maps of the sites potentially dating to OIS 13, shown in Figures 5.69-5.71, demonstrate that a substantial increase in the number of sites in Europe took place during this period, and that occupation was focused in the Northwest, although sites were located throughout Central and Western Europe, corresponding to the patterns seen in the maps of the middle Middle Pleistocene, in Figures 5.38-5.43. However, the maps of the sites definitely dated to OIS 13, Figures 5.72 and 5.73, contain very few sites, all of which are located in the Northwest. These maps reveal the geographical bias in the quality of dates during this period, with high-resolution data only available in the Northwest. The sites definitely dated to OIS 13 that possess definite evidence of hominid presence, shown in Figure 5.73, are Boxgrove (Roberts and Parfitt 1999) and High Lodge in England (Cook *et al.* 1991; Ashton *et al.* 1992), and Mauer in Germany (Vollbrecht 1995b); and the additional site shown in Figure 5.72 with probable evidence of hominids is Wivenhoe in England (Bridgland 1994, 1998).

Figure 5.69. Map showing all the possible hominid sites, probably or definitely dated to oxygen isotope stage 13.

Figure 5.70. Map showing the probable and definite hominid sites, probably or definitely dated to oxygen isotope stage 13.

Figure 5.71. Map showing the definite hominid sites, probably or definitely dated to oxygen isotope stage 13.

Figure 5.72. Map showing the probable or definite hominid sites, definitely dated to oxygen isotope stage 13.

Figure 5.73. Map showing the definite hominid sites definitely dated to oxygen isotope stage 13.

The sites probably dated to OIS 12 include both probable and definite evidence of hominids, shown in Figure 5.74 and Figure 5.75, whereas the definitely dated sites only contain definite evidence, shown in Figure 5.76. There are no unlikely traces of hominids dated to OIS 12. The maps of the sites uncertainly dated to OIS 12 show widespread occupation across Europe, with a concentration of sites in the Northwest, particularly in Britain. This pattern becomes more extreme in Figure 5.76, which lacks any sites in areas of Europe other than the Northwest. This distribution is unexpected, as OIS 12 was a particularly intense glacial, and conditions in Northern Europe during this period are believed to have been uninhabitable for hominids (Gamble 1995c). Therefore, the expected distribution of sites during OIS 12 would be focused in southerly refugia, with few or no sites in Northern Europe. The sites possessing definite evidence of hominid presence during OIS 12, shown in Figure 5.76, are Kärlich H in Germany (Würges 1984; Gaudzinski and Vollbrecht 1995; Bosinski 1995a), Cagny-la Garenne unit 1 in France (Agache 1971; Bourdier *et al.* 1974a; Bourdier 1976a; Lamotte 2001), and Boxgrove units 6-8 (Roberts and Parfitt 1999), Maldon (Bridgland 1994), St. George's Hill in Weybridge (Wymer 1999) and Tilehurst (Roe 1968; Wymer 1999) in England.

Figure 5.74. Map showing the probable and definite hominid sites, probably or definitely dated to oxygen isotope stage 12.

Figure 5.75. Map showing the definite hominid sites, probably or definitely dated to oxygen isotope stage 12.

Figure 5.76. Map showing the definite hominid sites definitely dated to oxygen isotope stage 12.

Figures 5.77-5.79 show the sites probably and definitely dated to OIS 11. There are no sites that were classed as unlikely evidence of hominid presence during this period, and all the sites that definitely dated from OIS 11 also contained definite traces of hominids. The maps of the sites uncertainly assigned to OIS 11, Figures 5.77 and 5.78, demonstrate that occupation was the most widespread in Europe of any of the interglacials during the study period. The Northwest was the most densely occupied region, but sites were also located Southern and Central Europe, and in the Northeast for the first time during the study. However, Figure 5.79 reveals that the only areas of Europe with both definite archaeological and dating evidence of occupation during OIS 11 were the Northwest and the Caucasus, further reinforcing the regional bias in the quality of dating evidence in Europe.

Figure 5.77. Map showing the probable and definite hominid sites, probably or definitely dated to oxygen isotope stage 11.

Figure 5.78. Map showing the definite hominid sites, probably or definitely dated to oxygen isotope stage 11.

Figure 5.79. Map showing the definite hominid sites definitely dated to oxygen isotope stage 11.

Figures 5.80-5.83 show the sites dated to phases of the oxygen isotope stages in all the potentially hominid sites with definite dates, as this data had the strongest relationship between date and position in the OIS phases, shown in Figure 5.15. These maps reveal the small number of sites and the restricted area in which the OIS phases have been applied, with such high-resolution dates only being available in the Caucasus and Northwest Europe, particularly in Britain. During OIS 15 the only site dated to a phase within the interglacial is Treugol'naja Cave layer 7a in Russia (Doronichev 2000b; Lioubine 2000, 2002; Hoffecker *et al.* 2003), shown in Figure 5.80. The sites dated to phases within the OIS 13 interglacial, shown in Figure 5.81, are Boxgrove (Roberts and Parfitt 1999) and High Lodge (Wymer 1985; Cook *et al.* 1991; Ashton *et al.* 1992) in England. The sites dating to phases of the OIS 12 glacial, shown in Figure 5.82, are Boxgrove and St. George's Hill (Weybridge) (Wymer 1999) in England, Cagny-la Garenne unit 2 in France (Bourdier *et al.* 1974a; Bourdier 1976a; Tuffreau and Antoine 1995), and Kärlich H in Germany (Würges 1984; Gaudzinski and Vollbrecht 1995; Bosinski 1995a). The number of sites dated to phases within the OIS 11 interglacial is substantially larger than the amount dated to phases within any other oxygen isotope stage during the study.

Figure 5.80. Map showing all the possible hominid sites, definitely dated to phases of oxygen isotope stage 15.

Figure 5.81. Map showing all the possible hominid sites, definitely dated to phases of oxygen isotope stage 13.

Figure 5.82. Map showing all the possible hominid sites, definitely dated to phases of oxygen isotope stage 12.

Figure 5.83. Map showing all the possible hominid sites, definitely dated phases of oxygen isotope stage 11.

Interpretation of the spatial patterning in the oxygen isotope stages.

The maps showing sites dated to oxygen isotope stages involve a smaller sample of sites than the major divisions of the Pleistocene, but were intended to offer the possibility of detecting population movement in response to climatic cycles. Abandonment of northern Europe has been predicted to occur during glacials and recolonisation from refugia within Europe or areas outside Europe to take place during interglacials (Gamble 1984). However, the number of sites dated at this level of accuracy is very low, especially in the periods before OIS 19, shown in Figures 5.50-5.56; therefore, no significance in the spatial patterning of the early sites can be discerned. Moreover, the geographical bias in dating accuracy is more acute in the oxygen isotope stage data. Once hominids arrived in northern Europe, sites in Britain, France and Germany dominated the sample of sites dated to a single isotope stage, resulting in a picture of depopulation of the south in favour of the north, which is unsupported when compared against the site distribution seen in the lower resolution date categories in Figures 5.38-5.49. This problem results in the identification of refugia in southern Europe during glacials, and routes of recolonisation of the north during interglacials becoming impossible.

The sites dated to glacial periods are clustered in the northwest of Europe in OIS 14 and 12, and in the Mediterranean and the Caucasus in OIS 20 and 18, in lower numbers than the sites in the preceding interglacials but following the same geographical bias, suggesting that either the sites are misdated and formed during the interglacials, or that hominids survived glacials without movement. However, the Mediterranean and the Caucasus could have formed refugia, as these areas would not have experienced the extreme cold of northern Europe during the glacials. Therefore, the presence of hominids in northern Europe during the later glacials of the study period appears to be a significant behavioural development, as these regions would not have been refugia. However, it is possible that many of the sites in northern Europe were actually created during the milder early or late glacials, or have been incorrectly identified as forming in the glacial and in fact represent reworked material from preceding interglacials, but the evidence from the sites dated to the phases of the isotope stages, in Figure 5.82, implies that hominid groups survived in the mid glacial in northern Europe at Cagny-la Garenne unit 2 in France during OIS 12 (Bourdier *et al.* 1974a; Bourdier 1976a; Tuffreau and Antoine 1995).

The focus of occupation in the northwest during the later glacials can be interpreted as either caused by the dating resolution problems in the south, or as a reflection of inhospitable conditions in Southern Europe. It is possible that areas of the Mediterranean became more arid during glacials, creating less hospitable conditions than during interglacials. However, floral and faunal refugia were certainly present in the south (Naveh and Vernet 1991), and the data with poor dating resolution suggests that hominids were present as well. Nevertheless, the population may have decreased in the south as well as the north during glacials. The possible routes of recolonisation of the north likewise cannot be identified given the problems of poor sample sizes and a lack of strong dating resolution. The appearance of large sites in northern Europe during OIS 12, discussed in Chapter 7 (Figures 7.43-7.44, pages 358-359) suggests that the refugia used by hominids were not restricted to the most southerly parts of Europe, as recolonisation times must have been rapid, and thus the distances involved were probably not great.

The maps of the phases of the oxygen isotope stages were intended to reveal information about the areas abandoned during glacials and the routes of recolonisation during interglacials. However, it was found that it is only sites in northwestern Europe or the Caucasus that can be dated to this level of precision, and thus the sample studied is geographically highly biased. Furthermore, there is only one site dated to a phase of a climatic cycle that is older than OIS 15, Atapuerca TD4 and TD5 possibly dated to middle-late OIS 22 (Carbonell and Rodriguez 1994; Carbonell *et al.* 1999a), see Figure 5.13. The sample of sites dated at this level of precision is heavily dominated by a few modern major excavations. Nevertheless, the presence of hominids at Cagny-la Garenne unit 2 in northern Europe during mid OIS 12 is significant. Three possible explanations for this phenomenon are possible, either this site was occupied during an interstadial within the glacial, when conditions were not too harsh, or hominid groups were able to cope with conditions in glacial northern Europe, at least on a seasonal basis, or the archaeological material is in secondary context. The presence of early interglacial sites in northwest Europe supports the suggestion from the dating evidence alone, that the distance to refugia decreased towards the end of the study period, and therefore that hominids were able to access northwest Europe soon after climatic amelioration began.

Conclusions.

In summary, three periods of population growth in Europe during the study period have been detected, the early Early Pleistocene, the late Early-early Middle Pleistocene, and the middle Middle Pleistocene. The first of these periods must represent a movement into Europe, and the later episodes could be explained by either further movements of groups into the continent or by indigenous population growth. The later episodes of population growth coincide with increases in the area of Europe occupied by hominids, and may also coincide with behavioural and ecological developments. The physical environmental and ecological circumstances surrounding these events will be explored in the following chapter, and the behavioural context of the potential episodes of movement will be addressed in Chapter 7.

Chapter 6 : The Physical and Ecological Context of Lower Palaeolithic movements.

This chapter will present the results of the collection of the landscape, environmental, hominid species and faunal data. These aspects of the data relate to the conditions encountered by hominids on arrival in Europe, in terms of the ecological niche that they occupied, and the levels of competition and adaptation that need to be overcome in order for the population to become established and to survive. The landscape data address issues of physical tolerance limits, such as the suggested physical barriers to spread in the form of mountains and highlands (Rolland 1992, 1995, 1998b, 2001); and also the means by which hominids coped with the need to build knowledge of resource distribution in newly occupied regions. The environmental data address the questions of the tolerance limits and ecological preferences of hominids during the Early and Middle Pleistocene, hence, issues of barriers to occupation and the sequence of environmental adaptations, raised by Foley (1987b), can be considered. The hominid species data will also be addressed with respect to the evidence generated concerning hominid physical adaptations to conditions in Europe. The faunal data allow access to issues such as the timing of opportunities for movement into Europe during periods of lessened competition during faunal turnovers, and the possible correlation between the arrival of hominids and other guilds of species in Europe suggested by Rolland (1992; 1995; 1998b; 2001). These physical environmental and ecological interactions have behavioural implications that underlie the ability of hominids to inhabit Europe. The behaviours involved in the movement into Europe will be explored further in the following chapter. The landscape data will be presented with the discussion of the meaning of the patterning revealed in the analysis, followed by the environmental data, and finally the faunal data.

The investigation into the effects of varying the resolution of the dating and the certainty of hominid presence, presented in the previous chapter, has highlighted the general trend that increasing resolution results in the reduction of sample sizes, often to the point where statistical significance between variables is destroyed. In the oxygen isotope stage datasets this problem is even greater, as the earlier sites are excluded, with no material older than OIS 15 in the definitely dated sample. Therefore, many patterns seen in the poorer resolution dates disappear in the oxygen isotope stage data due to this removal of the early sites. This problem is particularly acute when the data under investigation were not available at all sites, and thus had a small sample problem at the broadest resolution of the data. However, certain relationships proved to be strong, and resilient enough to overcome the problems of sample size. This chapter will address the meaning of these resilient relationships, and the causes of the strength of the relationships between the landscape, environmental and faunal data and factors such as time and assemblage size.

What landscapes did hominids occupy?

The Lower Palaeolithic landscape data.

Data concerning the landscape of the sites were available for the majority of the dataset, with 6% of the sites in the database lacking this information. Therefore, the landscape data can be considered reasonably representative for the data as a whole.

Figure 6.1 and Figure 6.2 show the number of definite hominid sites in each major division of the Pleistocene, defined in Chapter 4, and landscape type, divided into probable and definite dates. The pattern in the sites with less confidence of hominid presence is the same as in the definite hominid sites. The sequence of occupation of landscape types during the major date categories can be seen to be: riverine, lacustrine, coastal, hilly, plains, high plateau and mountainous. Hominid occupation was strongly focused on riverine landscapes throughout the study period. Coastal and lacustrine landscapes were inhabited at moderate frequencies throughout the Pleistocene, and the remaining types of landscape were occupied rarely and later in the study period. The null hypothesis that there is no significant relationship between the date of a site and the landscape in which the site is situated was examined using chi-squared and lambda tests. The chi-squared results were invalid, and lambda produced no significant results, upholding the null hypothesis at all dating and archaeological resolutions of the major date categories.

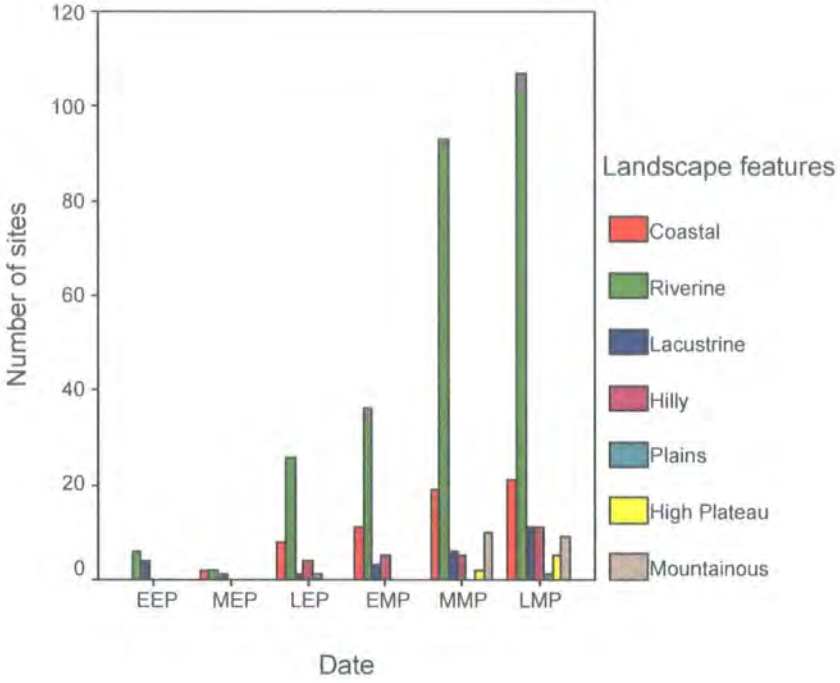


Figure 6.1. Chart showing the number of definite hominid sites in each landscape type, probably or definitely dated to each major date category. N=410.

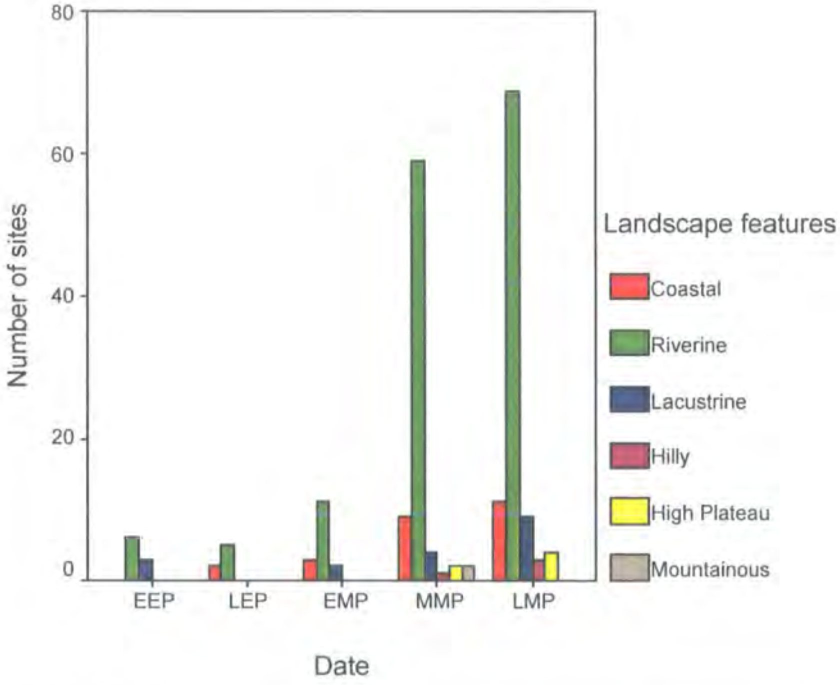


Figure 6.2. Chart showing the number of definite hominid sites in each landscape type, definitely dated to each major date category. N=205.

The patterning in the sequence of landscapes occupied in sites dated to oxygen isotope stages follows the same sequence of occupation and patterns of prevalence as the major date category. The null hypothesis of no relationship existing between the date of a site and its landscape setting was upheld at all resolutions of the dates and hominid presence, except for unlikely sites with probable dates. However, this data produced a value of lambda =0.019 (α=0.013), which indicates a very weakly significant relationship. As this dataset is the poorest quality, this result can probably be rejected since all the better resolution data shows that the null hypothesis should be upheld. Figure 6.3 displays this significant relationship between landscape type and date.

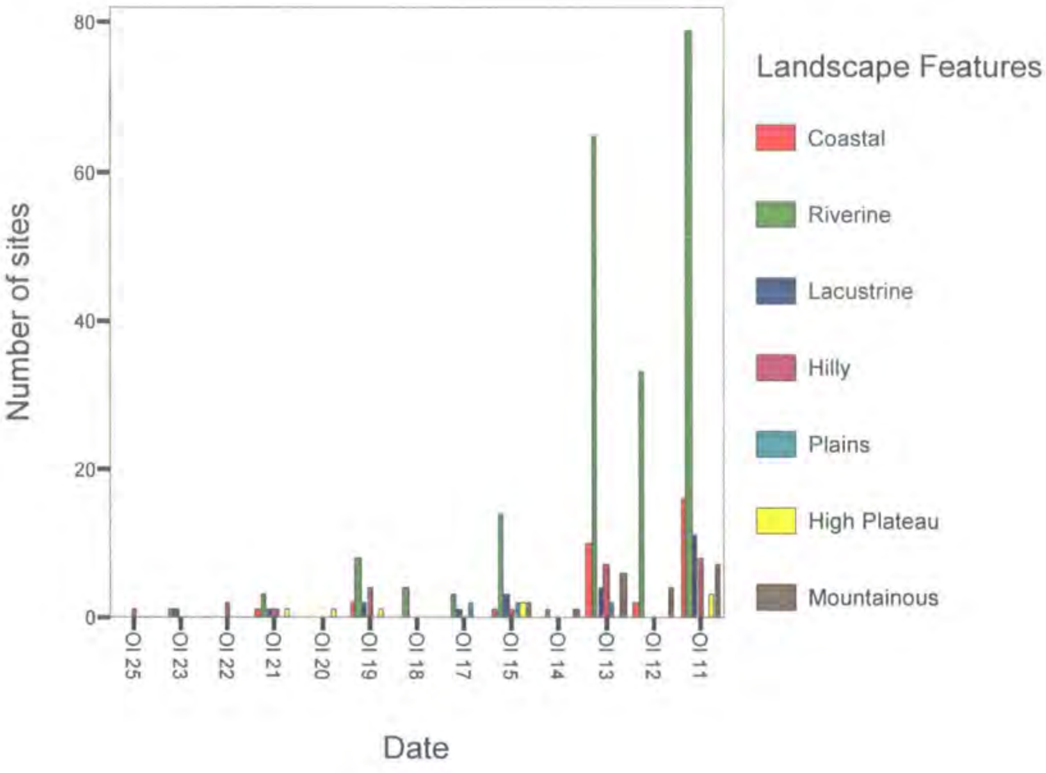


Figure 6.3. Chart showing the number of all possible hominid sites in each landscape type, probably or definitely dated to each oxygen isotope stage. N=324.

The relationship between the landscape surrounding a site and the assemblage size of the site was investigated, with the aim of establishing whether large sites were associated with particular landscapes, and whether certain landscapes were only occupied at a low level. Chi-squared and lambda tests were performed using the null hypothesis that there is no relationship between the landscape in which a site is situated and the size of the assemblage at the site, using five classes of assemblage size of: 0-10, 11-50, 51-100, 101-1000, and 1001+ artefacts. The chi-squared tests were invalid, but the lambda tests rejected the null hypothesis when the dating resolution was poor, and the presence of hominids was not certain. However, the strength of the dependence of assemblage size on landscape type was weak in all cases, with a maximum value of lambda =0.123 (α=0) for the oxygen isotope stage probable dates and probable presence of hominids, shown in Figure 6.4. The results that uphold the null hypothesis have a reduced sample size, which may explain their lack of significance. There are no large sites in plains or high plateaux, and the majority of sites in mountainous landscapes are very small. The sites in coastal, riverine, lacustrine and hilly landscapes are more likely to be large, with modal values of 101-1000 artefacts per assemblage. These results suggest that the landscapes occupied earlier were also occupied more substantially than other physiognomies. However, these relationships are weak, and are not significant in the high-resolution datasets; thus, these findings remain provisional.

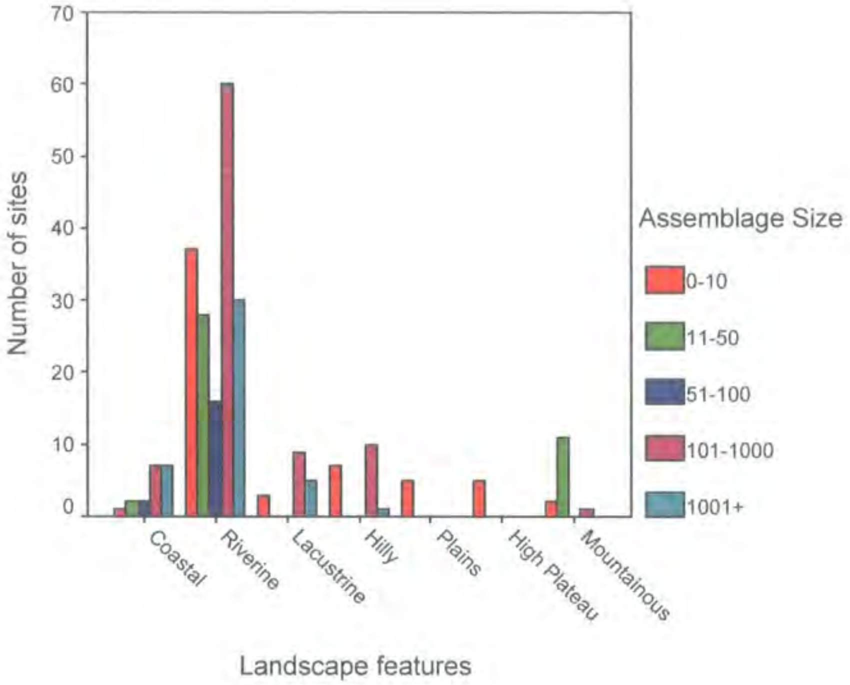


Figure 6.4. Chart showing the number of probable and definite hominid sites with probable or definite dates to oxygen isotope stages in each landscape type, by the assemblage size present in the site. N=249.

Landscapes occupied in the Lower Palaeolithic.

The results of the investigation into the landscapes occupied by hominids, presented in Figures 6.1-6.3, show that riverine areas always contained the majority of Lower Palaeolithic sites. The possible explanations of this pattern are that for taphonomic reasons sites in other landscapes are under-represented, riverine landscapes are physically the most common across Europe, hominids were tied to water resources, or that rivers were the corridors of movement allowing dispersal. A taphonomic explanation is plausible because sites in river valleys are more likely to be covered by deposits and preserved than those on exposed hills or mountains, which undergo more erosion (Bell and Boardman 1992). Moreover, sites situated in river terraces can be dated, whereas sites in plains, hills, mountains and high plateaux are not easily placed within a regional geological sequence, and thus are harder to date, resulting in exclusion from the database and under-representation.

The definition used of a riverine landscape included areas within a valley, which were not immediately adjacent to the river, resulting in the majority of the landscape being defined as riverine. Sites were also assigned to the riverine category when their location was in a valley within a hilly, mountainous or plateaux region because it was believed that the presence of the river valley was the factor allowing hominid presence. Therefore, it is possible that the riverine category has been artificially inflated by this procedure; nevertheless, sites do not appear outside of valleys in the plains, hills, mountains or high plateaux until the middle Middle Pleistocene, which suggests that their total absence in earlier periods is genuine.

It has been proposed that early hominids were most abundant in landscapes with water resources available locally (Deocampo *et al.* 2002); therefore, the dominance of riverine, lacustrine and coastal terrain could be determined by the need for water. This argument is strong, given that no evidence of water carrying devices has been recovered in the Lower Palaeolithic. Excursions beyond areas with available water may have been limited, resulting in little or no possibility of recovery in the archaeological record. This is supported by the small assemblage size of the majority of sites found in mountains, high plateaux or plains, shown in Figure 6.4.

The fourth possible explanation of the dominance of riverine landscapes is that hominid occupation was limited to natural corridors through the landscape. Valleys provide routes through regions, allowing more easy navigation (Kelly 2003), access to water, and a focus for obtaining faunal resources. During a dispersal a network of destination nodes is expected to develop, before the destination becomes familiar and secondary dispersal across the hinterland takes place. It is possible that river valleys formed the network for dispersals, and that later occupation of more diverse landscapes reflects movement after familiarisation. Rivers create pathways through unknown regions, and thus they are likely to form the nodes because they can be easily relocated and contain known resources, reducing the risk of subsistence failure in unfamiliar conditions (Kelly 2003). Other natural pathways through territory are coasts and linear mountain chains. Coastal sites do occur early in the occupation of Europe, supporting the notion that navigational concerns operated during the initial exploration.

The sites in mountains, plains and high plateaux can be interpreted as exploratory forays into these landscapes, rather than settlement, because the size of the sites involved is almost always very small, see Figure 6.4, supporting either the presence of small groups, or short durations of occupation. These landscapes are more difficult to colonise due to a lack of critical resources in close proximity to one another, as the habitat grain scale of these landscapes tends to be large (Bailey 1996), requiring planning to overcome the difficulties of widely dispersed resources (Gamble 1984, 1986). Thus, occupation of these landscapes may have depended on the acquisition of knowledge before settlement, hence the evidence shows exploration but not settlement. Moreover, the topography of these areas is difficult to navigate, creating problems for learning where resources are located (Kelly 2003). Therefore, there is evidence that mountains formed barriers to occupation, but not to movement and exploration, during the Middle Pleistocene. There are no sites in mountainous regions in the Lower Pleistocene, thus mountains may have been barriers to the initial dispersal into Europe, as suggested by Rolland (1992). Alternatively, in the Lower Pleistocene exploration was limited to the areas adjacent to riverine corridors due to the short period since arrival, which would result in familiarisation being focused on the areas closest to the nodes during the early phases of settlement.

In summary, there is some support for the dispersal of hominids being focused through river valleys. Water resources were critical throughout the study period, and the vast majority of sites are found in lacustrine, coastal or riverine settings. There is evidence for exploration of mountains, hills, plateaux and plains in the Middle Pleistocene, which can be explained either by the need for settlement and knowledge to build up within Europe before these settings became habitable, or by adaptation allowing hominids to overcome the difficulties posed in these areas. An explanation of these patterns by the need for exploration and knowledge acquisition implies that the spread into new territories in the Middle Pleistocene involved indigenous groups in Europe, whereas the adaptation argument could accommodate the changes in behaviour being caused by the arrival of new groups of hominids with more advanced behavioural capabilities than the earlier European populations. The oxygen isotope stage dataset lacked the earlier sites and showed less overall patterning as so few sites can be dated before OIS 15.

What environments did hominids occupy?

The Lower Palaeolithic environmental data.

The environmental data suffered significant problems of a lack of published information concerning the habitat surrounding Palaeolithic sites, with no data available for 60% of the sites in the database. Therefore, the findings of the environmental analyses remain provisional, as it cannot be assumed that those sites with environmental data are a representative sample of all the habitats occupied by hominids in the Early and Middle Pleistocene.

Chi-squared tests of the null hypothesis that there is no relationship between the environment of a site and its date were invalid, whereas lambda tests were significant for all resolutions of the oxygen isotope stage data, and the strength of the relationship increased with improved dating resolution. The strongest relationship found was between the date and environment of the definitely hominid sites with definite oxygen isotope stage dates, with a value of lambda =0.263 (α=0.017) for the environment being dependent on the date of the site, illustrated in Figure 6.5. The sequence in which environmental types were occupied by hominids begins with temperate woodland, temperate shrubland, savannah and steppe. At a later stage temperate deciduous forest, alpine shrubland, saltmarsh and temperate evergreen forest were occupied. The last environments to be inhabited were taiga and cool temperate bog. Thus, there is a trend towards a greater diversity of environmental types to be occupied later in the Pleistocene. However, the majority of hominid sites were always found in temperate woodland or steppic habitats.

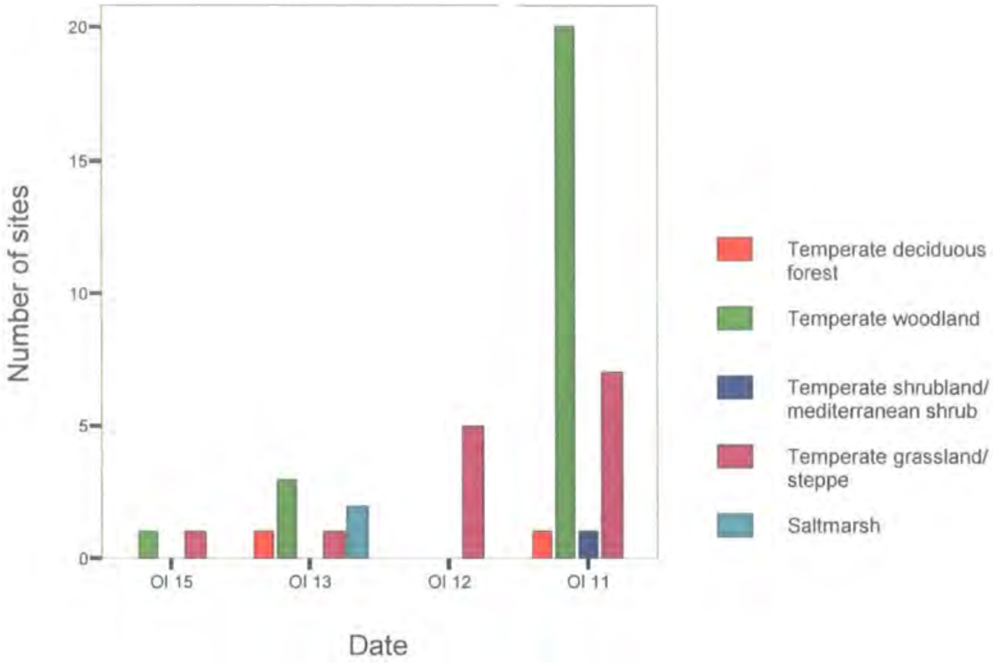


Figure 6.5. Chart showing the number of definite hominid sites in each environmental type, definitely dated to each oxygen isotope stage. N=43.

The poorer resolution datasets show a greater range of environments occupied earlier in the Pleistocene, and more diverse habitats being inhabited throughout the study period. The major date category data only shows a significant relationship between environment and date when the dating is certain, and the unlikely or probably hominid sites are included. The strongest relationship between the environment and date of sites in the major date categories was in the probably hominid sites with definite dates data, with a value of lambda =0.204 (α=0.037), shown in Figure 6.6.

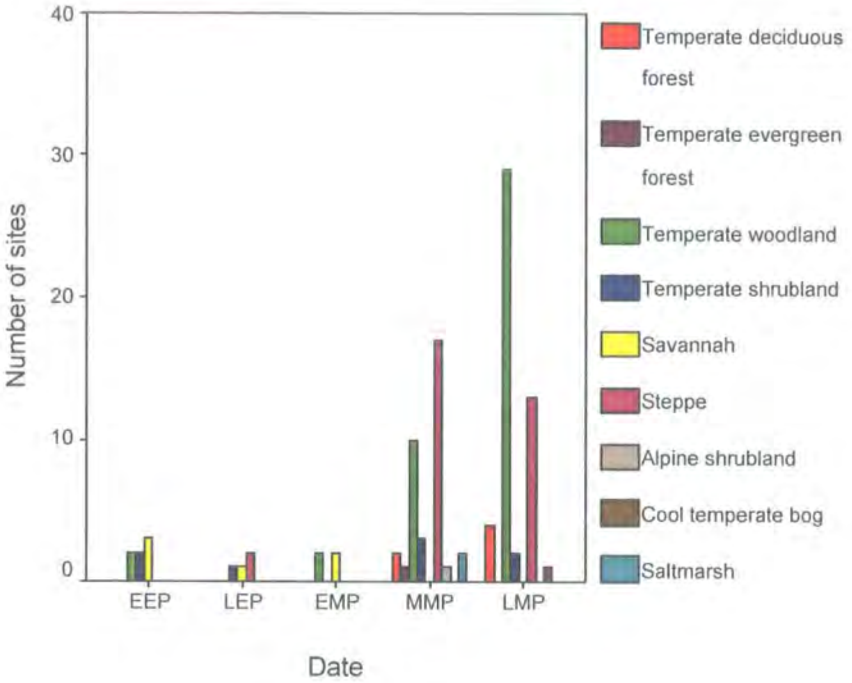


Figure 6.6. Chart showing the number of probable and definite hominid sites in each environmental type, definitely dated to each major date category. N=100.

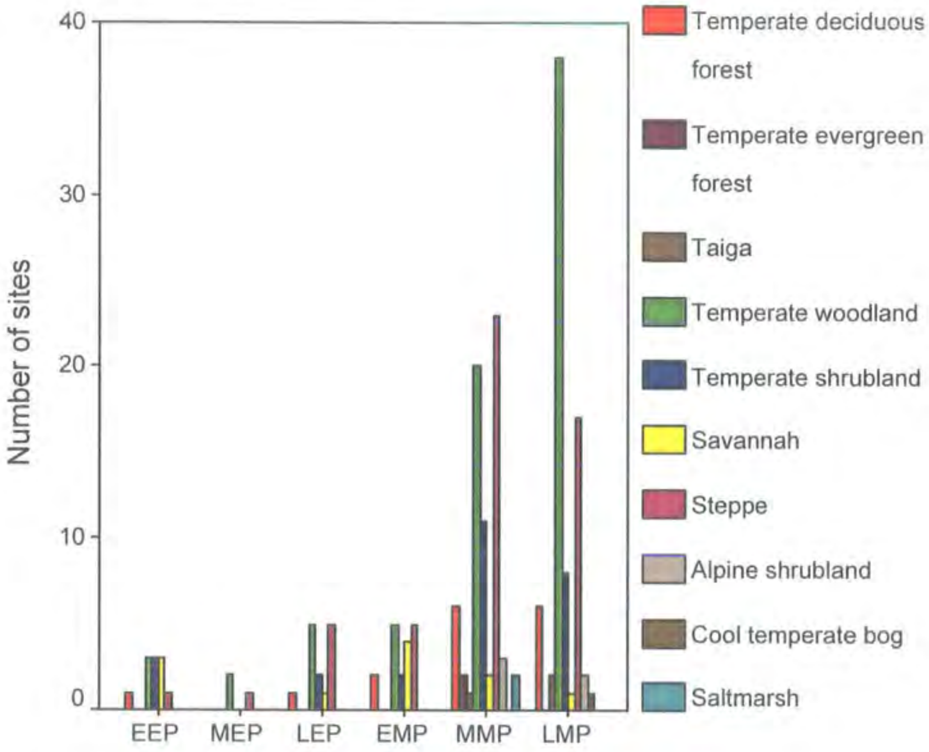


Figure 6.7. Chart showing the number of all possible hominid sites in each environmental type, probably or definitely dated to each major date category. N=191.

Figure 6.7 shows the environments occupied in each major date category in all the potentially hominid sites with both probable and definite dates, which displays the broadest range of environmental types inhabited.

The environments occupied by hominids were compared against those at non-hominid sites, using chi-squared and lambda tests of the null hypothesis that there are no differences between the proportion of hominid and non-hominid sites in each environmental type. The chi-squared tests were invalid, but the lambda tests upheld the null hypothesis, with lambda=0 (α=1.0). In order to increase the sample size of the non-hominid sites the unlikely hominid sites were combined with the faunal data, and removed from the hominid sample. This procedure did not falsify the null hypothesis, as lambda =0.012 (α=0.414); therefore, it can be concluded that there are no differences between the environments in which faunal sites and hominid sites are found. Figure 6.8 shows the number of hominid sites compared to faunal and unlikely hominid sites in each environmental type, illustrating the level of similarity in the proportion of sites in each habitat.

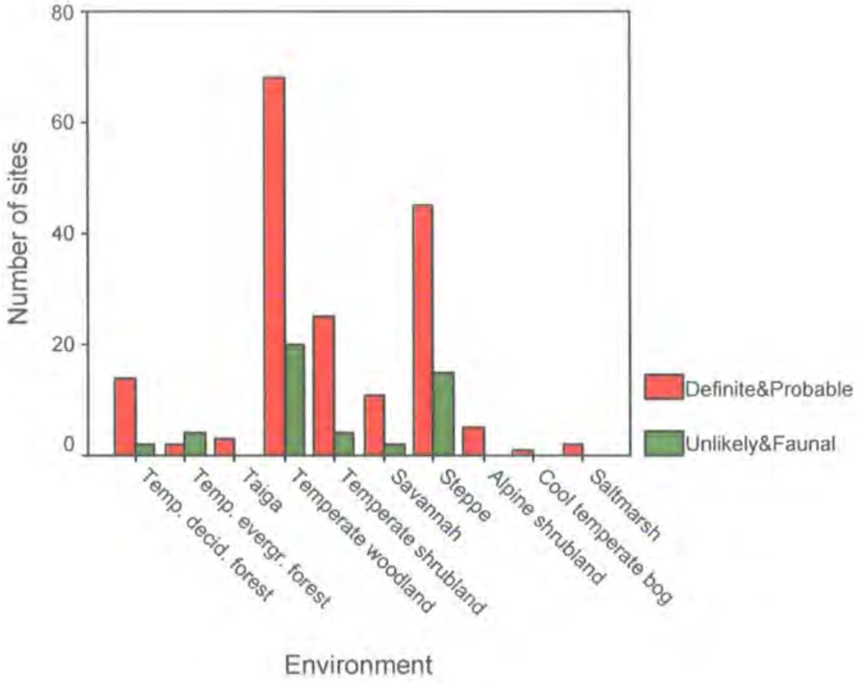


Figure 6.8. Chart showing the number of definite and probable hominid sites, compared to the number of unlikely hominid and faunal sites in each environmental type. N=223.

In order to investigate whether the patterning in the habitats occupied by hominids over time could be explained by changes in the Pleistocene environments of Europe chi-squared and lambda tests were performed on the null hypothesis that there was no relationship between the date of a site and the environment in which it was located, using both the archaeological and the faunal sites in the database. The tests produced an invalid chi-squared result; nonetheless, the lambda test provided a significant result, with lambda =0.15 (α=0.047) for sites definitely dated to major date categories, which rejects the null hypothesis. Therefore, there is a significant relationship between environment and date in the Pleistocene. However, although this test used all the sites in the database, hominid sites dominated the data and the patterning produced was highly similar to the distribution of hominid sites over time. A further set of tests were conducted to investigate whether faunal sites show a relationship between environment and date, and thus were sufficient to produce a picture of Pleistocene environments when the larger archaeological sample was excluded. The chi-squared tests were again invalid, and lambda =0.1 (α=0.365) for sites with probable dates, and lambda =0.294 (α=0.169) for sites with definite dates, neither of which is significant. Therefore, the faunal sites show no relationship between the environment and date of a site, whereas the occurrence of hominids in an environment is related to time.

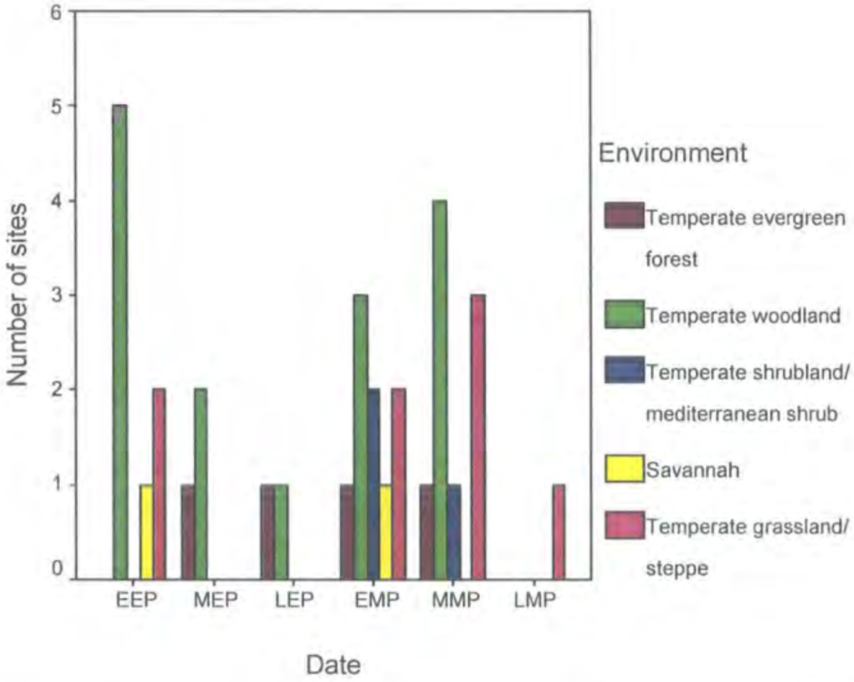


Figure 6.9. Chart showing the number of faunal sites in each environmental type, probably or definitely dated to each major date category. N=32.

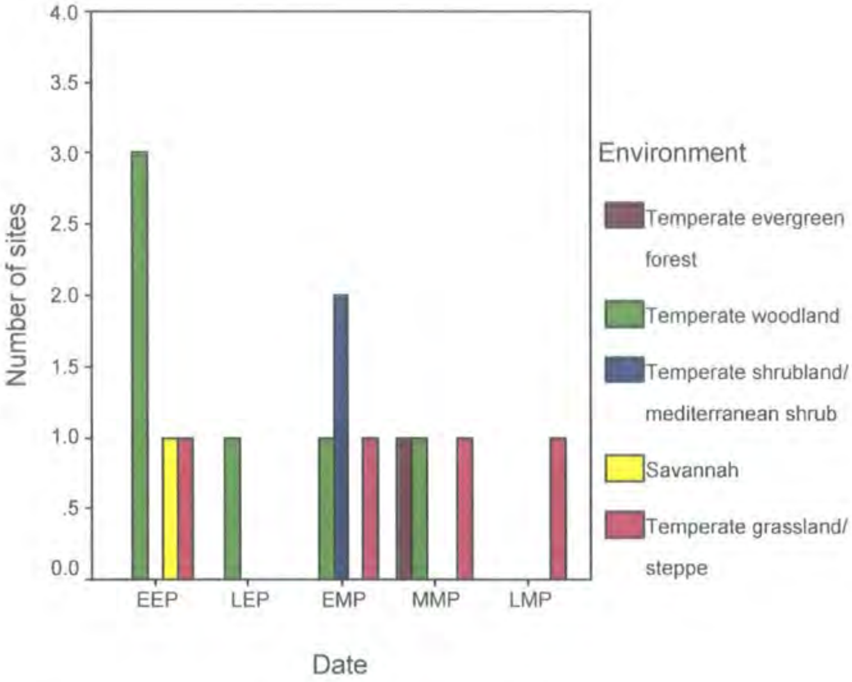


Figure 6.10. Chart showing the number of faunal sites in each environmental type, definitely dated to each major date category. N=14.

In order to investigate the relative level of hominid occupation of each environmental type, the null hypothesis that there is no relationship between the environment of an archaeological site and its assemblage size was examined using chi-squared and lambda tests, with the assemblage sizes in the five categories of: 0-10, 11-50, 51-100, 101-1000 artefacts. The chi-squared tests were invalid, whereas the results of the lambda tests upheld the null hypothesis, producing insignificant results for all the datasets with either definite oxygen isotope stage dates or major divisions of the Pleistocene dates, regardless of the certainty of hominid presence. However, the tests including probable dates rejected the null hypothesis. The strongest relationship between the environment and assemblage size of sites was seen for the definitely hominid sites with probable oxygen isotope stage dates, with lambda =0.221 (α=0.009), shown in Figure 6.11. Therefore, a weak relationship between the environment and assemblage size of sites exists when dating resolution is poor. The lack of a relationship between these factors in the well-dated sample is probably due to the small sample size of sites with environmental evidence, assemblage sizes and definite dates. The relationship is unaffected by variations in the certainty of hominid presence. The range of assemblage sizes in temperate woodland and steppe habitats was broad, whereas alpine shrubland and temperate evergreen forest contained small assemblages, and taiga, saltmarsh and savannah had large assemblages, shown in Figure 6.12.

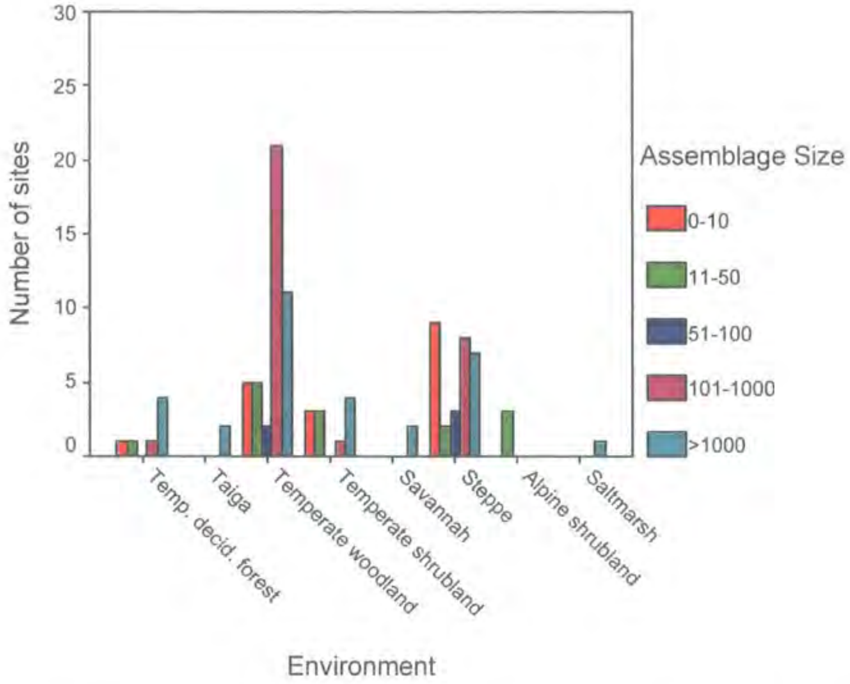


Figure 6.11. Chart showing the number of definite hominid sites with probable or definite dates to oxygen isotope stages, by the environment and assemblage size of the sites. N=99.

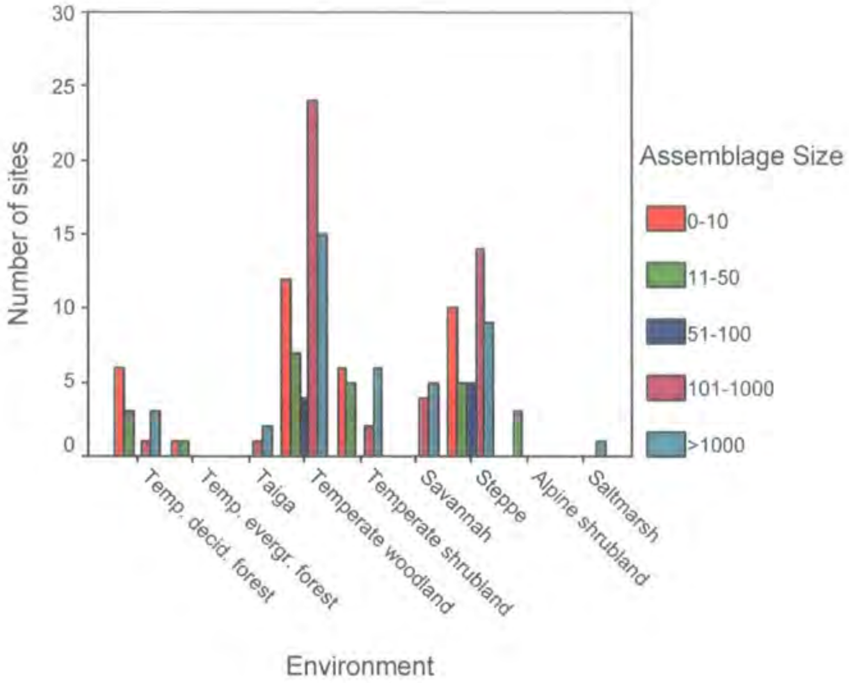


Figure 6.12. Chart showing the number of all potentially hominid sites with probable or definite dates to major date categories, by the environment and assemblage size of the sites. N=155.

Environments occupied in the Lower Palaeolithic.

Sequence of occupation of the environmental types.

The environmental data, shown in Figures 6.5-6.7, suggest that the habitats initially occupied by hominids were temperate woodland, temperate shrubland, savannah and steppe, followed by temperate deciduous and evergreen forest, alpine shrubland and saltmarsh, and finally taiga and cool temperate bog. The datasets with poor date resolution show a greater range of environments occupied, especially in the latest phases of the study period. It is possible that these additional environments, such as taiga and cool temperate bog, were actually occupied later than the study period, and have been included only because of poor dating control. The putative occupation of taiga may be connected to the spread into the northeast of Europe, which probably took place immediately after the end of the study period, as discussed in Chapter 5. Nevertheless, even when the poor resolution data is removed a trend remains for the occupation of a more diverse range of habitats in the Middle Pleistocene, compared to the initial Early Pleistocene occupation of a restricted range of environments in

Europe. Moreover, the sequence of environments occupied remains the same, despite changes in the date of first occupation of each ecosystem as the resolution of the dates and hominid presence is varied. Therefore, this sequence appears to be valid despite the uncertainty over the precise timing of hominid appearance in each habitat. This finding supports the suggestion by Foley (1987b) that dispersal should follow a pattern of occupation of familiar habitats, adaptation and spread into further newly encountered ecological conditions. Furthermore, Gamble's (1984; 1986; 1995d) proposal that environmental conditions limited the range of hominids, through the mechanism of resource structure not matching social abilities is also compatible with this evidence.

The possible reasons for the greater diversity of habitats occupied by hominids at the end of the study period include ecological changes in Europe, taphonomic effects, sampling problems, exploration and increased knowledge and familiarity of European habitats, and adaptation. The potential for environmental change driving an increase in habitat diversity in Europe in the Middle Pleistocene was investigated by comparing the environments of faunal and hominid sites, see Figure 6.8, following the reasoning that faunal sites should be found in a representative sample of European environments. These tests revealed no significant differences in the environments at faunal and hominid sites, and as the faunal sites were recovered from a more restricted range of environments than those seen at hominid sites, these findings imply that hominids were not seeking out any particular environments, beyond the natural level of prevalence of each biome in Europe. However, as the number of faunal sites in the database is very low compared to the hominid sites these results remain tentative. No relationship between the environments and date of faunal sites was found, suggesting that environmental change cannot explain the increased diversity of habitats occupied by hominids in the Middle Pleistocene. However, the small sample of faunal sites prevents these findings from being conclusive. Moreover, the faunal sites may not be located in a representative sample of European habitats, due to preservational biases, and therefore this material may not provide a good picture of Pleistocene European environments, or a comparable sample of data for the hominid environmental findings. Therefore, further investigation into the Pleistocene environments of Europe would be necessary to confirm these results of hominid spread into diverse habitats over time being the result of adaptation rather than external environmental changes.

The habitats initially occupied in the Middle Pleistocene are all inhabited at very low levels, in terms of the number of sites, and generally in the size of the assemblages present at the sites, shown in Figure 6.11 and Figure 6.12. Therefore, it is possible that the lack detection of sites in these habitats in the Early Pleistocene is a sampling effect, caused by the general increase in site number over time. However, the presence of some large sites in ecosystems such as temperate deciduous forest and taiga, suggests that large-scale occupation of these environments was possible, and should have resulted in detection in the archaeological record in the Early Pleistocene if these habitats were inhabited.

Taphonomic explanations of the absence of hominids from certain habitats in the Early Pleistocene would have to explain why a change in preservation and recovery occurred during the Middle Pleistocene, discussed above. Although preservation conditions vary between habitats, due to different soil chemistry, climatic regimes, and physical traits of the areas in which each community occurs (Waters 1992), these conditions would have been similar in each habitat over the duration of the Early and Middle Pleistocene, and thus cannot explain the initial absence of sites from some biomes.

Adaptation to new conditions, allowing a greater range of habitats to be occupied is plausible, given the time lag between hominid appearance in Europe and occupation of ecosystems such as taiga, cool temperate bog and temperate forests. Adaptation is argued to be the mechanism allowing spread in historical biogeographical models, and in Foley's approach to hominid dispersal. Gamble (1984; 1986; 1995d) also forwards a model of social adaptation allowing occupation of habitats with widely dispersed resources, such as forests, although he argues that this process took place after the Lower Palaeolithic. Adaptation should be detected through physical or behavioural changes occurring at the time of dispersal. Physical adaptations were not directly investigated, but the evidence from the hominid species, presented in the following section in Figure 6.13 and Figure 6.14, does suggest that *Homo heidelbergensis* appeared in the fossil record at the time of expansion into a broader range of habitats, which could reflect adaptation. Behavioural adaptation could be seen through changes in the composition of lithic assemblages, and other aspects of the archaeological record such as raw material transfer distances, discussed in the following chapter. There is evidence of the appearance in Europe of handaxes, prepared cores and wooden tools in the Middle Pleistocene, shown in Figures 7.48-7.49 (pages 368-369), potentially supporting the argument that behavioural changes allowed a broader range of habitats to be inhabited. However, there was no significant relationship between the environment of the sites and the artefacts types present; therefore, no single technological innovation is associated with the occupation of a particular habitat. No significant patterning in the timing of other archaeological traits was found. Therefore, there is some evidence of physical and behavioural changes accompanying the occupation of new ecosystems, but the evidence is not conclusive. Adaptation driving spread into new habitats could support either an indigenous development or an influx of new groups of hominids during the Middle Pleistocene.

The final explanation for the pattern of environmental occupation over time relates to the processes of exploration and establishment of population during movements. The habitats occupied after the initial appearance of hominids in Europe may have been those that create more difficulties for survival, and therefore demand a higher level of knowledge of the area before large-scale settlement can take place. In this scenario, the habitats providing resources without knowledge of the area would be occupied first, and those that contained resources separated over long distances, or with greater problems of location, would be occupied only after a phase of exploration and knowledge building. Forests may present particular problems for locating resources as the dense vegetation cover obscures landmarks and results in difficulties in learning where resources are situated, and in the formation of pathways through the landscape (Kelly 2003). The small size of the majority of the sites in forest and alpine shrubland can thus be interpreted as an exploratory stage of occupation, without large populations or prolonged habitation. The explanation of increased diversity of habitats occupied over time by increasing local knowledge supports the growth in the number of sites in the Middle Pleistocene being caused by an increase in the indigenous population size, not the arrival of newcomers to Europe.

Habitat preferences.

Throughout the study period the majority of hominid sites were located in temperate woodland or temperate grassland/steppe conditions. These areas could represent the preferred habitat of hominids, due to their similarity to the habitats occupied before entry to Europe, or because of the favourable resource structure of these communities. Alternatively, these habitats may have been the most commonly occurring in Europe during the Early and Middle Pleistocene, resulting in their dominance of the environmental conditions encountered by hominids. This is supported by the evidence from the faunal sites, which also show the greatest number of sites occurring in temperate woodland or grassland, displayed in Figure 6.10. However, the sample of faunal sites was small and further investigation of the environments of Pleistocene Europe would be required to confirm these findings. The final possible explanation for this pattern is that for taphonomic reasons sites in temperate woodland or grassland are better preserved or more easily recovered than in other habitats. It is possible that sites have been destroyed in areas that experienced glaciation, which are likely to have contained taiga, cool temperate bog, alpine shrubland and temperate forests. Temperate woodland and grassland could therefore have been geographically biased towards areas that never underwent glaciation, and thus sites in these regions have been preserved. However, the entire lack of hominid presence in the less commonly occupied habitats during the Early Pleistocene, and the evidence for their habitation during the Middle Pleistocene undermines this argument, as some preservation must have been possible, and it seems unlikely that temporal factors would have affected preservation to this degree.

What hominid species were involved in the movement?

Hominid species data.

Information concerning the hominid species was available from only a small fraction of the sites in the database, as the vast majority are archaeological, and lack any hominid remains, or are faunal sites. However, since hominid fossils are deemed to be extremely important, the recorded occurrences of each species in the database is probably accurate, as hominid fossils are well published at all sites in which they occur. Therefore, despite only being associated with 16% of the sites in the database, the hominid species data can be regarded as accurate and representative of the species distribution spatially and temporally in Europe. Nevertheless, problems of controversial species attributions and unidentifiable fossils further diminish the strength of the hominid species data.

Chi-squared tests of the null hypothesis that hominid species were not related to date were invalid, but lambda tests rejected the null hypothesis at all levels of dating resolution and certainty of hominid presence. The strength of the relationship between species and date increased as resolution of the data improved, with lambda =0.5 (α=0.021) for definitely dated sites with definite hominid presence, as shown in Figure 6.13. Thus, the hominid species present at sites during major date categories reveal a strongly significant relationship between species and dates. A greater range of hominid species was identified at sites with poor dating resolution, presented in Figure 6.14. There was no relationship between the species present and date of a site in the oxygen isotope stage data, and lambda =0 for the definitely dated sample. This lack of a relationship between hominid species and date is explained by the small sample size of well-dated sites with hominid fossil remains and the lack of early sites at this level of dating resolution.

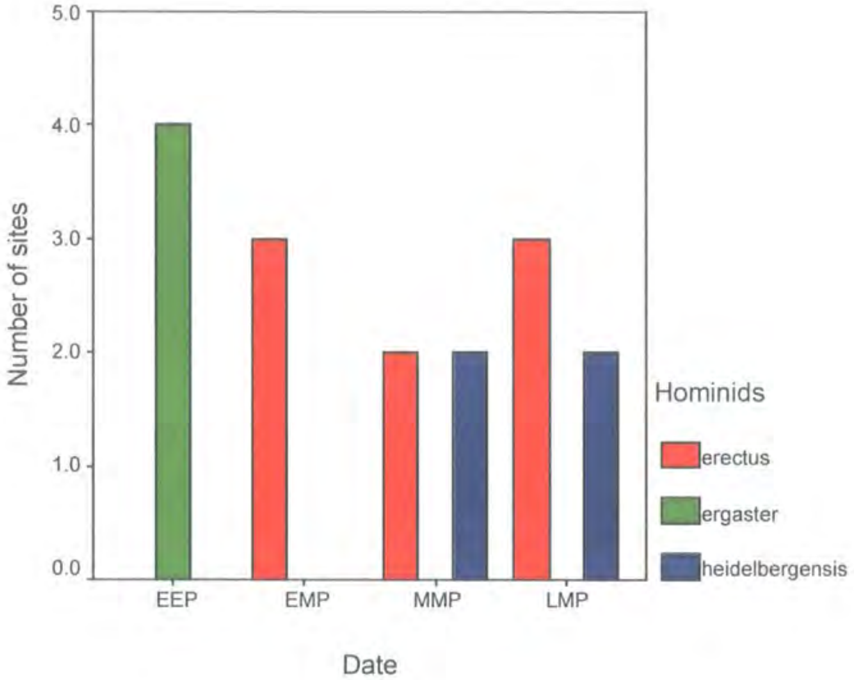


Figure 6.13. Chart showing the number of definitely hominid sites with occurrences of each hominid species, definitely dated to each major date category. N=16.

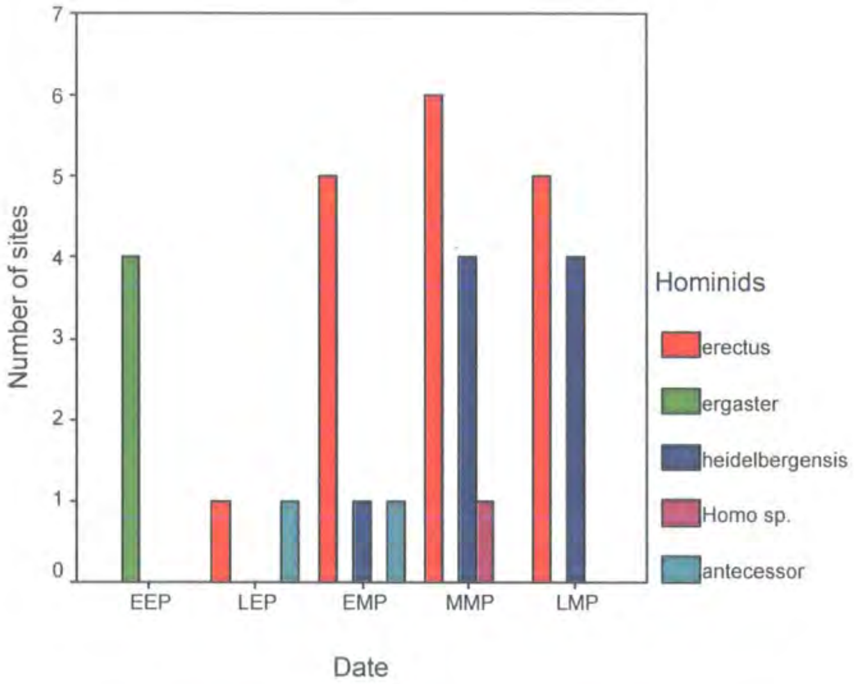


Figure 6.14. Chart showing the number of definitely hominid sites with occurrences of each hominid species, probably or definitely dated to each major date category. N=33.

Interpretation of the hominid species data.

The data regarding the species of hominid present in the study area during each period shows a strong relationship between the age of a site and the species present, shown in Figure 6.13 and Figure 6.14. However, these charts also highlight the presence of *Homo erectus* throughout the Early and Middle Pleistocene, resulting in *Homo heidelbergensis* and *Homo erectus* inhabiting Europe in the middle and late Middle Pleistocene, despite *Homo erectus sensu lato* forming an ancestor-descendent relationship with *Homo heidelbergensis* (Stringer and Hublin 1999; Rightmire 2001). This pattern is caused by the traditional assignment of Early and Middle Pleistocene fossils in southern Europe to *Homo erectus*, whereas similar material in northern Europe is usually attributed to *Homo heidelbergensis*. This tradition within anthropology creates the misleading picture of there being two distinct species present within Europe, which could be taken to support Foley's assertion that hominid species correlate with assemblage types, and thus two species are expected in Europe because Acheulean and non-handaxe assemblages occur during the Middle Pleistocene. However, given the high degree of subjectivity in species attribution, this pattern is more likely to be due to the traditional assignments of fossils to different species regionally across Europe. In addition, greater problems are raised by the recent trend of splitting hominid species and announcing new species, such as *Homo georgicus* for the Dmanisi material (Gabounia *et al.* 2002), and *Homo cepranensis* for the Ceprano cranium (Mallegni *et al.* 2003). In the analysis these new species were merged back into *Homo erectus*, because the majority of anthropologists do not accept the new designations (Manzi *et al.* 2001; Anton 2003; Gilbert *et al.* 2003). Nevertheless, regional trends in species attributions strongly bias the published record of the species present in Pleistocene Europe.

Despite all of these limitations in the small sample size and problems of attribution to species, these results imply that Middle Pleistocene hominids were significantly different to those in the early Early Pleistocene. These differences may have had implications for adaptation to conditions in Europe, and could be related to the spread of hominids into new regions of Europe, and their interaction with a broader range of environments and landscapes over time, as discussed above. Nevertheless, the only solid conclusion that can be drawn from the published record of the hominid species is that movement during the early Early Pleistocene involved *Homo erectus* or *Homo ergaster*, whereas dispersal in the late Early or early Middle Pleistocene concerned *Homo antecessor*, and in the middle Middle Pleistocene or later *Homo heidelbergensis*.

What patterns are seen in the timing of faunal extinctions and appearances?

Several potential problems emerged during the collection and analysis of the faunal data. Data concerning the species present at the sites in the study was available for a sample of sites only, although many of the sites lacking faunal data may not have contained bones due to preservation problems or a genuine absence of animals in the site during its formation. Further problems were encountered in the collection of the data concerning the origins of the species recorded, resulting in several species in the database being excluded from the analysis of the first appearance dates (FADs) and last appearance dates (LADs) and geographical origins. Moreover, the control sample of non-hominid faunal sites was extremely small in comparison to the archaeological database, producing problems in the calculation of valid statistical tests. Nevertheless, a substantial database of fauna at the sites was generated, and as the problems of data collection were related to individual sites rather than regions or time periods, the data can be treated as a representative sample of the fauna of the Early and Middle Pleistocene of Europe.

Two problems concerning the analysis of the data were caused by the collection methodology. The species present at non-hominid and archaeological sites were recorded, rather than the number of individuals present. This resulted in the quantity of each species at the sites being impossible to calculate, demanding measures of prevalence to be restricted to presence or absence, producing a measure of rarity versus ubiquity, not numerical dominance. FADs of species that evolved or dispersed into Europe before the start of the study period were recorded as falling within the early Early Pleistocene, and the LADs of the species that survived after the study were assigned to the late Middle Pleistocene. This resulted in an artificial inflation of the number of FADs and LADs in each of these periods respectively. Therefore, the data cannot be used to determine the level of faunal turnover in these periods, although inspection of the level of LADs in the early Early Pleistocene, and the number of FADs in the late Middle Pleistocene provides some evidence of turnover, because FADs and LADs usually co-occur in time (McKee 2001).

The first appearance dates and last appearance dates data.

The FADs and LADs of the species present in Europe and the entire study area were investigated, in order to establish the timing of periods of high levels of extinctions and appearances, forming faunal turnovers, which have been suggested to facilitate hominid spread into Europe.

Chi-squared tests of the patterning of FADs over time were conducted on the null hypothesis that there is no relationship between the FAD and major division of the Pleistocene. The tests were applied to all the fauna, and repeated excluding species with a FAD in the early Early Pleistocene, as this category included all species with a FAD in this period or earlier. The analysis was replicated excluding the species that only existed in North Africa or the Near East, in order to compare the trends within Europe to the whole study area. The chi-squared tests proved produced significant results for the entire study region and the European data, both including and excluding the species with a FAD in the early Early Pleistocene. Therefore, there is significant patterning in the timing of the FADs. The values of chi-squared were:
Entire study area excluding FADs in the early Early Pleistocene: $\chi^2=266.821$ ($\alpha=0$).
European species excluding FADs in the early Early Pleistocene: $\chi^2=38.06$ ($\alpha=0$).

Figure 6.15 and Figure 6.16 show the dates of the FADs for the fauna in the whole study area, compared to the fauna in Europe. These charts reveal that the late Early Pleistocene and middle Middle Pleistocene are the periods with the most FADs in Europe, and that the early Middle Pleistocene has a substantial number of species appearing outside of Europe. The middle Early Pleistocene and late Middle Pleistocene have relatively low levels of FADs. The level of FADs is very high in the early Early Pleistocene, but this may include the species that originated before the

Pleistocene, artificially inflating the number of species appearances, and therefore has not been shown in the graphs.

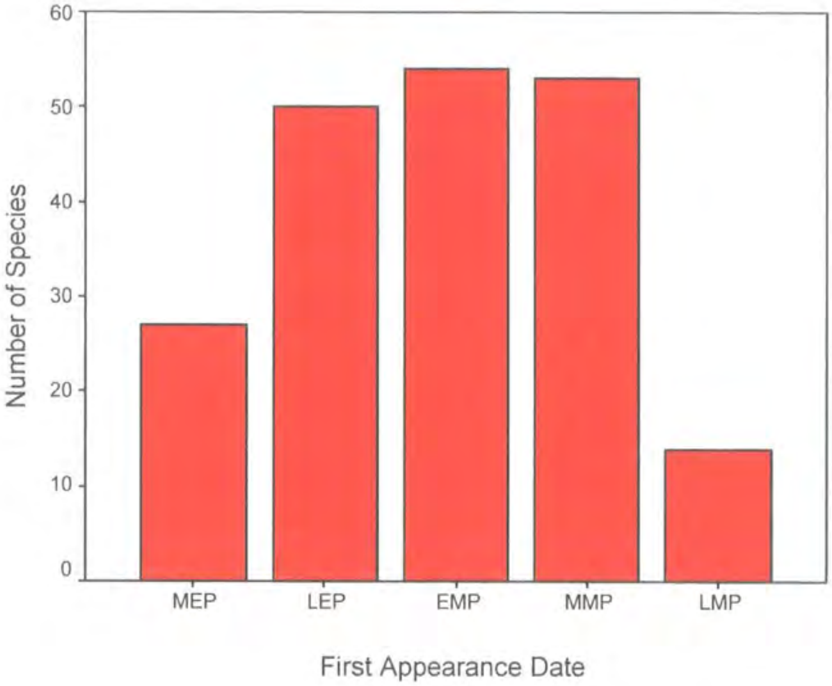


Figure 6.15. Chart showing the number of species with a FAD in each major date category, excluding the early Early Pleistocene, for all fauna in the study area. N=373.

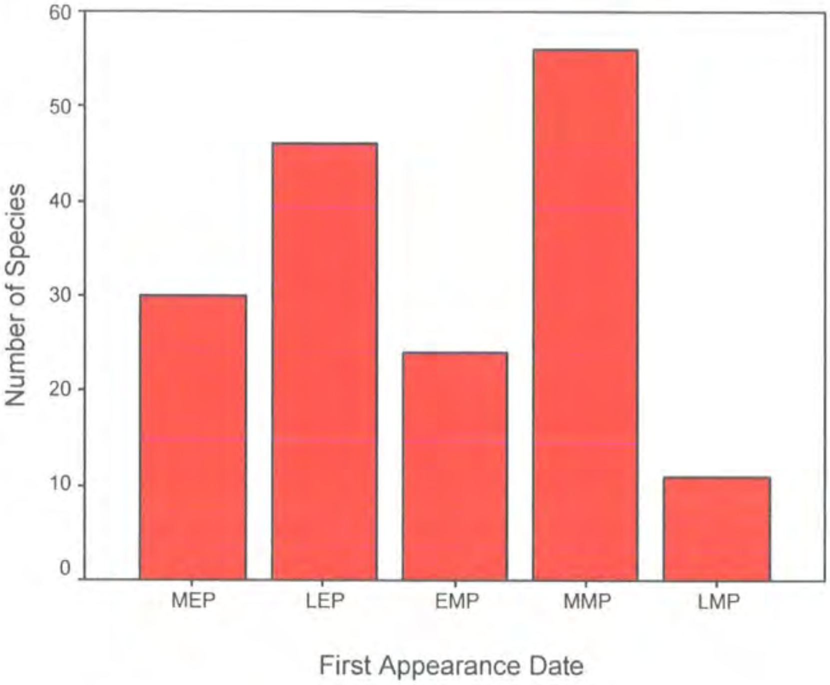


Figure 6.16. Chart showing the number of species with a FAD in each major date category, excluding the early Early Pleistocene, and excluding species that never appear in Europe. N=291.

The procedures used to investigate the FADs were replicated to test for patterning in the timing of LADs, with the use of the entire faunal data, and data excluding species with a LAD in the late Middle Pleistocene, because this category included all the species that survived beyond the study period, and thus skewed the data. The results of the chi-squared tests were significant in both Europe and the whole study area, including and excluding the species with a LAD in the late Middle Pleistocene. Therefore, there is a significant relationship between the major divisions of the Pleistocene and the number of LADs. The values of chi-squared were:
Entire study area excluding LADs in the late Middle Pleistocene: χ^2=283.083 (α=0).
European species excluding LADs in the late Middle Pleistocene: χ^2=27.642 (α=0).

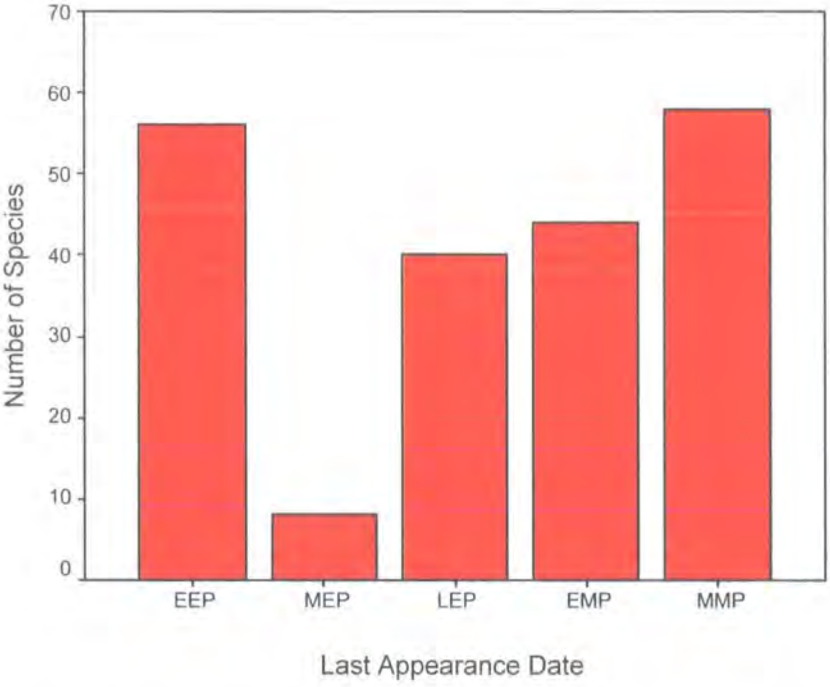


Figure 6.17. Chart showing the number of species with a LAD in each major date category, excluding the late Middle Pleistocene, for all fauna in the study area. N=373.

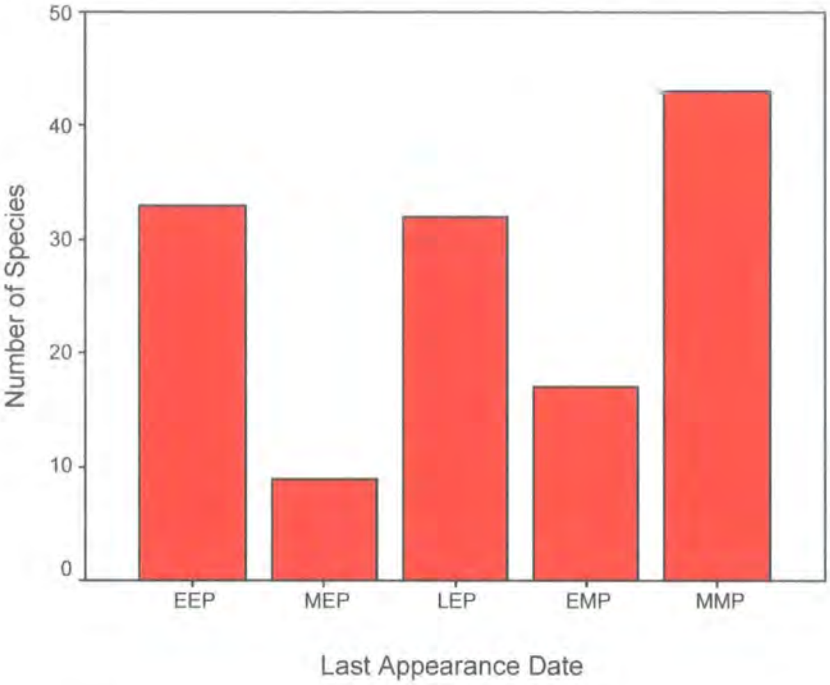


Figure 6.18. Chart showing the number of species with a LAD in each major date category, excluding the late Middle Pleistocene, and excluding species that never appear in Europe. N=134.

Figure 6.17 and Figure 6.18 display the number of species with a LAD in each major division of the Pleistocene in the whole study area and in Europe. These charts reveal that the early Early Pleistocene and the middle Middle Pleistocene were periods of major faunal extinctions. However, in Europe the late Early Pleistocene is also a time of substantial numbers of extinctions, whereas the early Middle Pleistocene has a lowered level of extinctions compared to the entire study area.

The null hypothesis that there is no relationship between the diet of an animal and its FAD was assessed using chi-squared and lambda tests, which produced no significant results for either the European or the entire faunal data, including or excluding the species with a FAD during the early Early Pleistocene. Therefore, there is no significant relationship between the date of the FAD and dietary type of a species. However, the patterning seen in Figure 6.19 and Figure 6.20 demonstrates that herbivores always dominated the FADs, and the omnivores were the least frequent. The highest proportion of omnivore and carnivore FADs were in the late Early Pleistocene and middle Middle Pleistocene.

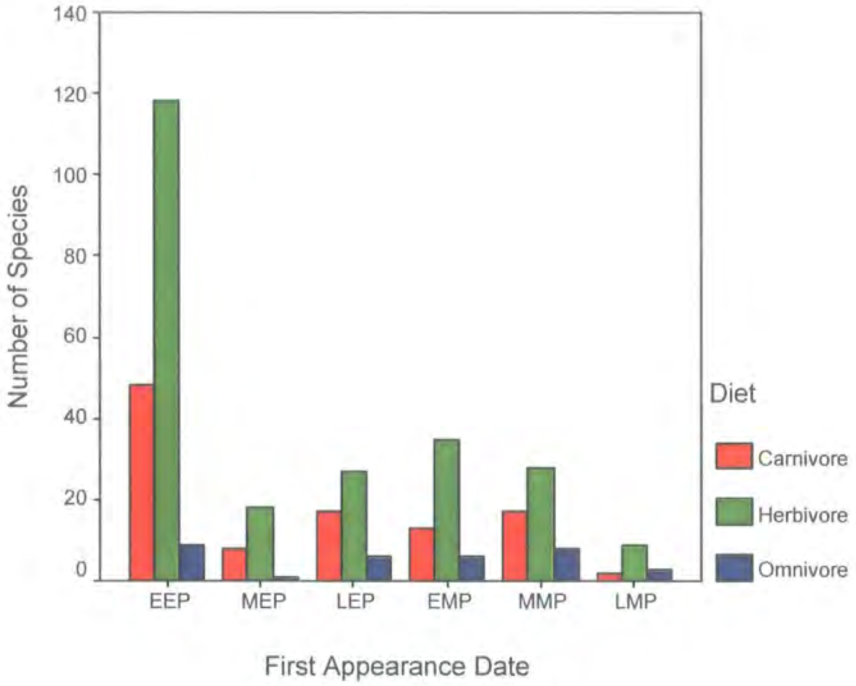


Figure 6.19. Chart showing the number of species with a FAD in each major date category, divided by dietary type, for all fauna in the study area. N=373.

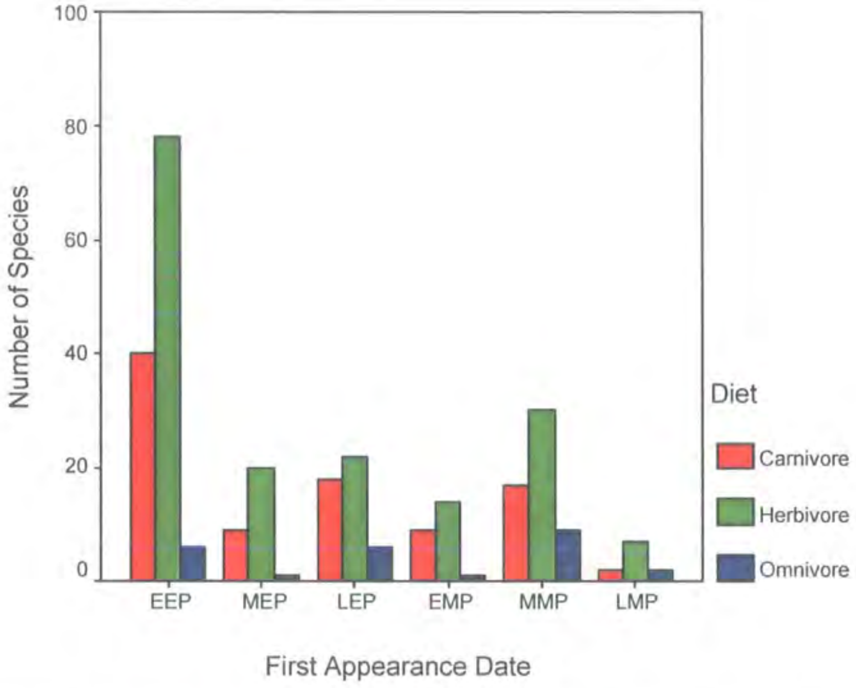


Figure 6.20. Chart showing the number of species with a FAD in each major date category, divided by dietary type, excluding species that never appear in Europe. N=291.

The null hypothesis that there is no relationship between the diet of an animal and its LAD was tested using chi-squared and lambda on the fauna in the entire study region and in Europe, which resulted in no significant relationships being seen in either the European or whole study area data, including or excluding species with a LAD in the late Middle Pleistocene. Therefore, there is no relationship between the diet of a species and the timing of its LAD. However, the peak numbers of LADs, shown in Figure 6.21 and Figure 6.22, are during the late Early Pleistocene and middle Middle Pleistocene. Moreover, the LADs are dominated by herbivores, as seen in the FADs data, except during the middle Early Pleistocene when more carnivores than herbivores become extinct. The early Early Pleistocene had particularly high levels of extinctions of herbivores, whereas later periods experienced more balanced patterns of extinctions. In comparison to the data from the entire study area, the European pattern of LADs shows little extinction during the early Middle Pleistocene, suggesting that turnover was happening outside of Europe.

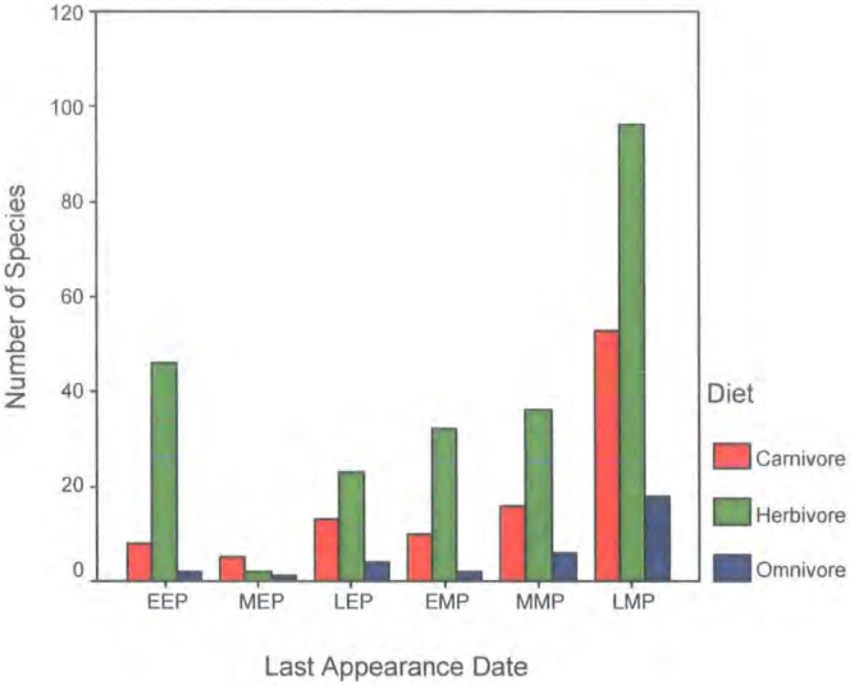


Figure 6.21. Chart showing the number of species with a LAD in each major date category, divided by dietary type, for all fauna in the study area. N=373.

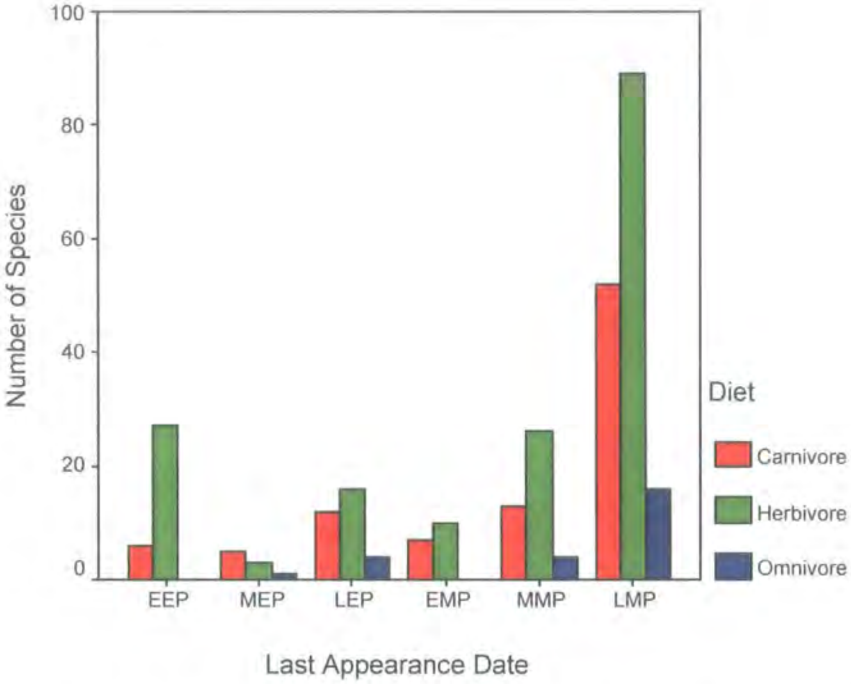


Figure 6.22. Chart showing the number of species with a LAD in each major date category, divided by dietary type, excluding species that never appear in Europe. N=291.

The patterning in the geographical origins of species was examined using chi-squared and lambda tests of the null hypothesis that there is no relationship between the area of origin of a species and its FAD, for all the species and for the European data. The results of these tests were invalid for chi-squared but lambda proved significant in the whole study area and in Europe, both including and excluding the early Early Pleistocene. The strength of the relationship was increased by removing the early Early Pleistocene sites, with lambda =0.247 (α=0) for all the fauna seen in Figure 6.23, and lambda =0.118 (α=0.049) for the European fauna illustrated in Figure 6.24. The patterning of African FADs was substantially different in Europe compared to the entire study area, with numbers of FADs falling through time to very low levels in the Middle Pleistocene, whereas in the whole study area the African FADs peaked in the early Middle Pleistocene. The greatest times of appearance of Asian fauna were during the late Early Pleistocene and middle Middle Pleistocene in the entire study area, whereas in Europe the Asian FADs were strongly concentrated in the middle Middle Pleistocene. The numbers of FADs of Eurasian fauna in Europe likewise increased over time, with the maximum in the middle Middle Pleistocene.

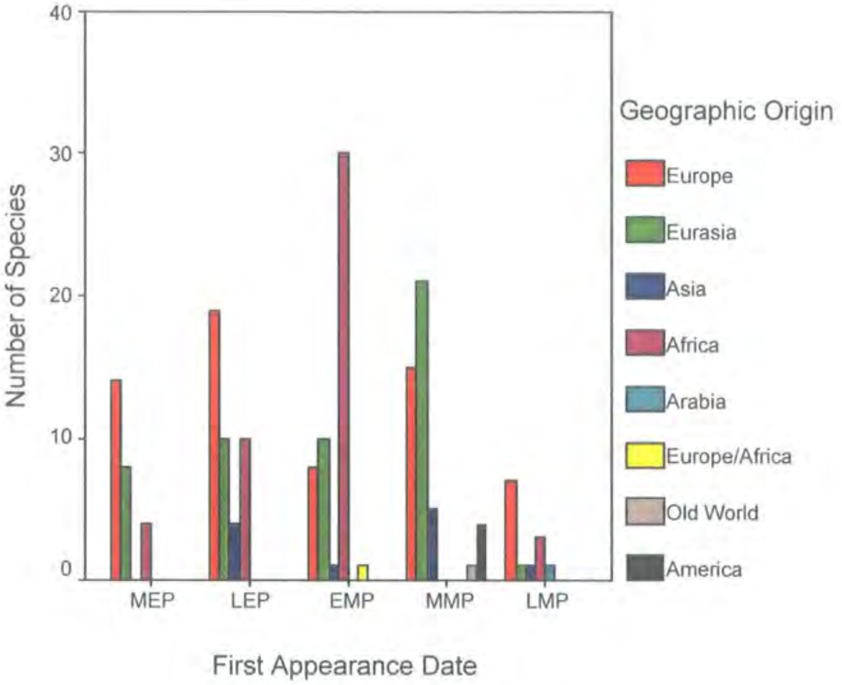


Figure 6.23. Chart showing the number of species with a FAD in each major date category, excluding the early Early Pleistocene, divided by geographical area of origin, for all fauna in the study area. N=178.

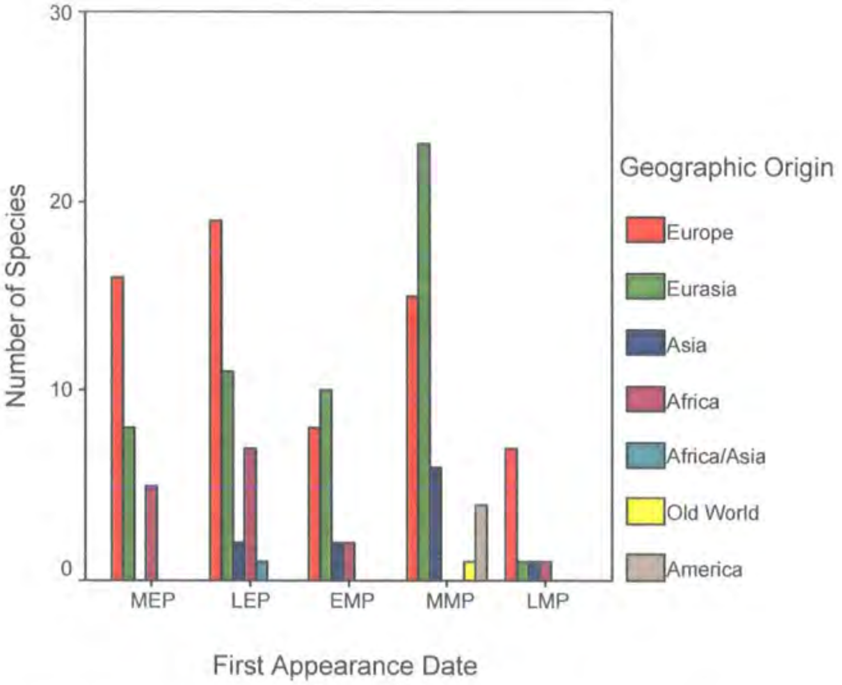


Figure 6.24. Chart showing the number of species with a FAD in each major date category, excluding the early Early Pleistocene, divided by geographical area of origin, excluding species that never appear in Europe. N=150.

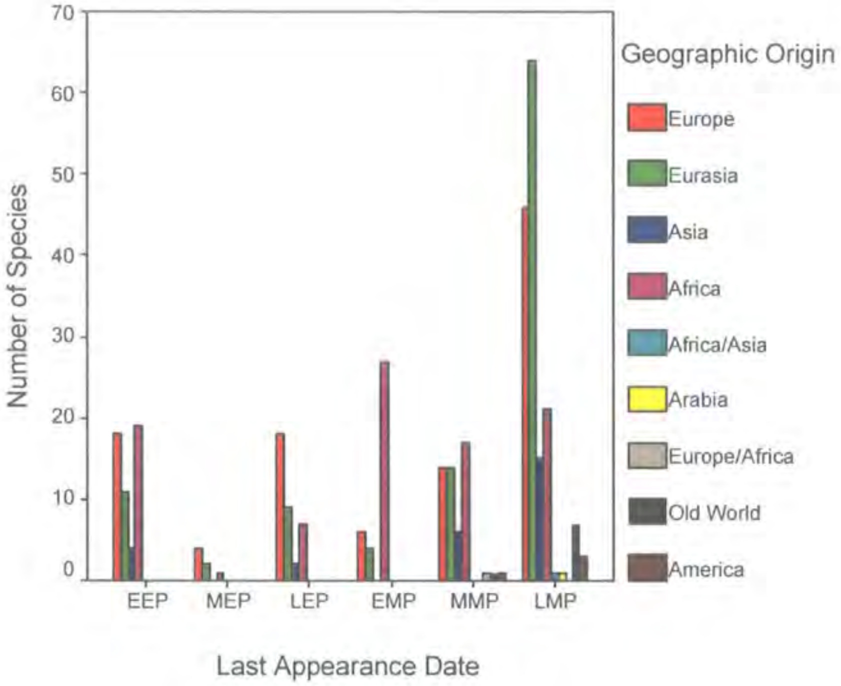


Figure 6.25. Chart showing the number of species with a LAD in each major date category, divided by geographical area of origin, for all fauna in the study area. N=344.

The null hypothesis that there is no relationship between the geographical area of origin of a species and the date of its LAD was tested using chi-squared and lambda for all the species and the European sample. Chi-squared tests were invalid but lambda proved significant for the entire study area, including and excluding the species with a LAD during the late Middle Pleistocene, with lambda =0.118 (α=0.004) for the sample including the late Middle Pleistocene, shown in Figure 6.25. However, the European fauna showed a weakly significant relationship only when the late Middle Pleistocene data was included, with lambda =0.073 (α=0.043), shown in Figure 6.26, suggesting that the relationship is dependent on the inclusion of all the species that survive after OIS 11, as well as those that became extinct during this period. Therefore, there is little evidence of a relationship between the geographical area of origin and the date of the LAD of species in Europe.

In comparison to the patterning in the entire study area shown in Figure 6.25, the European fauna seen in Figure 6.26 had few LADs of species of African origin during the early and middle Middle Pleistocene. This suggests that there is a significant faunal turnover happening in the early Middle Pleistocene outside of Europe.

Moreover, the proportion of African species becoming extinct compared to Asian species extinctions in Europe increases over time.

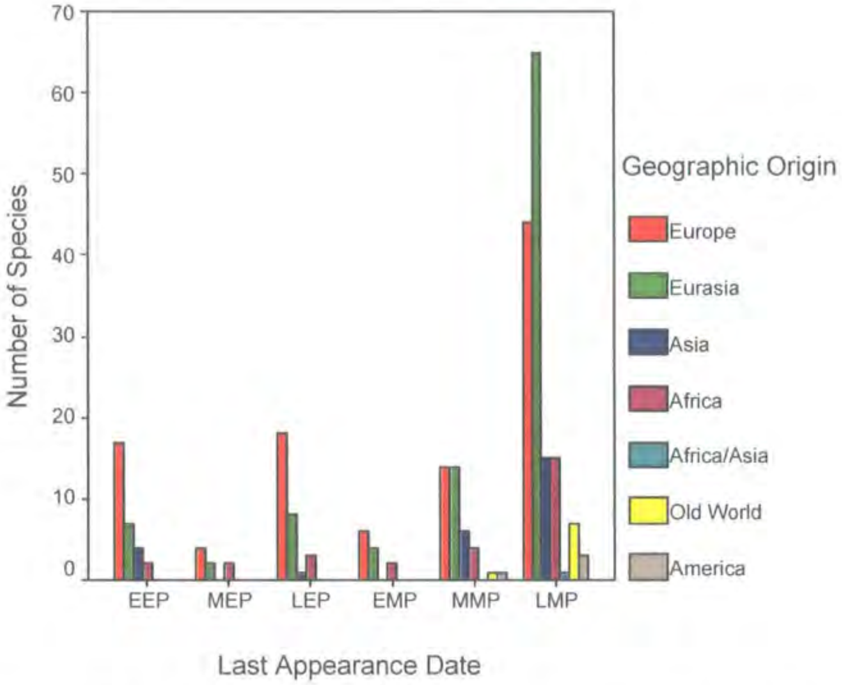


Figure 6.26. Chart showing the number of species with a LAD in each major date category, divided by geographical area of origin, excluding species that never appear in Europe. N=270.

Faunal turnover and opportunities for dispersal.

The timing of the FADs and LADs, shown in Figures 6.15-6.18, reveal that the early Early Pleistocene, the late Early Pleistocene and the middle Middle Pleistocene were the periods in which faunal turnover was greatest in Europe. The high level of LADs in the early Early Pleistocene allows the identification of the turnover despite the lack of the ability to use the FADs data. These three periods highlighted as times of high faunal turnover coincide with the potential times of hominid movements into Europe seen through the numbers of sites and nature of the lithic industries, supporting the idea that faunal turnover facilitated hominid entry to Europe, proposed by Rolland (1992).

An alternative explanation of the association between times of faunal turnover and increase in indicators of hominid presence in Europe, and the appearance of new behaviours, such as exploitation of new environments and the manufacture of new tool forms, is that the turnover opened niches exploited by the existing population in Europe. The initial group of hominids that arrived during the early Early Pleistocene may have increased in numbers and diversified in behaviours as a consequence of the extinction of competitors and arrival of new prey species and competitors, resulting in the increases seen in site numbers and ranges of behaviours in the late Early Pleistocene and middle Middle Pleistocene. Therefore, the patterning of the levels of FADs and LADs during the study period can reveal moments of opportunities for movement, but cannot definitively determine whether the response to these circumstances was the movement of new groups of hominids or a change in the behaviours of the existing groups in Europe.

The nature of the faunal turnover of Europe was further investigated with the aim of establishing whether certain types of species were involved in each event, and thus whether hominid arrival was associated with other species from either Africa or Asia in events such as the Galerian dispersal (Rolland 1992), or formed part of an event involving a dietary guild (Turner 1982). The results shown in Figures 6.19-6.22 establish that there is no significant patterning in the timing of FADs or LADs of the three dietary groups. However, omnivores and carnivores appear and become extinct in Europe in slightly higher than normal levels in the late Early Pleistocene and middle Middle Pleistocene, providing tentative support for a hominid movement during these periods associated with other carnivorous or omnivorous species, or a niche opening allowing movement.

The results of the investigation into the geographical origin of the species with FADs in each period, presented in Figures 6.23-6.26 show that the early period of faunal turnover is characterised by the appearance of African and indigenous fauna in Europe, whereas the two later episodes see the arrival of Asian and Holarctic, as well as native, fauna. This pattern increases in strength during the study period, and is reinforced by the patterning of the LADs, which reveals that the African species in Europe became extinct at greater rates than they were replaced, while Asian species died out less rapidly than they arrived. In summary, the nature of the Pleistocene fauna of Europe appears to become more Asian and European over time, with little or no presence of African species towards the end of the study period. Thus, if hominids did move into Europe during the three potential periods highlighted, in the early Early

Pleistocene movement with African species is plausible, in the late Early Pleistocene movement from either Africa or Asia is possible, and in the middle Middle Pleistocene movement from Asia is far more likely than from Africa, assuming that hominids did move as part of a faunal dispersal rather than alone. Furthermore, the faunal data show that hominid movements originating in Africa are decreasingly likely to be part of a dispersal event, whereas movement beginning in Asia is liable to be part of the movement of a set of species.

Hominid arrivals from Africa would have found conditions in Europe increasingly unfamiliar during the Early and Middle Pleistocene, providing greater problems for establishment and survival, whereas Asian hominids, particularly groups originating in temperate regions, would have entered a community increasingly similar to that at their origin. Although this data cannot be used to prove that early movements of hominids originated in Africa and later movements in Asia, it does reveal that later movements would have been independent of faunal dispersals if the hominids involved were African, which contradicts the model advocated by Rolland. Moreover, later movements originating in Africa would show that hominids had overcome the problem of ecological matching, and had gained the ability to survive and prosper in unfamiliar circumstances, given that the later events are marked by substantial evidence of hominid presence in Europe, discussed in the previous chapter, implying that the population was relatively large and well established. This finding supports the contention of Carbonell that significant behavioural advances were possessed by the hominids moving into Europe with Acheulean technology during the Middle Pleistocene.

A third possible interpretation of the patterns of the levels of FADs and LADs is that the levels of extinction and speciation may be driven by increases in the intensity of hominid occupation of Europe, rather than being the cause of increases in hominid presence. An increase in hominid occupation intensity could have repercussions for competitive and prey species, resulting in a restructuring of the faunal communities within Europe, leading to periods of high faunal turnover. These processes should involve a lag time between the increase in hominids and the speciations and extinctions driven by the pressures created. A lag time is not detected between the episodes of faunal turnover and increases in the proxies for hominid population size, which could prove that the hominid changes were part of a general turnover, rather than the cause of community restructuring. However, given the length of time in each division of the Pleistocene, it is likely that a possible lag time between hominid population increase and high levels of FADs and LADs cannot be detected. Thus, the possibility that hominids caused faunal changes cannot be dismissed until higher resolution dating is able to resolve whether the processes were contemporary or consecutive.

What types of species were present at sites with hominids?

Faunal community data from the Early and Middle Pleistocene in Europe.

The fauna that occurred at sites with evidence of hominid presence were studied, with the aim of determining the types of communities in which hominids survived. The proportion of the recorded species at each site that consisted of carnivores and omnivores was calculated. A Spearman's rank correlation test was used to establish whether a trend over time existed in the proportion of the species found at sites that were carnivorous, using the null hypothesis that there is no relationship between the date of a site and the proportion of the species represented at the site that were carnivorous. This test was repeated using the proportion of carnivores and omnivores combined, in order to investigate the total level of competition experienced by hominids. The results of the Spearman's rank correlation tests were insignificant for all of the datasets. Therefore, there is no relationship between the date of a site and the proportion of the fauna that were carnivorous or omnivorous.

The proportion of species from each geographical origin found at hominid sites in Europe was analysed, with the aim of revealing whether hominids occurred with species from a particular area, because hominid movement has been suggested to form part of faunal dispersals originating in either Africa or Asia. The investigation was limited to assemblages found in Europe, excluding the Caucasus. The proportion of the species found at each site that originated in Africa, Asia, and America, or were indigenous was calculated. The indigenous sample included species with an origin in either Europe or Eurasia. Species with an origin in the Old World, Africa/Asia, and Europe/Africa, or had an unknown origin were excluded from the analysis because the data was considered too imprecise. The null hypothesis that there is no relationship between the proportion of African fauna at a site and the date of the site was tested using chi-squared, lambda and Spearman's rank correlation tests. This procedure was repeated using the Asian, American and indigenous proportions of fauna.

The results of the chi-squared test of the null hypotheses that there is no relationship between the date of a site and the proportion of African, Asian, American or indigenous fauna in its assemblages were invalid in all cases. However, the results of the lambda test of the African fauna proved significant for all assemblages dated to major divisions of the Pleistocene, except those with definite evidence of hominids and definite dates. Lambda was also significant in the oxygen isotope stage data when the probably dated assemblages were included. The values of lambda were low, with the maximum value =0.132 (α=0.008) for all potentially hominid sites, definitely dated to major divisions of the Pleistocene. The results of the Spearman's rank correlation were only significant in the datasets including all potentially or probably hominid sites with probable dates to either major divisions of the Pleistocene or oxygen isotope stages. The greatest value of Spearman's rank correlation= -0.223 (α=0.012), for the data from probably hominid sites with uncertain oxygen isotope stage dates. Therefore, there is a weakly significant patterning in the levels of species of African origin in European archaeological sites, with a trend for the proportion to decrease over time.

The results of the analysis of the proportion of American fauna in the European assemblages provided significant results of lambda for the definitely dated sites in the major divisions of the Pleistocene, and for all the datasets with oxygen isotope stage dates. The strongest values of lambda were in the definitely dated oxygen isotope stage datasets, with values =0.235 (α=0.034) at all levels of confidence of hominid presence. The Spearman's rank correlation tests produced significant positive results in the definitely dated oxygen isotope stage data only, with values =0.392 (α=0.018) at all levels of confidence of hominid presence. Thus, there is a significant relationship between the date of a site and the proportion of the fauna that originated in the Americas at the site. The trend in the proportion of American fauna in European sites is positive, because these species only appear in Europe in the middle and late Middle Pleistocene, as shown in Figure 6.24.

The analysis of the proportion of Asian fauna in European assemblages produced significant values of lambda for the oxygen isotope stage data with probable dates, and for the major divisions of the Pleistocene data at definitely hominid sites with either probable or definite dates. The strongest value of lambda =0.107 (α=0.044) for the definitely hominid sites with definite dates to major divisions of the Pleistocene. The results of the Spearman's rank correlation only produced significant results in one case, when the data included all the potentially hominid sites definitely dated to major divisions of the Pleistocene, with a value =0.218 (α=0.024). Therefore, there is a weak but significant relationship between the date of a site and the proportion of Asian fauna in the assemblage; however, there is little evidence of a directional trend in the proportions of Asian fauna over time at European sites.

The proportion of indigenous fauna in assemblages at European archaeological sites shows no significant values of Spearman's rank correlation test, with the exception of the data including probably hominid sites with probable dates to either the major divisions of the Pleistocene or oxygen isotope stages. However, the values of Spearman's rank correlation are low, with a maximum value =0.247 (α=0.002) for the major divisions of the Pleistocene data. Therefore, there is a weak trend towards an increase in the proportion of indigenous fauna in European sites over time, which is insignificant in the majority of the data. The results of the lambda test were significant in all cases except for the definitely hominid sites with definite dates to the major divisions of the Pleistocene. Nevertheless, the values of lambda were small, with a maximum =0.171 (α=0.011) for all the datasets with definite oxygen isotope stage dates. Thus, there is a significant but weak relationship between the proportion of indigenous fauna and the dating of European sites.

Hominid interactions with the faunal community.

The proportion of species at the hominid sites that were carnivorous or omnivorous was found to remain steady throughout the study period. This could be interpreted to mean that the ability of hominids to cope with competition from other carnivores and omnivores was also constant throughout the Early and Middle Pleistocene in Europe. In all periods some sites had a high level of representation of carnivores and omnivores, suggesting that hominids had the ability to overcome high levels of competition from the time of their first arrival in Europe. This could in turn imply that hominids were immune to the effects of competition, and thus had already escaped from ecological constraints on movement and settlement patterns by the early Early Pleistocene. This interpretation undermines the association of hominid movement with periods of ecological opportunities caused by high levels of faunal turnover, discussed above, because it appears that hominids were unaffected by competition levels and should have possessed the ability to occupy Europe without waiting for moments of ecological instability to facilitate spread. This also counters the suggestion that hominid ability to move independently of other species increased during the study period, as the ecological constraints operating on hominids appear to have been constant.

However, the vast majority of the faunal assemblages at hominid sites are dominated by herbivorous species; those sites with a dominance of carnivores or omnivores can thus be seen as anomalous. The lack of data concerning the number of individuals of each species creates the problem of determining whether carnivores and omnivores actually dominated the faunal assemblages of these sites, or whether there are several carnivorous or omnivorous species represented at low levels and few herbivorous species with high numbers of individuals present, as would be expected in a stable ecological community. Moreover, the sites with high proportions of carnivorous species may contain very few faunal remains, and thus the carnivores could only be represented by one bone. This problem cannot be resolved using the data collected, and as detailed reports of the fauna present are not available for the overwhelming majority of European Lower Palaeolithic archaeological sites, refining the data collection methodology would not resolve this limitation. Reanalysis of the faunal assemblages from the archaeological sites would be necessary to resolve this issue, and is beyond the scope of this study. Nevertheless, carnivores and omnivores are usually rare in faunal communities because of their high position in the trophic pyramid, hence their representation in hominid sites is liable to be at low levels, and a large range of such species at sites may well indicate higher than normal levels of competition. However, as the majority of sites in all periods are dominated by herbivores, it appears that hominids generally avoided high competition environments, and that the ability to cope with competition in Europe did not increase or decrease during the study period.

The proportion of the number of species at hominid sites that originated in each geographical region mirrors the patterning of the FADs and LADs. African species decrease as a proportion over time, while indigenous species increase and Asian species remain at a constant level. The presence of American species during the middle and late Middle Pleistocene reflects the Holarctic nature of the fauna in Europe at the end of the study period, which had become increasingly characterised by species adapted to the climatic cycles of the Middle Pleistocene, particularly the colder conditions than the preceding periods. These species were *Canis latrans* (coyote), *Cervus canadensis* (moose), *Mustela erminea* (stoat) and *Lynx pardina* (lynx). Although it possible that these species have been incorrectly identified, particularly *Cervus canadensis*, which may be Eurasian *Alces sp.* (elk), the simultaneous appearance of American species in a single period of the Pleistocene implies that this pattern is genuine, and is related to the formation of the Eurasian cold adapted fauna of the "mammoth steppe" (Guthrie 1990).

The correspondence between the data from the FADs and LADs and the proportion of species represented at sites supports the use of the proportion of the species present as a proxy for the composition of the faunal assemblages in the absence of more detailed information. Furthermore, this similarity between the datasets suggests that a representative cross-section of the faunal community was present in hominid sites, and therefore that hominids were not seeking out any particular types of species. This undermines the argument that hominids moved as part of a faunal guild, and occurred with species from the same geographical origin. Thus, hominids appear to be fully integrated into the European faunal communities of the Pleistocene.

What genera were present or absent at hominid sites in Europe?

The faunal assemblage data.

The numbers of sites with evidence of each genus in the major date categories are presented in Tables 6.1-6.4. The data used included assemblages dated at the probable or definite level of certainty, because the majority of the non-hominid sites could not be assigned a definite date, and the analysis required the faunal control sample. Statistical comparisons between the assemblages at faunal and hominid sites were not used because the small sample size of faunal sites resulted in no valid results. These tables allow comparison of the genera found in hominid and faunal assemblages, providing a list of fauna that were not associated with hominids in Europe and thus did not contribute to the processes of movement into Europe during the Pleistocene. The tables also allow the identification of the genera that were often found in hominid sites, and therefore may have been associated with hominid success in moving into and surviving in Europe. Table 6.1 presents the number of faunal sites with an occurrence of each genus, Table 6.2 shows the genera present in the possible archaeological sites, Table 6.3 displays the fauna in the probable archaeological sites, and Table 6.4 exhibits the genera found in definite hominid sites.

	Date						
Genus	EEP	MEP	LEP	EMP	MMP	LMP	Total
Acinonyx			1				1
Alces		2	1	4	2		9
Anancus	4						4
Aonyx	1						1
Bison		2	2	8	5		17
Bos				2		1	3
Bovini		1	1		2		4
Canis	6	8	7	3	1		25
Capra				1			1
Capreolus	3	4	1	2	2		12
Castor	2	1	1				4
Cervidae	2	1	2				5
Cervus	3	6		7	3	1	20
Coelodonta					1		1
Crocuta		1	1	1	2		5

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Croizetoceros	2						2
Cuon				1			1
Dama	2	1	1	3			7
Elephantidae				1	1		2
Elephas		2		1			3
Eobison		1	1				2
Equus	12	13	13	16	12		66
Eucladoceros	8	1	4	3	2		18
Felis				2	1		3
Gazella	4						4
Gazellospira	2						2
Giraffa	1						1
Gulo					1		1
Hemitragus	2			1	1		4
Hippopotamus	1	5	7	5	1		19
Homotherium	1	1	3	2			7
Hyaena	1				1		2
Hyaenidae				1			1
Leptobos	5	4	7	1			17
Lutra				1			1
Lynx		1	2	1	1		5
Macaca		1	2	1			4
Mammuthus	7	10	12	9	6		44
Martes				1			1
Megaloceros		7	5	14	10		36
Megantereon		1	2				3
Meles			1		1		2
Mustela	2	2		1	1		6
Nyctereutes	1						1
Ovibos	1						1
Ovis	1						1
Pachycrocuta	3	3	3		1		10
Palaeoloxodon				4	2		6
Pannonictis		1	1	1			3
Panthera	2		1	2	1		6
Praeovibus					1		1
Pseudodama		4	4				8
Puma			1				1
Rangifer					1		1
Soergelia				1	2		3
Stephanorhinus	1	9	10	9	4		33
Sus		3	3	1	2		9
Trogontherium	1	1				1	3
Ursus	2	6	4	1	1	1	15
Vulpes	1	2	1		2		6
Total	84	105	105	112	74	4	484

Table 6.1. The number of non-hominid sites during each major date category containing each genus.

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Acinonyx	1	2					3
Alces		1	1		6		8
Anancus	1						1
Bison	1	1	2	5	26	17	52
Bos	1	2	1	1	12	22	39
Bovini	5	2	2		9	21	39
Bubalus	1					1	2
Canidae					1	1	2
Canis	5	2	3	3	30	24	67
Capra	1			1	4	7	13
Capreolus			1	1	14	17	33
Caprini	2	1			1		4
Castor					9	11	20
Cervidae	3		1	3	10	17	34
Cervus	6	3	5	2	41	44	101
Coelodonta						2	2
Crocuta	1		1	4	13	5	24
Cuon	1			1	5	2	9
Dama	1	2	1	4	17	25	50
Dinobastis					1	1	2
Elasmotherium					1		1
Elephantidae					8	12	20
Elephas			1	2	4	3	10
Equus	9	6	3	5	54	45	122
Eucladoceros	3	1	1	1	1	1	8
Euryboas	1						1
Felis	1		2	2	10	7	22
Gulo					1	1	2
Hemitragus	4	3	2	2	6	4	21
Hippopotamus	3	2	2	4	15	8	34
Homotherium	3		3	2	6	1	15
Hyaena			1	1	2	2	6
Leptobos	2	1	1				4
Lutra					1	3	4
Lynx	3	2	1	2	8	5	21
Macaca	1	1	1	1	6	8	18
Machairodontinae			1		2	1	4
Mammuthus	7	4	7	4	14	5	41
Martes					3	6	9
Megaloceros	5	4	2	6	28	15	60
Megantereon	4	2					6
Meles	1			1	7	6	15
Mustela			1	1	13	7	22
Mustelidae					1	2	3
Ovibos	1	2				1	4
Ovis					3	1	4
Pachycrocuta	3	3		3	4		13

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Palaeoloxodon			1	6	21	32	60
Panthera	3	4	3	5	24	20	59
Praealces					1	1	2
Praedama					1	1	2
Praeovibus			1		2		3
Rangifer			1		5	3	9
Rhinocerotidae						2	2
Rupicapra					1	1	2
Selenarctos						1	1
Soergelia	2		1				3
Stephanorhinus	7	4	3	9	46	53	122
Sus	2	1	1	3	19	21	47
Theropithecus	1	1					2
Trogontherium	1	1			3	9	14
Ursus	6	4	3	7	39	29	88
Viretailurus	1	1					2
Vulpes	2	2	1	4	11	7	27
Xenocyon	2	1			2		5
Total	108	66	62	96	572	541	1445

Table 6.2. The number of all potentially hominid sites in each major date category containing each genus.

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Alces					6		6
Bison			1	5	25	17	48
Bos	1	1	1	1	12	22	38
Bovini	2	1	1		9	21	34
Bubalus						1	1
Canidae					1	1	2
Canis			1	3	30	24	58
Capra				1	4	7	12
Capreolus			1	1	13	17	32
Caprini					1		1
Castor					9	11	20
Cervidae	2		1	3	10	17	33
Cervus	1	1	1	2	39	44	88
Coelodonta						2	2
Crocuta			1	4	13	5	23
Cuon				1	5	2	8
Dama			1	4	17	25	47
Dinobastis					1	1	2
Elasmotherium					1		1
Elephantidae					8	12	20
Elephas			1	2	4	3	10
Equus	2	1	2	3	52	45	105

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Eucladoceros			1	1	1	1	4
Felis			1	2	10	7	20
Gulo					1	1	2
Hemitragus	2	1	1	2	6	4	16
Hippopotamus	2	1	1	4	15	8	31
Homotherium	1		2	2	6	1	12
Hyaena				1	2	2	5
Lutra					1	3	4
Lynx			1	2	8	5	16
Macaca				1	6	8	15
Machairodontinae					2	1	3
Mammuthus	3	1	4	4	13	5	30
Martes					3	6	9
Megaloceros	2	1	2	6	28	15	54
Megantereon	1	1					2
Meles				1	7	6	14
Mustela			1	1	13	7	22
Mustelidae					1	2	3
Ovibos						1	1
Ovis					3	1	4
Pachycrocuta				3	4		7
Palaeoloxodon			1	6	21	32	60
Panthera			2	5	24	20	51
Praealces					1	1	2
Praedama					1	1	2
Praeovibus					2		2
Rangifer			1		5	3	9
Rhinocerotidae						2	2
Rupicapra					1	1	2
Selenarctos						1	1
Soergelia	1		1				2
Stephanorhinus	1	1	3	9	45	53	112
Sus			1	3	19	21	44
Trogontherium					3	9	12
Ursus	1	1	1	7	38	29	77
Vulpes			1	4	11	7	23
Xenocyon					2		2
Total	22	11	37	94	563	541	1268

Table 6.3. The number of probably hominid sites in each major date category containing each genus.

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Alces					3		3
Bison			1	5	21	15	42
Bos	1	1		1	11	21	35

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Bovini	1	1			9	21	32
Bubalus						1	1
Canidae					1	1	2
Canis			1	3	25	24	53
Capra				1	4	6	11
Capreolus			1	1	11	17	30
Caprini					1		1
Castor					6	10	16
Cervidae				3	10	17	30
Cervus	1	1	1	2	33	40	78
Coelodonta						1	1
Crocuta			1	3	11	5	20
Cuon				1	5	2	8
Dama			1	3	16	25	45
Dinobastis					1	1	2
Elasmotherium					1		1
Elephantidae					8	12	20
Elephas				2	4	2	8
Equus	1	1	1	3	44	42	92
Eucladoceros			1	1	1	1	4
Felis			1	2	10	7	20
Gulo					1	1	2
Hemitragus	1	1		2	5	4	13
Hippopotamus	1	1		3	12	7	24
Homotherium			1	2	4	1	8
Hyaena				1	2	2	5
Lutra					1	3	4
Lynx			1	2	8	5	16
Macaca				1	6	8	15
Machairodontinae					2	1	3
Mammuthus	1	1	2	3	9	4	20
Martes					1	6	7
Megaloceros	1	1	1	4	25	14	46
Megantereon	1	1					2
Meles				1	6	6	13
Mustela			1	1	10	7	19
Mustelidae					1	2	3
Ovibos						1	1
Ovis					3	1	4
Pachycrocuta				2	3		5
Palaeoloxodon				5	20	29	54
Panthera			1	5	20	20	46
Praealces					1	1	2
Praedama					1	1	2
Praeovibus					2		2
Rangifer					4	3	7
Rhinocerotidae						2	2
Rupicapra					1		1

Genus	Date						Total
	EEP	MEP	LEP	EMP	MMP	LMP	
Selenarctos						1	1
Stephanorhinus	1	1	2	8	39	48	99
Sus			1	3	18	20	42
Trogontherium					1	9	10
Ursus	1	1	1	7	31	28	69
Vulpes			1	4	9	7	21
Total	11	11	21	85	482	513	1123

Table 6.4. The number of definitely hominid sites in each major date category containing each genus.

The patterns in the prevalence of genera at the non-hominid sites seen in Table 6.1 reveal that Equus is the most common, and Mammuthus is the second most common genus throughout the study period. The most commonly occurring carnivore is Canis in all periods. The other genera that are widespread in non-hominid sites are Cervids, and in the Middle Pleistocene, Bos, Bison and Megaloceros. Ursus occurs in many sites in the middle Early Pleistocene only.

In the hominid sites, Equus and Cervids are also frequently found throughout the study period, although Equus is not the most common genus in all periods. Mammuthus is widespread in the early Pleistocene. In several periods Panthera is as prevalent as Canis, as the most widespread carnivores, and thus Panthera is more frequent at hominid sites than non-hominid sites. Megaloceros, Bos and Bison are also moderately common, and the bovids are found at a higher proportion of sites than in the non-hominid sample. The genera that appear in many hominid sites, which are not widespread in non-hominid sites, are Stephanorhinus and Ursus throughout the study period, and Palaeoloxodon in the Middle Pleistocene. In the late Early Pleistocene, Homotherium is also more frequent in hominid sites than in non-hominid sites. Changes in the certainty of hominid presence affect the rank order of the most prevalent genera in each period, but the same genera persistently form the most widespread groups of fauna, whereas the more rare genera tend to be removed from the higher resolution sample. The genera that are always widespread in hominid sites of all ages are Bos, Bison, Cervus, Equus and Stephanorhinus. The genera that become increasingly common at hominid sites over time are: Canis, Palaeoloxodon, Ursus, Equus, Panthera and Dama.

Hominid interactions with the genera of fauna in Europe.

The genera recovered at hominid and faunal sites were investigated with the aim of discerning whether any types of species were sought out or actively avoided by hominids, and whether particular types of species can be identified as moving with and forming an association with hominids. The low number of faunal sites compared to the number of archaeological sites resulted in a statistical approach to these questions being impossible to follow because the sample size of the faunal control group was too small to produce valid comparisons. The problems of sample size were compounded when the higher resolution dating and hominid presence data was used, because this excluded much of the archaeological material, further reducing sample sizes and removing the rarer genera from the study. The approach taken was to compare the presence or absence of each genus in the archaeological and faunal assemblages of each period, and then compare the genera that were the most widespread, in order to determine whether similar levels of prevalence of each genus occurred in the two datasets. However, this approach again suffered from the problem of the data recording presence or absence but not overall quantities of individuals at each site, and thus measures ubiquity not quantity. Nevertheless, this data provides a guide to the nature of the fauna that hominids interacted with in Europe during the Pleistocene, and therefore generates insights into the ecological role of hominids and the types of species with which they may have formed part of a dispersing group.

The problem of the small sample size of the faunal assemblages is illustrated by the number of genera found in unlikely archaeological but not faunal sites: *Bubalus* (water buffalo), *Dinobastis* (sabre-toothed cat), *Elasmotherium* (rhinoceros), *Euryboas* (hyena), *Praealces* (elk), *Praedama* (deer), *Rupicapra* (chamois) and *Selenarctos* (Asian black bear). These genera are found at a maximum of two sites throughout the study period; therefore, their absence from non-hominid sites can probably be explained by their rarity. *Xenocyon*, a large canid, can be added to this list, as it is only identified at five unlikely or probably hominid sites, never at non-hominid sites.

Genera not associated with hominids in Europe.

Aonyx (clawless otter), *Croizetoceros* (deer), *Eobison* (bovid), *Gazella* (gazelle), *Gazellospira* (gazelle), *Giraffa* (giraffe), *Nyctereutes* (raccoon dog), *Pannonictis* (mustelid), *Pseudodama* (deer) and *Puma* (puma) were identified as the genera that are present in faunal sites but never at hominid sites, at any level of certainty of hominid presence. These genera are found in Europe only in the Early Pleistocene, with the exception of *Pannonictis*, which survived until the early Middle Pleistocene, and the majority became extinct in Europe during the early Early Pleistocene. Therefore, the absence of these genera in hominid sites may be due to their pre-dating the presence of hominids in the majority of Europe. Alternatively, these genera may have been genuinely avoided by hominids. However, the majority of these genera are herbivores, only *Aonyx*, *Nyctereutes*, *Pannonictis* and *Puma* were carnivorous; therefore, it seems unlikely that hominids would avoid herbivorous prey species, especially as these herbivores were not particularly large bodied or dangerous. Alternatively, these genera may have avoided the hominids, as a dangerous predator.

Acinonyx (leopard), *Anancus* (mammoth), *Euryboas* (hyena), *Leptobos* (antelope), *Theropithecus* (baboon) and *Viretailurus* (panther) are the genera that only occur in unlikely hominid or faunal sites. These genera all became extinct before or during the late Early Pleistocene, and their absence from more certainly hominid sites can be explained by their early dates. Alternatively, their rarity could cause their absence in probably or definitely hominid sites, as none of these genera appear at more than four sites in the study period. They may be added to the list of fauna not found in hominid sites, which could have avoided, or been avoided by, hominids, and were not associated with the movement of hominids into Europe.

Soergelia (bovid) and *Xenocyon* (large canid) have never been recovered from definite hominid sites, and may be added to the list of fauna that were not associated with hominid dispersal. These genera are relatively rare, appearing at a maximum of five sites, and thus their absence from definitely hominid sites may be due to sampling effects of rare groups in small datasets. *Soergelia* disappears from the dataset at the end of the Early Pleistocene, hence its absence from more definitely hominid sites may be explained by its early dating; however, *Xenocyon* occurs in the Middle

Pleistocene, and thus was contemporary with undoubted hominid occupation of Europe.

In summary, there are a total of eighteen genera that are definitely or potentially never found at hominid sites, of which ten are herbivorous and six are carnivorous. Only two of these genera persisted into the Middle Pleistocene, and therefore are contemporary with significant hominid presence in Europe, both of which are carnivores and may have been avoided. Thus, the herbivores that are never found at hominid sites may all be absent due to their dating to periods before hominids were widespread in Europe, combined with their rarity, these genera would not be expected to be present in many archaeological assemblages.

Genera associated with hominids in Europe.

The patterning within the numbers of sites at which the genera occur was examined with the aim of determining whether particular types of species were sought out by hominids. This investigation was particularly affected by the problem of the limitation of the data to the presence or absence of each genus, rather than the levels of abundance within sites. However, the data does reveal the genera that were commonly present at hominid or faunal sites, and which were found at unexpectedly large numbers of archaeological sites compared to the faunal control sample. The genera commonly found at hominid sites were: *Equus* (horse), *Cervus* (deer), *Mammuthus* (mammoth), *Canis* (dog), *Panthera* (cat), *Megaloceros* (giant deer), *Bos* (auroch), *Bison* (bison), *Stephanorhinus* (woolly rhino), *Ursus* (bear), *Palaeoloxodon* (woolly mammoth) and *Homotherium* (sabre-toothed cat). In general, these genera were also represented in large numbers of faunal sites, and therefore represent a normal cross section of the faunal community present in Europe.

The genera that were found at higher than expected numbers of archaeological sites were: *Stephanorhinus*, *Ursus*, *Palaeoloxodon*, *Homotherium* and *Panthera*. These may have been actively sought out by hominids or may have shared a set of ecological requirements resulting in their co-habitation of the same areas within Europe, in the temperate grassland steppe and temperate woodland ecosystems which were the environments most inhabited by hominids, shown by Figures 6.5-6.7. Alternatively, the small sample of faunal assemblages against which the archaeological fauna was compared, may have resulted in the chance under-representation of these genera in the control group, and these patterns would therefore not be meaningful. Nevertheless, the particular genera that were over-represented at hominid sites have ecological and behavioural implications for hominids. *Stephanorhinus* and *Palaeoloxodon* are particularly large bodied herbivores, which may have been sought out as especially rich subsistence sources, either by scavenging carcasses or actively hunting these animals. *Ursus* may be over-represented at hominid sites due to the shared use of caves as habitations, or due to the shared ecology of large bodied omnivores.

Homotherium and *Panthera* are large cats, which appear in more sites than *Canis*, the most prevalent carnivore in the non-hominid control sample. Large cats may have provided carcasses for scavenging with large volumes of meat remaining after primary consumption (Turner 1982; Arribas and Palmqvist 1999), which were therefore sought out by hominid groups. Large cats may also have shared prey ecology with hominids, resulting in their appearance in the same areas, due to similar hunting techniques and choice of prey, in terms of prey size and behaviour, such as predator avoidance tactics. Therefore, this finding could be interpreted as evidence for hominid occupation of an ambush predator niche. The seeming avoidance of Canids, large cursorial predators, thus implies that hominids were not involved in open landscape chasing down of prey. Moreover, Canids are large social predators, which could have deterred hominid attempts at scavenging due to the threat posed by the large groups of these animals, and because of the more complete carcass destruction caused by dogs compared to cats.

Conclusions.

The data presented in this chapter show that ecological opportunities that facilitate movement did coincide with the periods of increase in site numbers and the area of Europe occupied by hominids discussed in Chapter 5. Therefore, the increases in hominid presence in Europe during the early Early Pleistocene, the late Early-early Middle Pleistocene, and the middle Middle Pleistocene could have been assisted or driven by the changes in the ecological community in Europe that occurred during these periods. The landscape and environmental evidence demonstrate that the expansions were associated with an increasing diversity of the regions occupied, and suggest that behavioural developments also coincided with these episodes. The hominid fossil evidence suggests that a process of physical adaptation to the conditions in Europe also occurred at the time of the increases in the evidence of hominid presence in Europe. Furthermore, the faunal data indicate that movements from Africa were unlikely to have occurred as an expansion of a group of species during the Middle Pleistocene, whereas movements originating in Asia would have taken place in a context of dispersal of several other species. This has implications for the route of dispersal into Europe and the source of the European hominids, and also has behavioural significance, as hominids may have become independent of faunal dispersals. Therefore, the nature of movement into Europe seems to have changed during the Lower Palaeolithic, with a degree of independence from ecological constraints developing in the later episodes, if movement does explain the increase in traces of hominids in the Middle Pleistocene. These behavioural aspects of the potential movements into Europe will be further explored in the following chapter.

Chapter 7 : Behaviours associated with movements during the Lower Palaeolithic.

This chapter concerns the key issues of the behavioural context, exploration and knowledge building during movement into Europe in the Lower Palaeolithic. The possibility of exploration preceding more major movements into Europe will be investigated through the proxies of population size and distribution, which are the data concerning assemblage size and spatial distribution of the Lower Palaeolithic sites over time. The development of local knowledge of resources will be explored using data concerning the raw material transfers and levels of faunal utilisation. The assemblages of artefacts will be used to establish the technologies possessed by the hominids entering Europe, particularly whether the pre-Acheulean phase proposed by Carbonell and Rolland did exist. The data from the artefacts will also be used to evaluate the possibility of behavioural innovation coinciding, preceding or following movement, and thus will determine whether behavioural change drove movement or occurred as a consequence of occupying Europe. Spatial patterns in the production of artefacts will be investigated, with the aim of establishing whether novel behaviours developed during the movement into Europe as a result of adaptation or social isolation. The question of the number and timing of events of movement into Europe during the Lower Palaeolithic will be considered in the light of the behavioural context discussed in this chapter. The issues of exploration and knowledge building will be presented, followed by the temporal and spatial patterning in the artefacts.

Exploration and the development of local knowledge during the Lower Palaeolithic.

The data concerning the possibility of an exploratory stage preceding full establishment of hominid populations in Europe suffered from extensive problems of the data sources not being published in the majority of site reports. The quantity of artefacts in the assemblages was published for only 28% of the sites in the database, and in some reports it was not clear whether the quantity of artefacts quoted included or excluded debitage; therefore, there are additional problems with the assemblage size data as the quantities recorded may not be comparable, despite the aim of collecting data concerning the complete assemblage included debitage, as a reflection of the total level of activities present at a site. The distance of raw material transfers was available in the site reports of 14% of the archaeological sites. The number of species utilised at the archaeological sites was published for 67% of the sites; however, the overwhelming majority of these sites had no species utilised because no faunal remains were preserved at the site. Positive numbers of species utilised were available for only 7% of the sites. Although the lack of faunal remains at many sites cannot be overcome, there were a significant number of sites that did contain fauna for which no information concerning the subsistence practices of the hominids was published. Therefore, the findings of the analysis of these data classes are provisional since the available data is clearly not representative of the whole dataset.

What size population moved into Europe?

The first proxy used for the population size in Europe was the number of sites in each period, presented in Chapter 5, Figures 5.1-5.12. The second means of discerning the population size was the assemblage size data. Patterning in the size of assemblages over time was investigated by dividing the assemblage sizes into the following nine categories of the number of artefacts: 0-5, 6-10, 11-20, 21-50, 51-100, 101-500, 501-1000, 1001-5000, and 5001+. The relationship between the size of assemblage and date of a site was examined using a tau-C test of the null hypothesis that there is no relationship between the date and assemblage size of a site. The assemblage sizes were re-categorised into the following five classes: 0-10, 11-50, 51-100, 101-1000, and 1001+, and the tau-C tests were repeated with the same null hypothesis, in order to determine whether the patterning found was robust to changes in the size of the categories used.

The chi-squared tests were invalid and the tau-C tests showed no differences in the patterning in the analysis conducted with nine and with five classes of assemblage size. The null hypothesis was only rejected in the datasets with poor archaeological and dating resolution. Moreover, values of tau-C were very low, revealing a weak trend for assemblage size to increase over time. Large assemblages were present since the early Early Pleistocene, but increased as a proportion of the sites in more recent periods. The strongest relationship between assemblage size and date was a value of tau-C =0.166 (α=0) for all possibly hominid sites with probable and definite dates to the major divisions of the Pleistocene, shown in Figure 7.1.

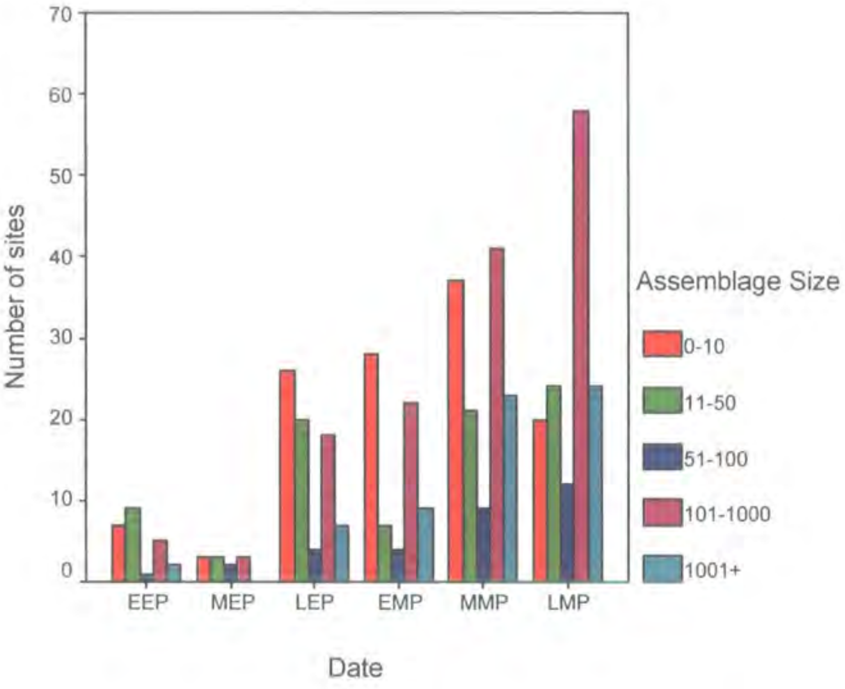


Figure 7.1. Chart showing the number of all possible hominid sites probably or definitely in each major date category, by the assemblage size present in the site. N=449.

Improving the resolution of the dates removed many early sites, which reduced the strength of the relationship between the date and size of assemblages. The oxygen isotope stage data showed no relationship between these variables, except at the poorest archaeological and dating certainty, which had a value of tau-C =0.111 (α=0.018), illustrated in Figure 7.2.

Increasing the archaeological certainty of hominid presence has a greater effect on the reduction of the strength and significance of the relationship between assemblage size and date than improving dating resolution. No definitely hominid datasets showed a significant relationship between assemblage size and date. Figure 7.3 displays the assemblage sizes of the definitely hominid sites probably or definitely dated to each major division of the Pleistocene, for which tau-C =0.01 (α=0.793), showing the substantial reduction in the strength and significance of the relationship between assemblage size and date as archaeological resolution is increased.

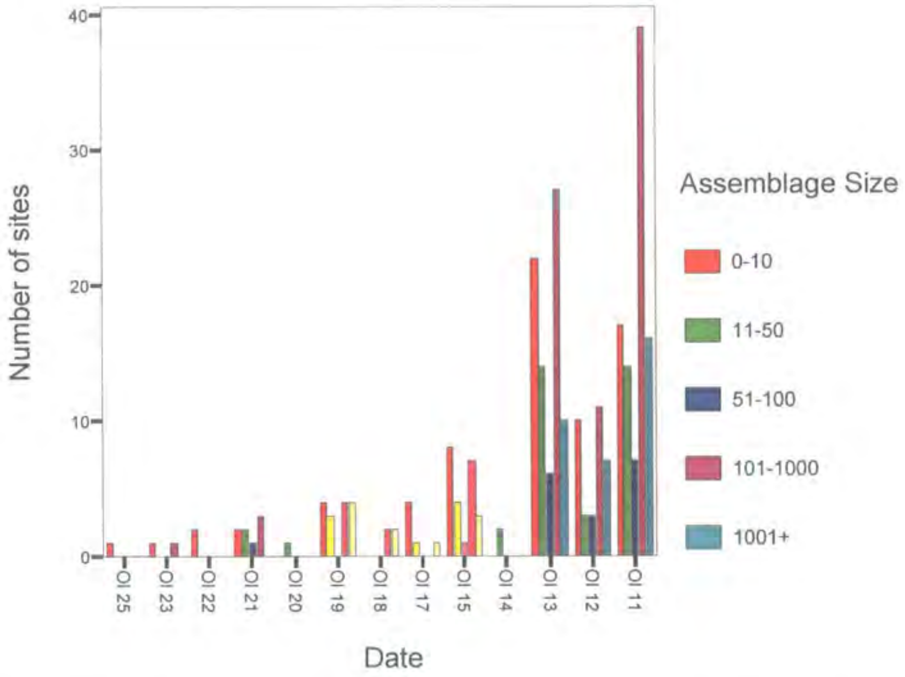


Figure 7.2. Chart showing the number of all possible hominid sites, probably or definitely dated to each oxygen isotope stage, by the assemblage size present in the site. N=270.

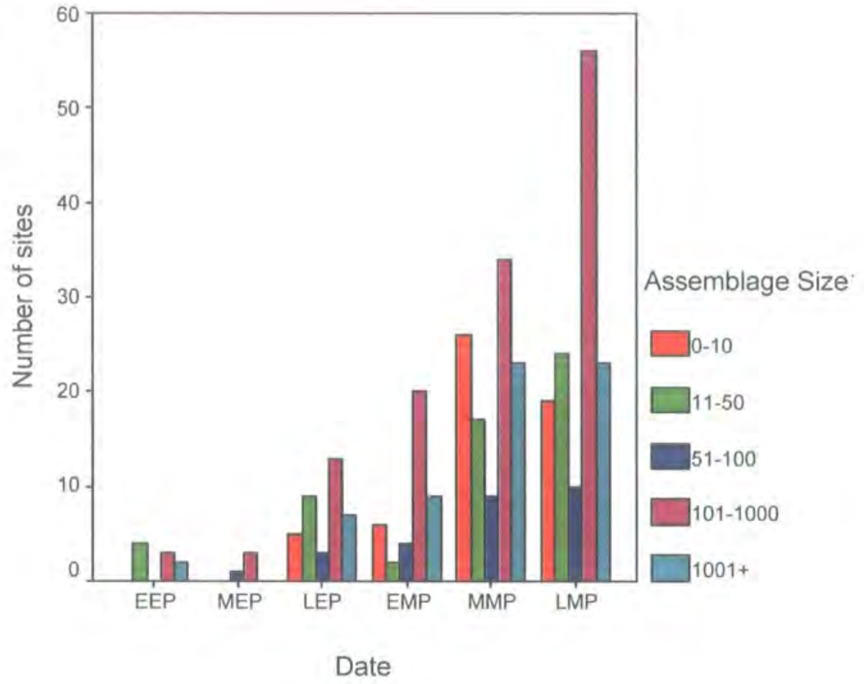


Figure 7.3. Chart showing the number of definite hominid sites, probably or definitely dated to each major date category, by the assemblage size present in the site. N=332.

In summary, the possibility of a relationship between the size and date of assemblages cannot be excluded, but the null hypothesis is retained for the higher quality datasets, suggesting that assemblage sizes are evenly distributed in time.

The relationship between assemblage size and exploration.

The size of assemblages was used as a possible proxy for an exploration preceding major settlement. The reasoning behind this choice of proxy is that small groups, moving rapidly over long distances and undertaking a restricted range of activities are expected during a pioneering exploration of an area. Thus, assemblage sizes were anticipated to be small at first, and then to increase as major movement occurred and larger groups including less mobile individuals became involved in the colonisation. This establishment phase is predicted by the chain migration model to be seen in major population nodes, reflected by large sites. At a late stage in movement, secondary dispersal from the destination nodes is expected, creating a greater range in size of groups and sites.

The assemblage size data demonstrate that a trend towards increasing site size over time only occurs when the unlikely and probably hominid sites are included in the analysis, and the relationship present is weak. The definitely archaeological sample shows that assemblage sizes are equally distributed over time. These results can be interpreted as a genuine absence of patterning over time in assemblage sizes. The absence of a trend may be caused by the choice of the classes of assemblage size used in the analysis; however, as two sets of classes were used, producing identical results, the patterns are robust enough to survive variations in the boundaries of the assemblage size classes, and thus can be treated as valid.

The alternative interpretation of these results is that there is a weak trend for site size to increase over time as predicted, but the relationship is destroyed by reducing the sample size of sites analysed. Archaeological assemblages that are widely accepted as showing hominid presence in Europe tend to be large and relatively late, and therefore the small early assemblages are removed from the sample, destroying the association between assemblage size and date. The size of an assemblage is a factor used in determining whether it was humanly manufactured, particularly when an assemblage is suggested to be dated to the Early Pleistocene. Thus, the archaeological validation processes used to discern the timing of hominid arrival in Europe remove any ephemeral early traces of occupation, which may represent an initial exploratory phase, because these assemblages are deemed too uncertain of representing hominid presence. Thus, proponents of the short chronology of European occupation prefigure the data to fit their favoured chronology of dispersal, by dismissing all the early evidence of hominid presence in Europe, without considering the processes of movement, which result in a phase of ephemeral occupation characterised by small assemblages. Nevertheless, the increase in population size over time seen through the increase in site numbers, with a steady or slightly increasing assemblage size, implies that the initial population in Europe was substantially smaller than that of the end of the study period, and thus a small pioneer group may have been present in the Early Pleistocene.

How were populations distributed across Europe?

Figures 7.4-7.46 show the distribution of sites in each period, by the confidence of hominid presence and dating. These maps display the same sites as those in Figures 5.16-5.79, scaled to the size of the assemblage at each site, using the five categories of assemblage size. Sites classed as possessing an assemblage size of zero are either hominid fossil sites with no archaeological material, or archaeological sites for which the assemblage size was not recorded in any publication. These maps aim to highlight the presence of core areas with large sites, and regions containing only small assemblages, with ephemeral exploratory presence, as well as clustering of sites.

Figures 7.4-7.9 present the maps of the early Early Pleistocene, demonstrating that the larger sites are found outside of Europe, in the Levant and North Africa, which could provide sources of the European population. The sites in Europe are smaller and not certainly indicative of hominid presence. The larger sites within Europe, with a higher degree of confidence of hominid presence, are located in the south, but may date to a later stage of the Early Pleistocene.

Figure 7.4. Map showing all the possible hominid sites with probable or definite dates to the early Early Pleistocene, by assemblage size.

Figure 7.5. Map showing the probable and definite hominid sites with probable or definite dates to the early Early Pleistocene, by assemblage size.

Figure 7.6. Map showing the definite hominid sites with probable and definite dates to the early Early Pleistocene, by assemblage size.

Figure 7.7. Map showing all the possible hominid sites definitely dated to the early Early Pleistocene, by assemblage size.

Figure 7.8. Map showing the probable and definite hominid sites definitely dated to the early Early Pleistocene, by assemblage size.

Figure 7.9. Map showing the definite hominid sites definitely dated to the early Early Pleistocene, by assemblage size.

Figures 7.10 and 7.11 display the middle Early Pleistocene maps. There are no definitely dated sites during this period with data regarding assemblage sizes. The maps of the probable and definite hominid sites with probable dates are identical, thus only the definite sites are shown. Larger assemblages are restricted to the south, especially in Iberia.

Figure 7.10. Map showing all the possible hominid sites, probably or definitely dated to the middle Early Pleistocene, by assemblage size.

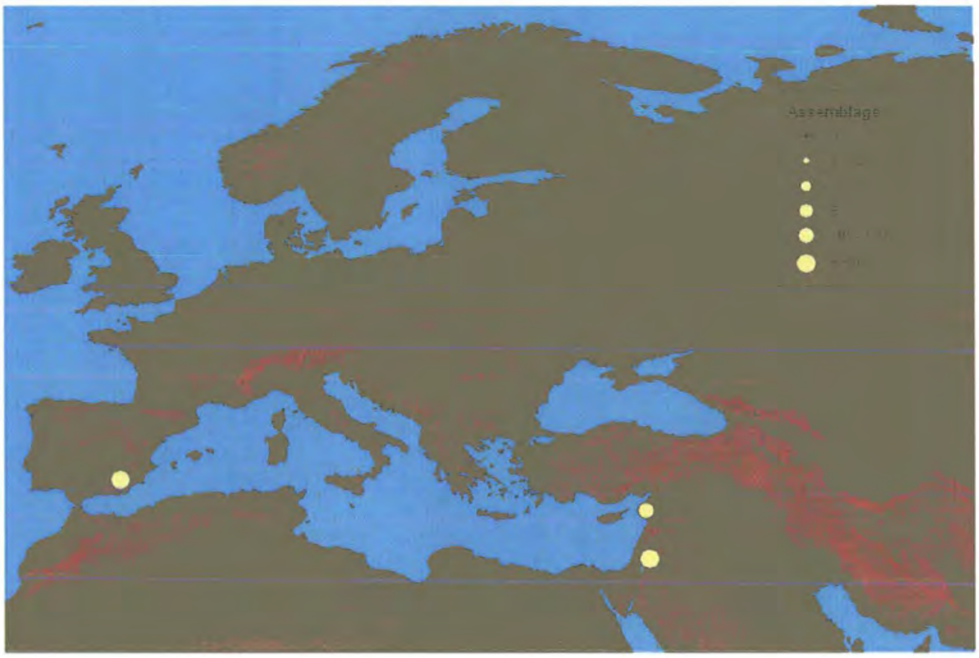


Figure 7.11. Map showing the definite hominid sites probably dated to the middle Early Pleistocene, by assemblage size.

Figures 7.12-7.17 display the maps of the assemblage sizes during the late Early Pleistocene, revealing that clusters of large sites had developed by this time, particularly in the Po Valley. Large sites remain located in the south, with smaller sites in the north that disappear as certainty of hominid presence increases. Sites in Iberia suffer dating problems, resulting in the maps of definitely dated sites showing abandonment of Iberia. The Levant shows evidence of substantial occupation during the late Early Pleistocene in the probably dated dataset, but few definitely dated sites are located in the Levant.

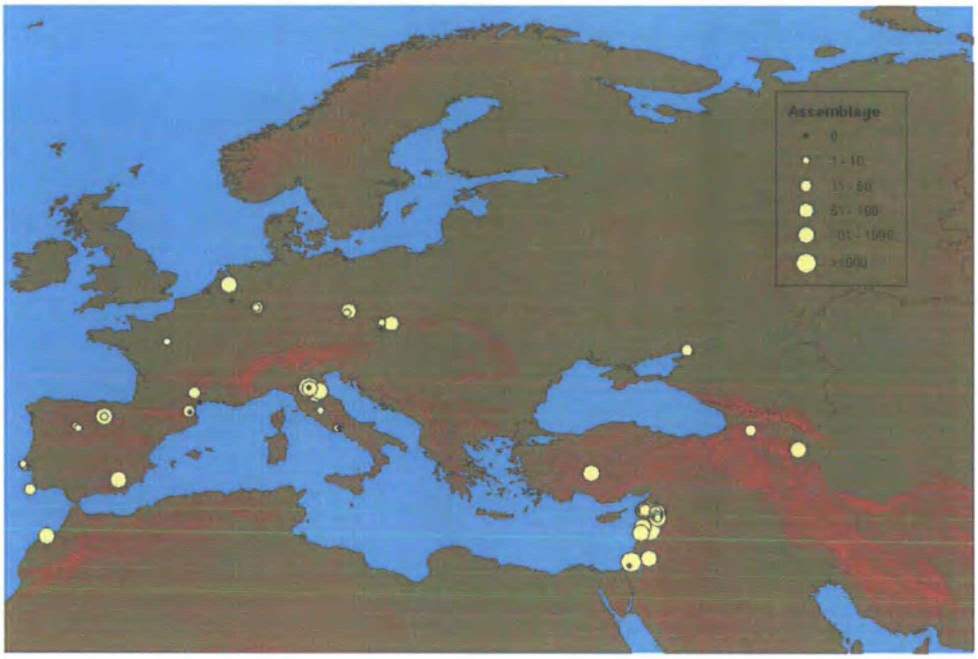


Figure 7.12. Map showing all the possible hominid sites probably or definitely dated to the late Early Pleistocene, by assemblage size.

Figure 7.13. Map showing the probable and definite hominid sites, probably or definitely dated to the late Early Pleistocene, by assemblage size.

Figure 7.14. Map showing the definite hominid sites, probably or definitely dated to the late Early Pleistocene, by assemblage size.

Figure 7.15. Map showing all the possible hominid sites definitely dated to the late Early Pleistocene, by assemblage size.

Figure 7.16. Map showing the probable and definite hominid sites, definitely dated to the late Early Pleistocene, by assemblage size.

Figure 7.17. Map showing the definite hominid sites definitely dated to the late Early Pleistocene, by assemblage size.

Figures 7.18-7.23 present the assemblage sizes during the early Middle Pleistocene, during which larger sites remain concentrated in the Levant, the Maghreb, Iberia and Italy, however, the well-dated samples remove many of the Levantine sites, creating the impression that occupation centred on Western Europe. Increasing the certainty of the dates and hominid presence produces a picture of occupation focused on Iberia.

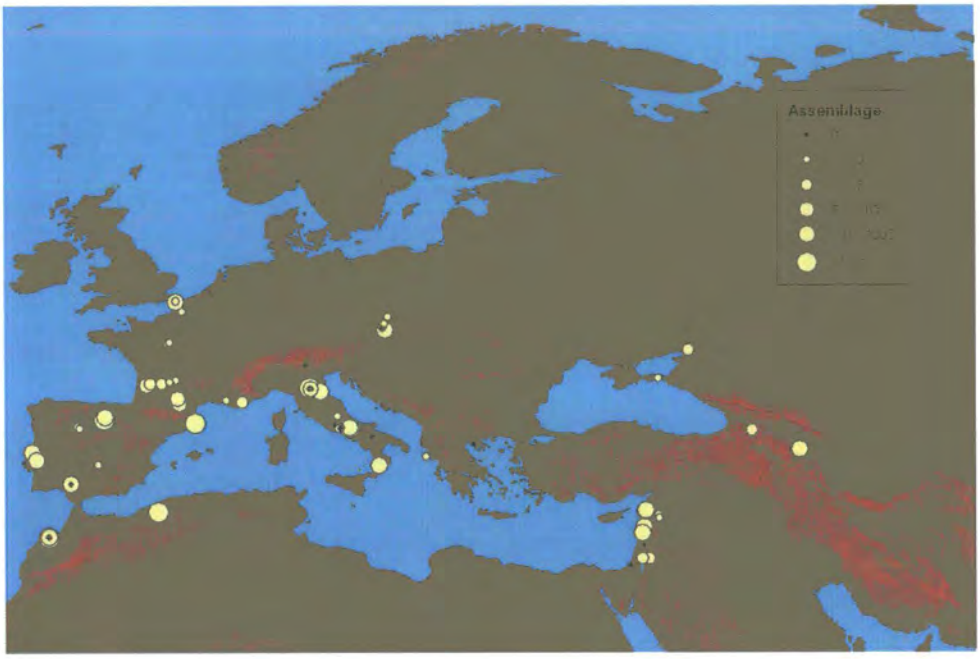


Figure 7.18. Map showing all the possible hominid sites, probably or definitely dated to the early Middle Pleistocene, by assemblage size.

Figure 7.19. Map showing the probable and definite hominid sites, probably or definitely dated to the early Middle Pleistocene, by assemblage size.

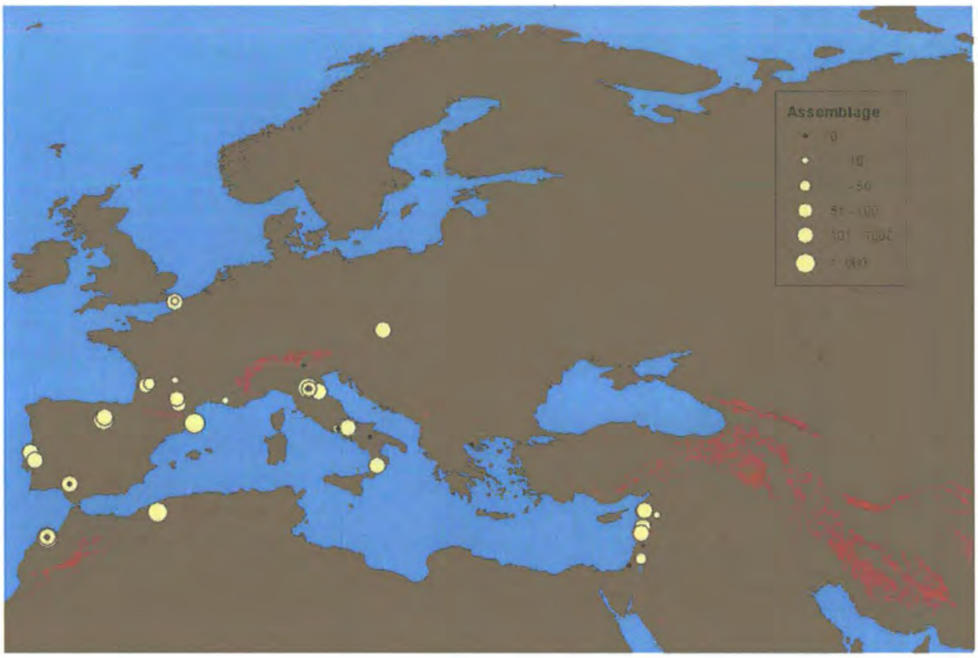


Figure 7.20. Map showing the definite hominid sites, probably or definitely dated to the early Middle Pleistocene, by assemblage size.

Figure 7.21. Map showing all the possible hominid sites definitely dated to the early Middle Pleistocene, by assemblage size.

Figure 7.22. Map showing the probable and definite hominid sites, definitely dated to the early Middle Pleistocene, by assemblage size.

Figure 7.23. Map showing the definite hominid sites definitely dated to the early Middle Pleistocene, by assemblage size.

Figures 7.24-7.27 show the assemblage sizes during the middle Middle Pleistocene. The unlikely and probably hominid samples are identical, thus the unlikely sites are omitted. These maps reveal large sites in the north for the first time during the study, with better dating than the south, which produces an impression of depopulation in Iberia in the well-dated samples, shown in Figure 7.26 and Figure 7.27. Clusters of large sites were situated in major river valleys, such as the Thames and the Tiber.

Figure 7.24. Map showing the probable and definite hominid sites, probably or definitely dated to the middle Middle Pleistocene, by assemblage size.

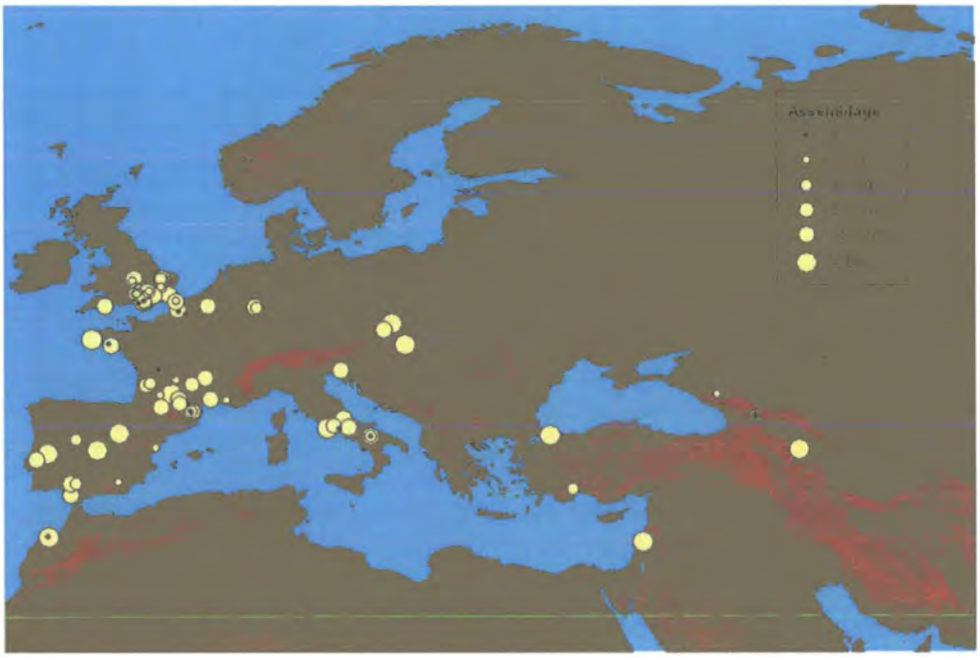


Figure 7.25. Map showing the definite hominid sites, probably or definitely dated to the middle Middle Pleistocene, by assemblage size.

Figure 7.26. Map showing the probable and definite hominid sites, definitely dated to the middle Middle Pleistocene, by assemblage size.

Figure 7.27. Map showing the definite hominid sites, definitely dated to the middle Middle Pleistocene, by assemblage size.

Figures 7.28-7.30 display the assemblage sizes during the late Middle Pleistocene. There are no sites with unlikely hominid presence in this period, and all definitely dated sites have definite traces of hominids. The assemblage sizes had increased compared to earlier periods, with large sites throughout the area occupied. Relatively large sites appear in Eastern Europe, but only with uncertain dates. The well-dated sample, shown in Figure 7.30, contains very few small sites in Iberia and Eastern Europe. The large sites are again clustered in major river valleys, and Northwest Europe, especially Southeast England is particularly densely occupied.

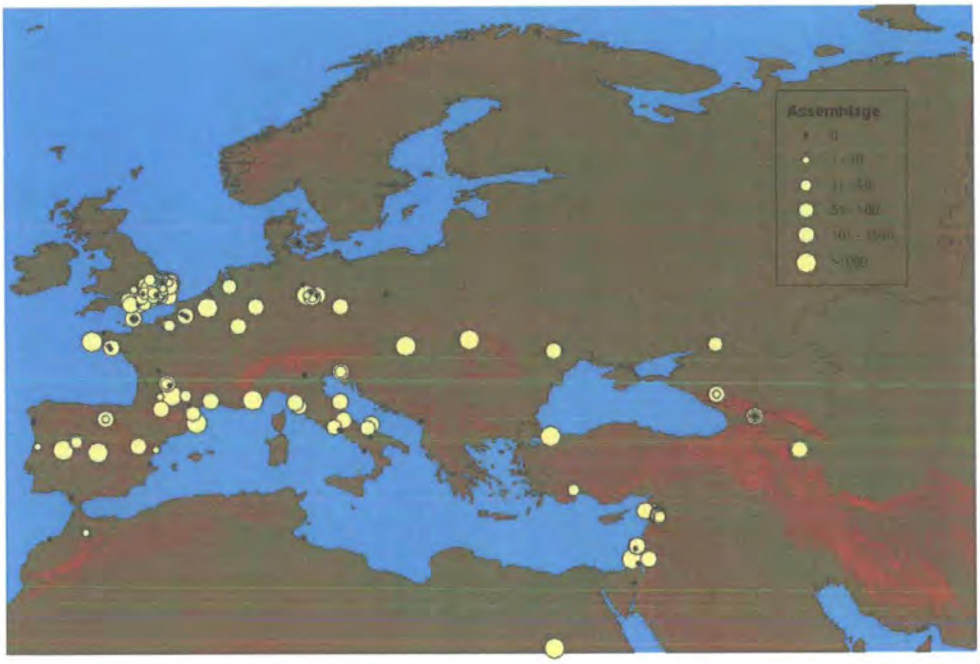


Figure 7.28. Map showing the probable and definite hominid sites, probably or definitely dated to the late Middle Pleistocene, by assemblage size.

Figure 7.29. Map showing the definite hominid sites, probably or definitely dated to the late Middle Pleistocene, by assemblage size.

Figure 7.30. Map showing the definite hominid sites definitely dated to the late Middle Pleistocene, by assemblage size.

Figures 7.31-7.46 present the maps of assemblage sizes at sites dated to oxygen isotope stages. These maps disclose many of the same spatial patterns seen in the assemblages dated to the major divisions of the Pleistocene. The effect of increasing the dating resolution significantly reduces the number of sites in the analysis, particularly in Iberia and Italy, producing a picture of settlement focused on Northwest Europe. The earliest sites in Europe placed in oxygen isotope stages date to OIS 25-22, and all contain questionable evidence of hominid presence, lack definite dates, and are virtually all small assemblages, as shown in Figure 7.31. These sites are Kärlich A in Germany (Würges 1986; Gaudzinski and Vollbrecht 1995), Atapuerca TD4 in Spain (Carbonell and Rodriguez 1994; Carbonell *et al.* 1999a), Monte Peglia in Italy (van der Meulen 1973; Radmilli 1976) and Dursunlu in Turkey (Güleç *et al.* 1999).

Figure 7.31. Map showing the possible hominid sites with probable dates to oxygen isotope stages 25-22, by assemblage size.

However, during OIS 21 larger sites occur in Europe, which contain definite evidence of hominids at Atapuerca TD6 in Spain (Carbonell *et al.* 1995a; Bermudez de Castro *et al.* 1999; Carbonell *et al.* 1999b) and Staré Mesto 1 series 1 in the Czech Republic (Chlachula 1993, 1994), but remain poorly dated. Figure 7.32 displays all the possible hominid sites dated to OIS 21, and Figure 7.33 shows the definite hominid sites, highlighting the loss of smaller sites as certainty of hominid presence is increased. These maps also reveal limited occupation of central Europe by this time.

Figure 7.32. Map showing all the possible hominid sites probably dated to oxygen isotope stage 21, by assemblage size.

Figure 7.33. Map showing the definite hominid sites probably dated to oxygen isotope stage 21, by assemblage size.

The presence of large sites in southern Europe and small sites in the north is apparent in OIS 19. There are no sites definitely dated to this period, but the large sites demonstrate unquestionable hominid presence. However, the small northern sites are deemed to be uncertain evidence of hominid occupation. Figure 7.34 and Figure 7.35 compare the definitely accepted archaeological sites with all possible hominid traces during OIS 19, highlighting the lack of definite or large sites beyond Mediterranean Europe. The sites containing definite evidence of hominid presence probably dated to OIS 19 are Podere Canestri/Forlimpopoli (Aldini *et al.* 1998), Bel Poggio (Fontana *et al.* 1998), Fornace (Fontana *et al.* 1998), and Ca'Poggio (Fontana *et al.* 1998) in Italy, and Atapuerca TD6 in Spain (Carbonell *et al.* 1995a; Bermudez de Castro *et al.* 1999; Carbonell *et al.* 1999b).

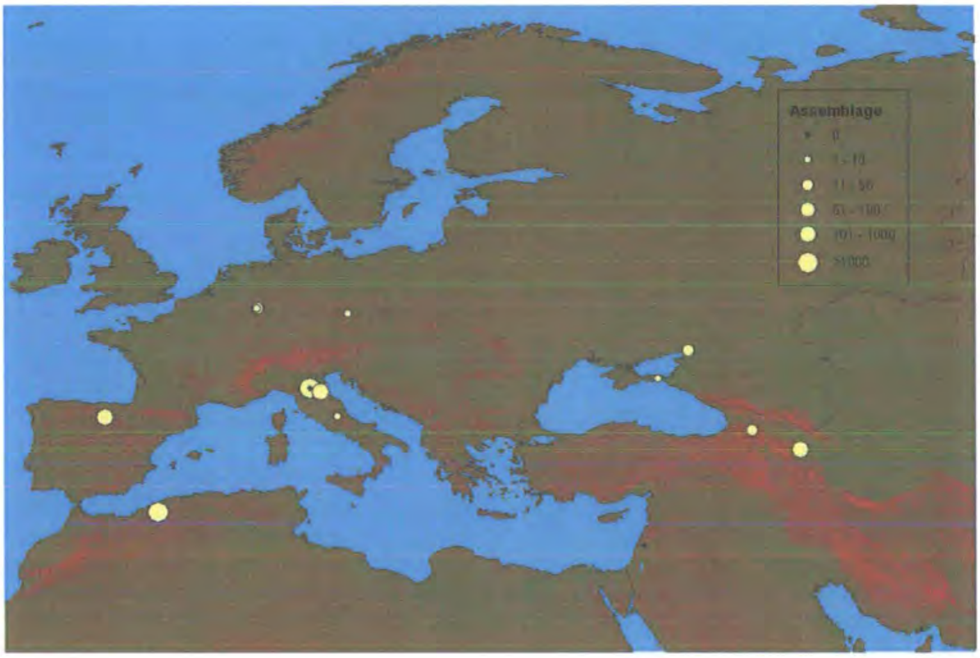


Figure 7.34. Map showing all the possible hominid sites probably dated to oxygen isotope stage 19, by assemblage size.

Figure 7.35. Map showing the definite hominid sites probably dated to oxygen isotope stage 19, by assemblage size.

Figure 7.36. Map showing all the possible and definite hominid sites, probably dated to oxygen isotope stages 20 or 18, by assemblage size.

There are very few sites dated to the early glacial stages of OIS 20 and OIS 18, and those present are located in the south of Europe, in Italy at Isernia La Pineta

(Cremaschi and Peretto 1988b) and the Caucasus at Achalkalaki (Ljubin and Bosinski 1995), as shown in Figure 7.36.

The sites dated to the OIS 17 interglacial in Europe, shown in Figure 7.37, are all small, and none are definitely accepted as showing hominid presence. These sites are Montières, Ferme de Grâce in Northern France (Bourdier 1976a, 1976b; Tuffreau and Antoine 1995), Vidauban in Southern France (Defleur *et al.* 1991), Pagliare di Sassa in Italy (Palombo *et al.* 2001), and Švédské Šance and Černovice in the Czech Republic (Valoch 1995, 1996b). In comparison with Figures 7.12-7.17, which show the equivalent period in the major date categories, the sites are smaller and substantially fewer in number.

Figure 7.37. Map showing all the possible hominid sites probably dated to oxygen isotope stage 17, by assemblage size.

There are no sites in Europe that date to the OIS 16 glacial.

The problem of small sample sizes is again seen during OIS 15. There are several large sites that probably date to this time, shown in Figure 7.38, however increasing the dating resolution removes virtually all evidence of hominid presence, leaving only Treugol'naja Cave layer 7a in Russia (Doronichev 2000b; Lioubine 2000, 2002;

Hoffecker *et al.* 2003) and Carrière Carpentier in France (Bourdier 1974; Tuffreau and Antoine 1995), shown in Figure 7.39. OIS 15 sees the first presence of large assemblages to the north of the Alps, at Miesenheim 1 in Germany (Turner 2000b) and Staré Mesto series 2 in the Czech Republic (Chlachula 1993, 1994); and witnesses the potential appearance of hominids in Britain at Waverley Wood (Shotten *et al.* 1993).

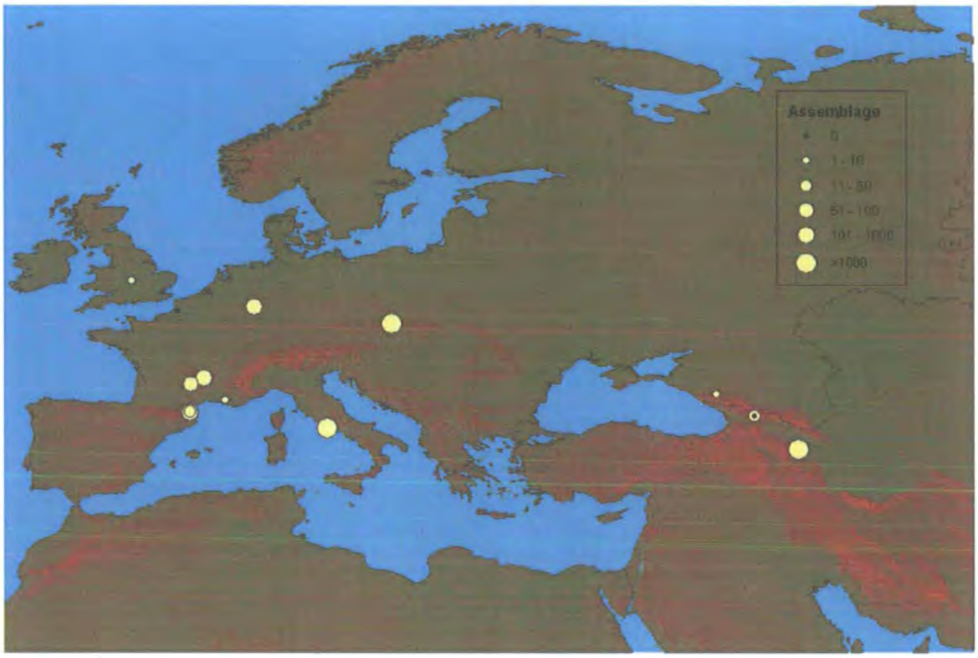


Figure 7.38. Map showing the definite hominid sites probably dated to oxygen isotope stage 15, by assemblage size.

Figure 7.39. Map showing the definite hominid sites definitely dated to oxygen isotope stage 15, by assemblage size.

The OIS 14 glacial appears to have resulted in a virtually complete depopulation of Europe, shown in Figure 7.40. There is only one small site in Europe, Kärlich G in Germany (Bosinski 1995a; Gaudzinski and Vollbrecht 1995), with the exception of the possible refugium in the Caucasus at Kudaro III level 8 in Georgia (Doronichev 2000a; Lioubine 2000, 2002). Nevertheless, the possible presence of hominids during a glacial is potentially significant, as discussed in Chapter 5.

Figure 7.40. Map showing the definitely hominid sites probably dated to oxygen isotope stage 14, by assemblage size.

OIS 13 contains larger sites than previous periods, which are widespread across Europe, shown in Figure 7.41. The sites definitely dated to OIS 13 are only found in Britain, see Figure 7.42, which is not representative of the population dispersion across Europe indicated by the datasets including uncertain dates. This interglacial shows evidence of significant clustering of large sites, especially in southern France and Southeast England in the dataset including probable dates, shown in Figure 7.41.

Figure 7.41. Map showing the probable and definite hominid sites, probably or definitely dated to oxygen isotope stage 13, by assemblage size.

Figure 7.42. Map showing the definite hominid sites, definitely dated to oxygen isotope stage 13, by assemblage size.

Hominid presence appears to have continued into the OIS 12 glacial, with large sites remaining as far north as Britain in the dataset including uncertainly dated sites, as seen in Figure 7.43. The sites definitely dated to OIS 12 are all in Northern Europe, shown in Figure 7.44, precluding the possibility of detecting areas of dense occupation in Southern Europe that would have formed refugia during the glacial.

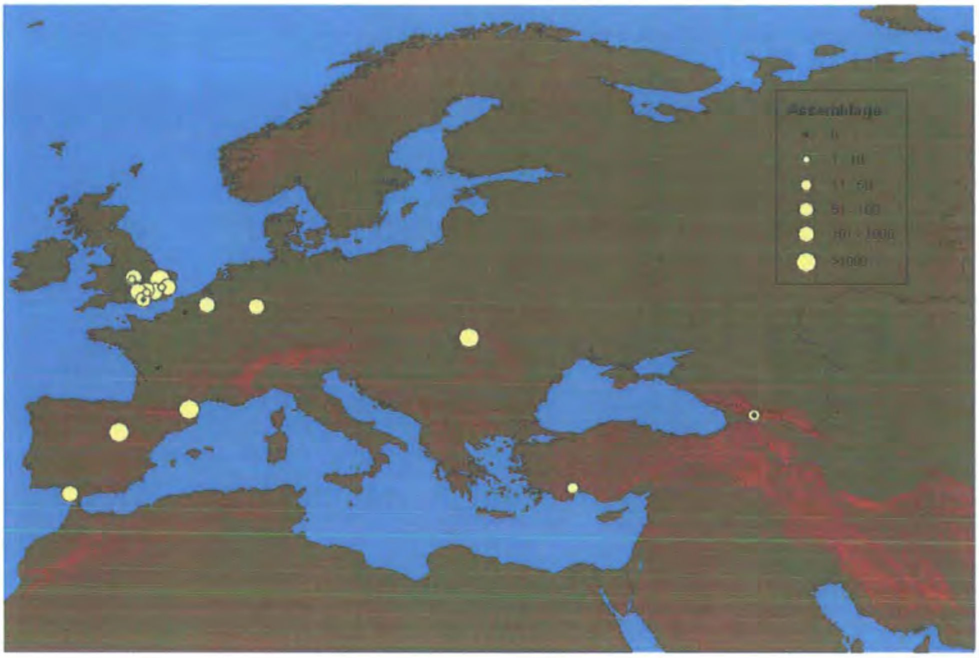


Figure 7.43. Map showing the definite hominid sites probably dated to oxygen isotope stage 12, by assemblage size.

Figure 7.44. Map showing the definite hominid sites definitely dated to oxygen isotope stage 12, by assemblage size.

During OIS 11 large sites were widespread across Europe, shown in Figure 7.45. Clustering of large sites in the Thames Valley is seen again in this period, and the same bias towards Northern Europe in the precise dates is displayed in Figure 7.46.

Figure 7.45. Map showing the definite hominid sites, probably or definitely dated to oxygen isotope stage 11, by assemblage size.

Figure 7.46. Map showing the definite hominid sites definitely dated to oxygen isotope stage 11, by assemblage size.

Behavioural implications of the spatial patterning.

The spatial distribution of the evidence for large or small-scale occupation was investigated to shed light on the issues of initially small-scale dispersed occupation, followed by clustering of population at destination nodes during major movement, and subsequently by secondary dispersal in later phases of movement. This data suffers from the additional limitation of the loss of sites without geographical locations, as well as those lacking published assemblage sizes. However, as locations were available for 95% of the sites, and geographical biases in the publication of locations and assemblage sizes were not apparent, the resulting patterning can be treated as valid, if not entirely complete.

Figures 7.4-7.9 suggest that the sites in Europe during the early Early Pleistocene were relatively small, and if the sites classed as showing unlikely hominid presence are included, the distribution is spread over a wide area of Europe. The later major divisions of the Pleistocene contain larger sites and possible evidence of clustering, perhaps representing the formation of destination nodes in the later phases of movement. The oxygen isotope stage data reveals better support for an exploration phase during OIS 25-17, shown in Figures 7.31-7.37. The majority of the sites in Europe during this period are small, and larger assemblages are confined to the Mediterranean, with small, widely dispersed and not universally accepted sites to the north of the Alps. In comparison with the late Early Pleistocene and early Middle Pleistocene, the corresponding major divisions of the Pleistocene, there are fewer and smaller sites in Northern Europe in the oxygen isotope stage data. However, the definitely dated sample of major divisions of the Pleistocene removes many of these sites, producing a picture similar to the oxygen isotope stage data. In the early Middle Pleistocene the definitely dated sample suggests major occupation was focused on Iberia, while the whole of Central Europe, including Italy, had only small and widely dispersed sites.

This comparison suggests that the lack of clear evidence for an exploratory stage of movement in the major divisions of the Pleistocene, after the early Early Pleistocene, may be the result of the time averaging of the patterning during the longer periods covered by each division. The grouping together of sites from several climatic cycles could be creating a picture of more established settlement than was actually the case, by showing groups of several sites co-occurring regionally, which were potentially separated by hundreds of thousands of years. The oxygen isotope stage data separates these sites, and allows processes happening within a single climatic cycle to be seen. However, the oxygen isotope stage data suffers from the problem of small sample size, as relatively few sites could be dated to this level of accuracy. Therefore, it is possible that the impression of ephemeral settlement is created by removing a large number of sites with poor dates, which actually were inhabited at the same time as the well-dated sites. However, given the small number of sites in Europe during the Early Pleistocene, and the early Middle Pleistocene, compared to later periods, it seems unlikely that dating problems could be the only explanation for the low levels of occupation of Northern Europe, as the sites present were probably not all occupied contemporaneously. Moreover, the consistent geographical pattern of larger sites and a greater number of sites in Southern Europe, especially Iberia, during the early phases of occupation suggests that the phenomenon is genuine.

Clusters of large sites are predicted to occur in the establishment phase of movement, as destination nodes at known locations of good resources. The maps of assemblage sizes indicate that this phenomenon might be detected from the late Early Pleistocene, with major river valleys containing clusters of sites with large assemblages, suggesting that large populations inhabited these areas, if these sites were contemporary and not simply placed together by the time averaging caused by the width of the date bands. However, persistent re-occupation of an area by hunter-gatherer groups could also be interpreted as the formation of an occupation node. Clustering of sites appears earlier when the unlikely hominid sites are included, reinforcing the impression that the removal of these sites masks important processes occurring during the earliest phases of movement. Some evidence of the clustering of large sites is seen in the oxygen isotope stage data of the equivalent periods; for example, the maps of OIS 19, Figure 7.34 and Figure 7.35, show a cluster of sites in the Po Valley. However, clustering does not become a major pattern in the oxygen isotope stage data until OIS 13. This is probably explained by the smaller sample size of sites dated at this level of accuracy, which results in only one or two sites in each cluster being seen in each oxygen isotope stage. However, the absence of significant clustering until OIS 13 could be a real pattern, as the clusters shown in the major date category maps could actually represent sites inhabited over several climatic cycles. Therefore, it is difficult to conclusively show that these patterns represent a phase of established population flows. Nevertheless, the evidence is suggestive of these processes, as the potential clusters occur in major river valleys, such as the Thames, Po, Dordogne and Tajo, which is the expected distribution of population nodes during the establishment phase. Thus, the preference of hominids of river-valley habitats, discussed in Chapter 6, could have contributed to the formation of population nodes, and can be linked to dispersal processes as well as ecological factors, as the targeting of these areas led to the concentration of the European population in limited nodal areas.

The middle and late Middle Pleistocene, and OIS 13-11, show the presence of large sites throughout the majority of the study area, which can be interpreted as the consolidation phase of secondary dispersal to smaller nodes, once the region had become familiar. During this period there are no areas that contain only small sites, suggesting that the population had expanded to fill the periphery of the earlier phases, and that further expansions had not yet begun. Alternatively, this pattern may simply be the result of an increasing population size in Europe. However, the problem of time averaging also affects these findings. Each period consists of thousands of years, and thus the contemporanity of the sites is not proved. It is possible that the increase in large sites across Europe at the end of the study period could represent population growth, or a behavioural change that resulted in a more visible and prolific archaeological record, or simply that sites in these periods are easier to date and thus are over-represented in the database.

Is there evidence of the development of local knowledge of resources?

The size and distribution of sites discussed above was used as a means of determining whether areas of low intensity and widely dispersed settlement could be detected before substantial occupation took place. In addition, the distances of raw material transfers and the number of species utilised at each site were analysed, with the aim of determining whether earlier sites showed evidence of less intensive occupation and less knowledge of the surrounding landscape. The maximum distances of raw material transfers to each site were analysed using a tau-C test of the null hypothesis that there is no relationship between the date of a site and the distance that materials were transported to the site. The distances of transfers of raw materials were grouped into the following classes: 0-1, 2-5, 6-10, 11-25, 26-40 and more than 40 kilometres for the application of the statistical tests. A Spearman's rank correlation test was undertaken using the same null hypothesis, applied to the actual transfer distances rather than the classes of transport distance. The results of the tau-C tests were insignificant, and thus retained the null hypothesis at all levels of confidence in the data. Therefore, no relationship could be detected between the maximum distance of raw material transfers to a site and its date. However, the Spearman's rank correlation test produced a significantly negative relationship between the maximum distance of raw material transportation and time for the definitely dated sites in the major divisions of the Pleistocene, but not the probably dated sites or any of the oxygen isotope stage data. This suggests that a weak trend towards a decrease in maximum transfer distances over time could exist but is not robust enough to be seen in small sample sizes. Moreover, the strength of the relationship is greatest when all the possibly hominid sites are included in the sample. Figure 7.47 shows the number of possibly hominid sites with definite dates to the major divisions of the Pleistocene with each distance of raw material transfer, which has the strongest correlation between maximum raw material transport distance and time, with a Spearman's rank correlation value = -0.376 (α=0.006), illustrating the increase in the proportion of sites with very short transportation distances over time.

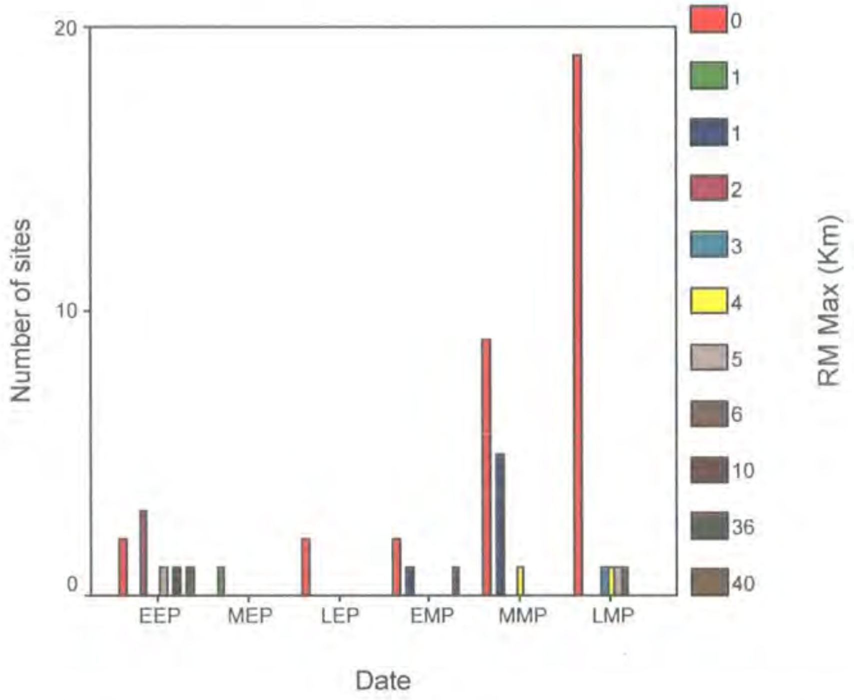


Figure 7.47. Chart showing the number of possible hominid sites, definitely dated to each major date category, by the maximum distance of raw material transportation at each site. N=53.

The data concerning the number of species showing signs of utilisation at each site was tested by a Spearman's rank correlation of the date and number of utilised species. These tests produced insignificant results at all levels of resolution of the dates and of hominid presence, hence the null hypothesis that there is no relationship between the date and number of utilised species was upheld in all cases.

Behavioural implications of the raw material transfer and faunal utilisation data.

Raw material transfers.

The investigation into the possible relationship between the maximum distance of raw material transfers and time aimed to establish whether a decrease occurred, signalling a growing familiarity with local resources, overcoming the need to transport materials (Steele and Rockman 2003). The results show a weak tendency for raw material transfer distances to decrease over time, which could support the idea of increasing local knowledge after the initial phase of dispersal. However, as the sample size of sites with information concerning raw material transfers was extremely small, and the tau-C tests did not produce significant results, the relationship between date and maximum raw material transfer distance remains inconclusive. Moreover, the distances involved were predominantly under 5 Km and none were greater than 40 Km, the distance defined by Gamble (1998) as the boundary of the local hominid network. Therefore, these findings support Gamble's contention that there is no evidence of hominid interaction beyond the local scale in the Lower Palaeolithic. There is no support for an initial period of long distance transport of raw materials to overcome the problems of a lack of knowledge of raw material sources, hence in the Lower Palaeolithic raw material transfers do not reveal a pioneering stage of movement; although given the paucity of the dataset, neither do they disprove its existence.

Faunal utilisation.

The faunal utilisation data showed no patterning over time, either towards an increase as local species were taken into the diet, or a decrease as local knowledge allowed specialisation. However, the number of sites for which it was possible to collect these data was very small, and the vast majority of sites were classified as containing no utilised species because no fauna had been preserved. Therefore, the lack of a relationship between these factors may be due to this lack of data.

Did exploration precede settlement?

The general lack of clear support for an exploratory phase of Lower Palaeolithic occupation of Europe in these proxies could reflect the genuine absence of such a phase. However, time averaging of the archaeological record of initial entry, de-population during harsh climatic episodes and re-colonisation during environmental amelioration could have destroyed the evidence for exploratory stages of occupation. Exploration may have taken place during each interglacial in the north of Europe, after abandonment during glacials; hence, evidence of ephemeral and widespread early occupation may be found in all periods of the Pleistocene. The extremely small sample of sites dated to phases of oxygen isotope stages precludes the possibility of tracing these processes. The evidence of the spatial distribution of the assemblage sizes and artefact types does suggest that exploration preceded movement into the northwestern and later the northeastern periphery. Thus, the lack of statistically significant results in the proxies of exploration could be the result of spatial averaging of the data, because in the south the population was established whilst exploration proceeded in the north.

Further reasons for the lack of proof of an exploratory stage are that archaeological means of validating hominid presence removes the traces of exploratory sites because these contain small assemblages and are found earlier and in more geographically widespread locations than expected when predictions of the nature of early sites are made from the mid-late Middle Pleistocene major sites. Furthermore, site publications tend to neglect the aspects of the archaeological record used to trace the exploratory phase, hence the sample of sites with good data regarding raw material provenance and faunal utilisation was small, even assemblage size data was not published for a substantial number of sites. Finally, the proxies used for the exploratory stage may be poor indicators of the processes under investigation. However, given the weak support for the predicted patterns of raw material transfers and assemblage sizes, it is not possible to entirely dismiss these factors until a more representative sample of data for European Pleistocene sites has been tested.

The possibility remains that an exploratory phase was genuinely absent in the Lower Palaeolithic movement into Europe. The investigation has not proved conclusively that widespread exploration preceded movement. Exploration is predicted by sociological and geographical models of modern human movement, and by ecological models of rapid dispersal of non-human mammals. However, slow spread would not require widespread exploration, as knowledge about the areas to be occupied could be gained by local exploration. Thus, if the exploratory phase did not occur the rate of spread was probably slow, and followed an historical biogeographical model of dispersal, rather than a rapid ecological invasion or modern human migration.

Lower Palaeolithic Artefacts.

The artefact data proved to be the most extensive and simple element of the data to collect because the nature of the lithic assemblages were recorded in the published record of the vast majority of Lower Palaeolithic sites. However, the problem of misattribution of tools may apply to some published site records. Nevertheless, this problem is probably equally applicable throughout the study area and time period, and thus affects the data evenly, producing no particular spatial or temporal anomalies. Therefore, the tools recorded in the assemblage data are likely to form a representative sample of the industries present in the study area and period, and the data produced can be considered reliable.

Is there evidence of changes in tool forms over time?

The artefact data were analysed with the aim of revealing whether a trend existed in the temporal distribution of tool forms. Chi-squared and lambda tests were applied to the null hypothesis of there being no relationship between the date of an assemblage and the tool forms that it contains. Initially the tests utilised data from the entire study area, and then were repeated using the archaeological assemblages recovered in Europe only. The results of the chi-squared tests of the entire study area data were invalid, and the lambda tests provided insignificant values, therefore the null hypothesis cannot be rejected. The lambda tests of the European data produced significant values for the major divisions of the Pleistocene, including the unlikely and probably hominid sites, at both probable and definite levels of dating. The data concerning the definite hominid sites dated to the major divisions of the Pleistocene, and all the oxygen isotope stage data did not produce significant values of lambda. The significant relationships were weak, with the maximum values for the definitely dated sites with all the possibly hominid produced assemblages included, for which lambda =0.03 (α=0.025), displayed in Figure 7.48. Therefore, there is a weak relationship between the presence of tool forms and date in European sites, but not in the North African or Levantine sites. The trends seen in Europe are the appearance of handaxes and cleavers from the late Early Pleistocene, and the late emergence of prepared core technologies and tools manufactured on organic materials. Debitage, flake tools and choppers were present throughout the study period in constant proportions, with the exception of choppers that decrease in the late Middle Pleistocene. In comparison with the data concerning the entire study area, shown in Figure 7.49, handaxes, cleavers and wooden tools appear later in Europe than in the Levant and North Africa.

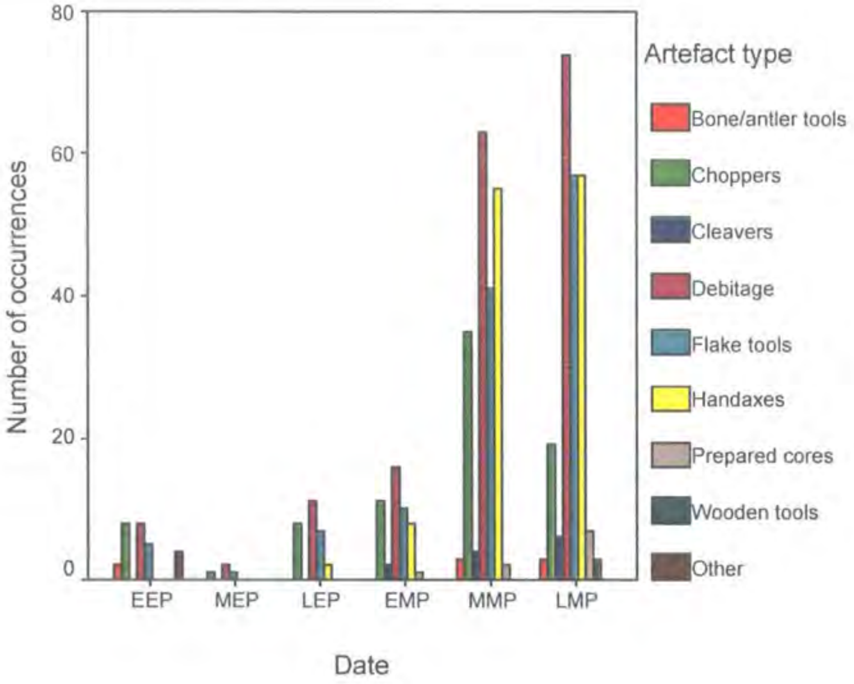


Figure 7.48. Chart showing the number of all possible hominid sites in Europe with occurrences of each artefact type, definitely dated to each major period. N=563.

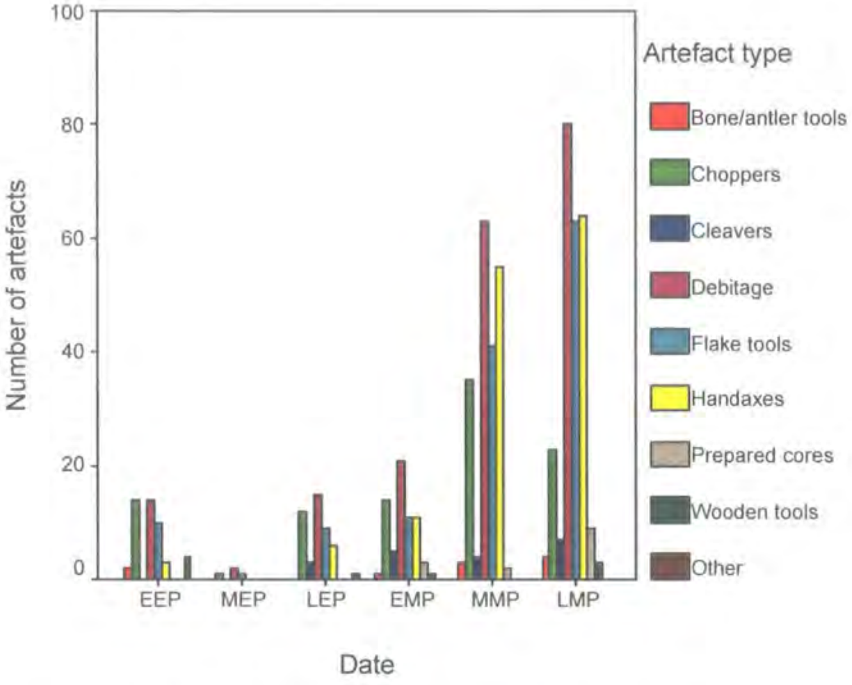


Figure 7.49. Chart showing the number of all possible hominid sites with occurrences of each artefact type, definitely dated to each major period. N=620.

The trends in the prevalence of handaxes and cleavers in the assemblages over time were investigated by calculating the proportion of the sites in each period that contained handaxes, and applying a Spearman's rank correlation test, using the null hypothesis that there is no significant correlation between the proportion of sites with handaxes and the date of the sites. This test was then repeated to include the proportion of sites with either handaxes or cleavers. The tests were applied to the entire study area and to the European data. The Spearman's rank correlation test resulted in identical patterns in the data concerning assemblages containing handaxes, and those with both handaxes and cleavers. The null hypothesis was rejected for all the datasets containing sites dated to the major divisions of the Pleistocene, in both Europe and the whole study area, with the exception of the definite hominid sites with definite dates in Europe. The correlation between the proportion of assemblages dated to oxygen isotope stages with handaxes and time was weaker than the major divisions of the Pleistocene data, and was not significant for the definitely dated datasets. Figure 7.50 shows the strongest relationship, which concerned the definitely hominid produced assemblages probably dated to major date categories, with a Spearman's rank correlation value =1.0 (α=0).

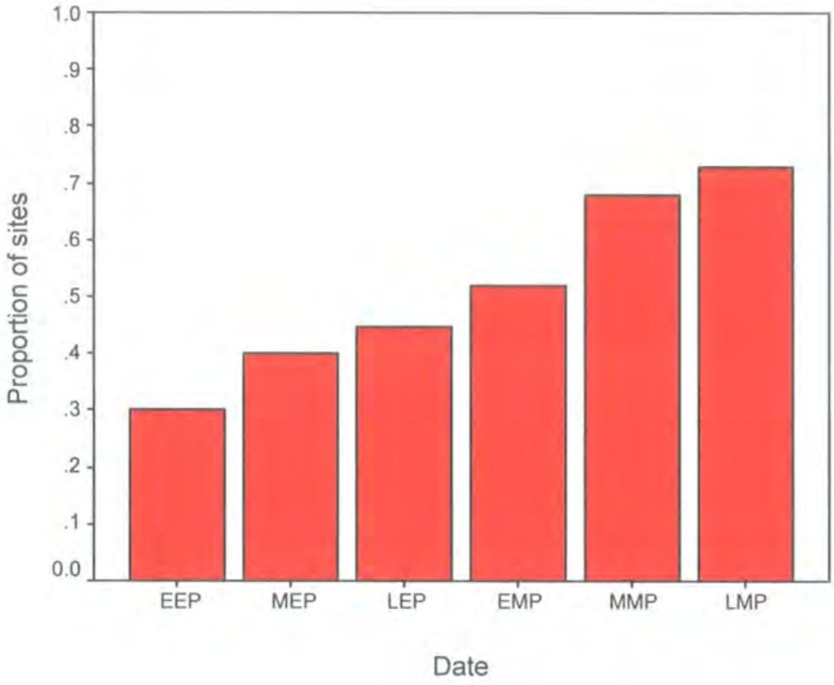


Figure 7.50. Chart showing the proportion of definite hominid sites in the whole study area containing handaxes, probably or definitely dated to each major date category.

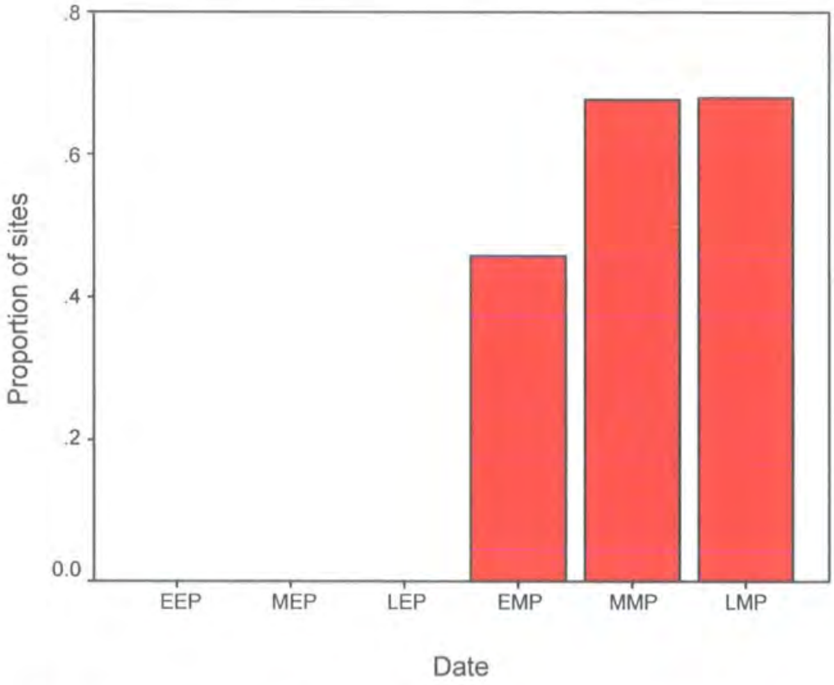


Figure 7.51. Chart showing the proportion of definite hominid sites in Europe containing handaxes, probably or definitely dated to each major date category.

The correlation was weaker in the European data, because handaxes do not appear until the early Middle Pleistocene. The relationship between the proportion of definite hominid sites in Europe that contained handaxes and time, illustrated by Figure 7.51, which is the equivalent dataset to that presented in Figure 7.50, had a Spearman's rank correlation =0.941 (α=0.005). In summary, the proportion of sites with handaxes and cleavers does significantly increase over time, with the exception of the assemblages definitely dated to oxygen isotope stages, for which early dates are not available.

What factors may have influenced the nature of the assemblages?

The lithic data were investigated with the aim of establishing whether the environment in which assemblages had been deposited influenced the nature of the tools. Chi-squared and lambda tests were applied to the null hypothesis that there is no relationship between the environment surrounding a site and the types of artefacts in the assemblage of the site. The chi-squared tests produced invalid results, and the lambda tests provided no significant values in any of the datasets. Therefore, the null hypothesis is upheld, there is no relationship between artefacts and environment.

In order to test whether hominid species were associated with distinct technologies, chi-squared and lambda tests were used to examine the null hypothesis that there is no relationship between the hominid species and the artefact types present at a site. Invalid results were produced for the chi-squared tests, and no significant values of lambda were found in all the datasets. Therefore, the null hypothesis is retained and there is no relationship between the types of artefacts found in a site and the species of hominid present.

The final test conducted on the nature of the lithic assemblages aimed to determine whether the size of an assemblage affected its contents. Chi-squared and lambda tests were applied to the null hypothesis that there is no relationship between the number of artefacts in an assemblage and the types of tools it contains. These tests were conducted using the assemblage size classes of: 0-10, 11-50, 51-100, 101-1000, >1000 tools. The results were invalid for all the chi-squared tests. The lambda test produced no significant results when the data used were limited to definitely dated assemblages, whereas the assemblages with probable dates to either oxygen isotope stages or the major divisions of the Pleistocene, and definite evidence of hominids, produced significant values of lambda. However, the strength of this relationship was weak, with lambda =0.013 (α=0.026) for the major divisions of the Pleistocene, shown in Figure 7.52, and lambda =0.016 (α=0.014) for the oxygen isotope stages. Therefore, there is a very weakly significant relationship between the size of an assemblage and the types of tools that it contains. The trends detected are that prepared cores, cleavers and tools manufactured on organic materials are more likely to be recovered in sites with large assemblages, whereas the other tool forms were equally present in all sizes of assemblages.

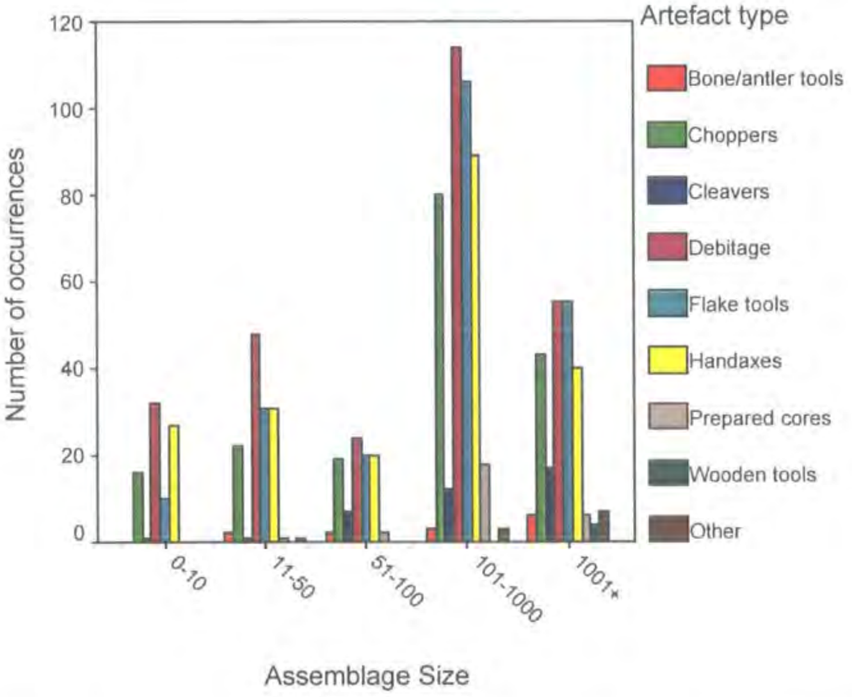


Figure 7.52. Chart showing the number of definite hominid sites containing each type of artefact, by the size of the assemblage, probably or definitely dated to major date categories. N=975.

Do spatial patterns in the occurrence of artefact types exist?

Figures 7.53-7.66 present the results of the spatial analysis of artefact occurrences. These maps aim to reveal whether any types of artefact were spatially restricted in their occurrence, and whether any temporal trends in the spatial patterning of artefact locations have meaningful patterning. The maps show the results for the major divisions of the Pleistocene, as the data concerning the oxygen isotope stage dates followed the same patterning. Debitage, choppers and flake tools were not plotted because these were the most common tool types and were found throughout the study area and period of interest. The maps drawn show the locations of definitely hominid manufactured occurrences of each tool type selected, for each period. The less certainly hominid material was not mapped because the artefacts of interest were only found in probable and definite hominid sites, and the addition of probable sites did not significantly change any of the patterning.

The handaxes and cleavers are presented together in Figures 7.53-7.59, overlying the occurrence of all archaeological sites, in order to highlight the areas that entirely lacked mode 2 industries. All assemblages containing cleavers also contained handaxes, and are labelled as possessing cleavers. The maps show the probably dated samples when no differences are apparent between the dating levels, and both sets of dates if notable differences do occur between the datasets. Figure 7.53 reveals that handaxes dated to the early Early Pleistocene have only been recovered from the Near East, and that no assemblages contained cleavers.

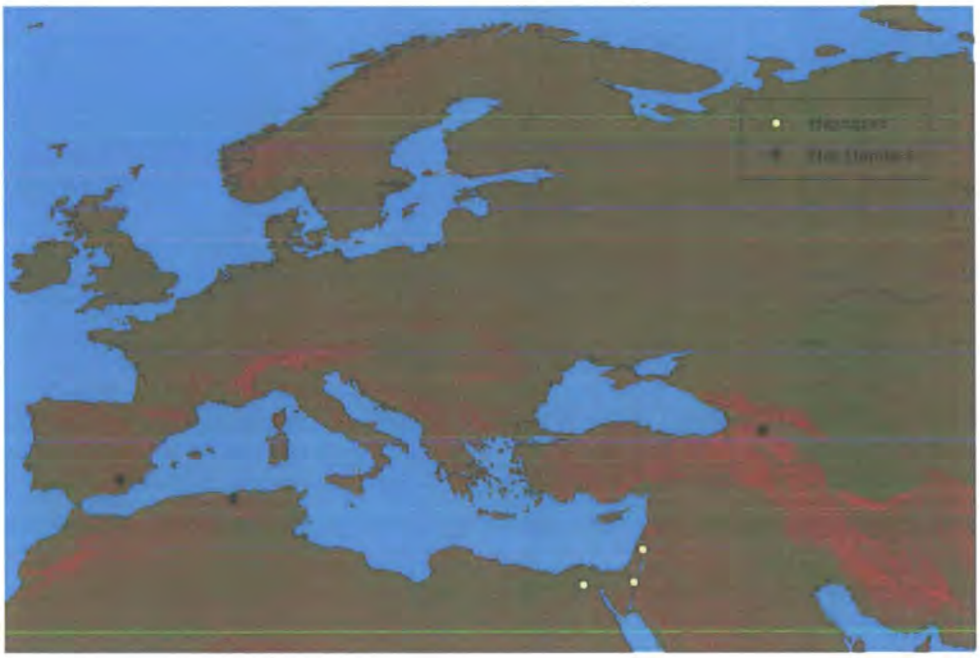


Figure 7.53. Map showing the locations of all definite hominid lithic assemblages probably dated to the early Early Pleistocene, highlighting the assemblages containing handaxes.

Figure 7.54 and Figure 7.55 show that handaxes and cleavers remained confined in the Near East and North Africa during the middle and late Early Pleistocene.

Figure 7.54. Map showing the location of all definite hominid lithic assemblages, probably dated to the middle Early Pleistocene, highlighting assemblages containing handaxes and cleavers.

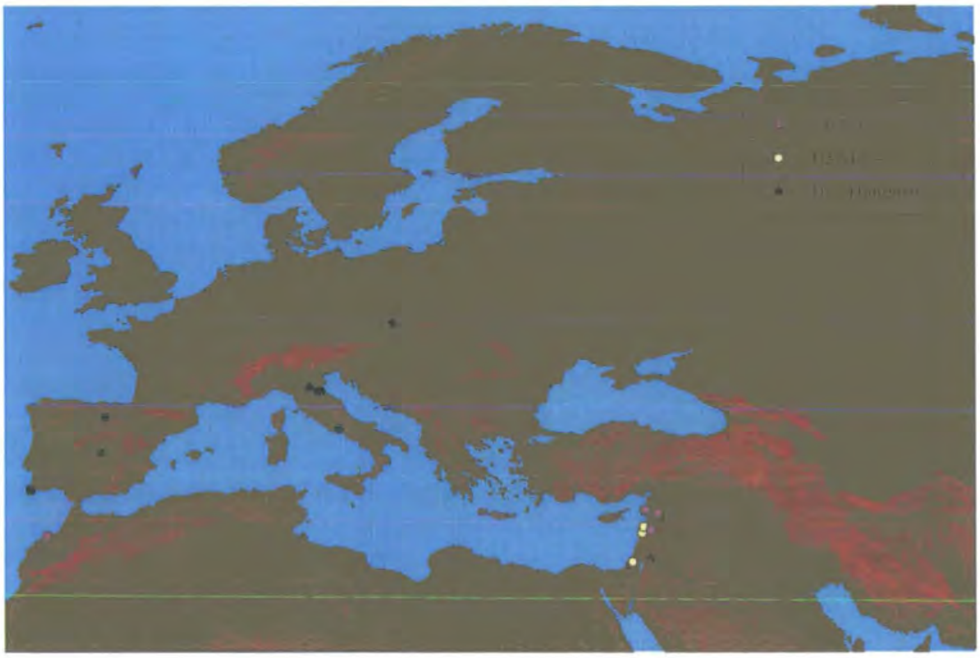


Figure 7.55. Map showing the location of all definite hominid lithic assemblages, probably dated to the late Early Pleistocene, highlighting assemblages containing handaxes and cleavers.

Handaxes and cleavers had appeared in Europe in the early Middle Pleistocene, but were predominantly in the south; the only sites in the north of Europe containing handaxes are Wimereux, La Pointe-aux-Oies (Tuffreau 1971; Agache 1971; Tuffreau and Antoine 1995), and Wissant (Agache 1971) in Northern France, shown in Figure 7.56. In the well-dated material this geographical pattern is more pronounced, with no Acheulean sites to the north of the Alps, illustrated in Figure 7.57. The sites that definitely date to the early Middle Pleistocene and contain handaxes are Venosa-Notarchirico H in Southern Italy (Barral and Simone 1983; Belli *et al.* 1991), Chiuse d'Idice and Cave S.A.F.R.A. in the Po Valley (Cremaschi and Peretto 1988a) and Monte Gazza in the foothills of the Italian Alps. The occurrence of cleavers is restricted further to the west than the handaxes, and is particularly focused on Iberia. The sites that contain cleavers and definitely date to the early Middle Pleistocene are Lis Valley Q2A in Portugal (Cunha-Ribeiro 1992, 1996; Meireles and Cunha-Ribeiro 1996) and San Quirce in Spain (Arnaiz Alonso 1990; Santonja 1995, 1996).

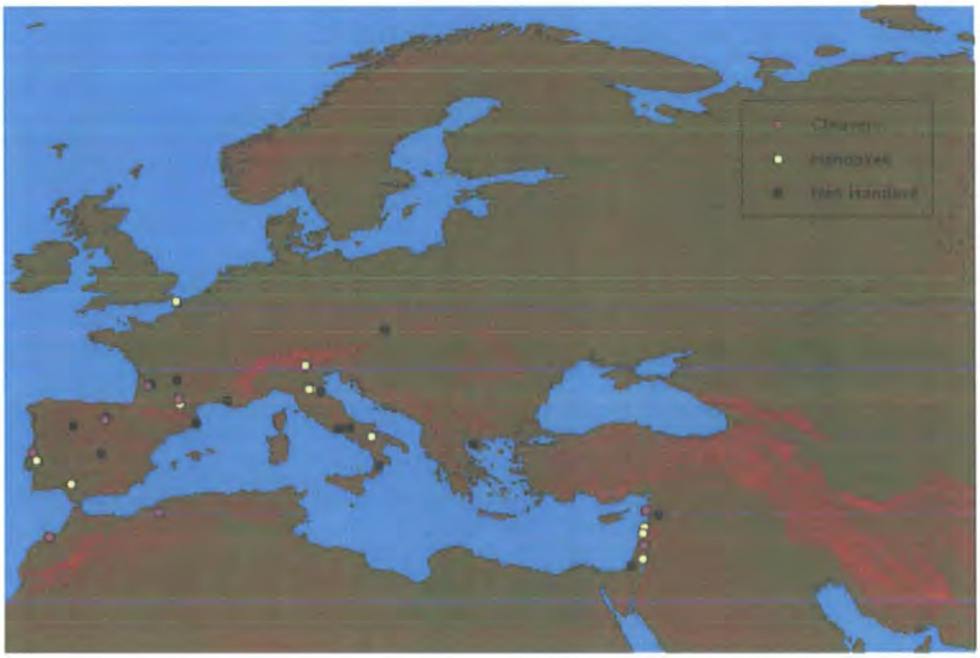


Figure 7.56. Map showing the location of all definite hominid lithic assemblages, probably dated to the early Middle Pleistocene, highlighting assemblages containing handaxes and cleavers.

Figure 7.57. Map showing the location of all definite hominid lithic assemblages, definitely dated to the early Middle Pleistocene, highlighting assemblages containing handaxes and cleavers.

Figure 7.58 demonstrates that sites containing handaxes and cleavers had spread across northwestern Europe by the middle Middle Pleistocene, but were still under-represented in central and northeastern Europe, compared to non-handaxe sites.

Figure 7.58. Map showing the location of all definite hominid lithic assemblages, probably dated to the middle Middle Pleistocene, highlighting assemblages containing handaxes and cleavers.

Figure 7.59 reveals that during the late Middle Pleistocene handaxe assemblages were widespread, and occurred occasionally in Eastern Europe, but cleavers remained confined to the west.

Figure 7.59. Map showing the location of all definite hominid lithic assemblages, probably dated to the late Middle Pleistocene, highlighting assemblages containing handaxes and cleavers.

The spatial patterning of the occurrences of prepared cores is shown in Figures 7.60-7.62. There are no prepared cores dated to the Early Pleistocene, and in the Middle Pleistocene these tools remain extremely rare. The only site in Europe that contained prepared cores during the early Middle Pleistocene, shown in Figure 7.60, was Quinta do Cónego/Pousias (Cunha-Ribeiro 1990, 1992, 1996) in Portugal. The sites in Europe containing prepared cores during the middle Middle Pleistocene, shown in Figure 7.61, were Cagny-la Garenne unit 1 (Agache 1971; Bourdier *et al.* 1974a; Bourdier 1976a; Lamotte 2001) and Saint-Acheul rue Marcelin Berthelot (Commont 1908; Tuffreau *et al.* 1982; Tuffreau and Antoine 1995) in Northern France, and Lunel-Viel/Mas de Caves (Bonifay 1968, 1976, 1991; Villa 1983) in Southern France. In the late Middle Pleistocene prepared cores were more widespread but remained rare. These maps divulge no distinctive spatial patterns, as prepared cores are too rare to discern regional occurrences.

Figure 7.60. Map showing the location of all definite hominid sites containing prepared cores, probably dated to the early Middle Pleistocene.

Figure 7.61. Map showing the location of all definite hominid sites containing prepared cores, probably dated to the middle Middle Pleistocene.

Figure 7.62. Map showing the location of all definite hominid sites containing prepared cores, probably dated to the late Middle Pleistocene.

Figures 7.63-7.66 present the spatial distribution of tools manufactured on organic materials. There is only one site with organic artefacts dated to the Early Pleistocene, shown in Figure 7.63, which is Dmanisi layer IV and V in Georgia (Džaparidze *et al.* 1989; Gabunia *et al.* 2000). There are no sites with organic tools in the middle or late Early Pleistocene, and only two sites with organic tools in the early Middle Pleistocene, which are Ternifine/Tighenif (Balout *et al.* 1967; Geraads *et al.* 1986) in Algeria and Gesher Benot Ya'aqov (Goren-Inbar 2000; Goren-Inbar *et al.* 2000; Saragusti and Goren-Inbar 2001) in Israel, shown in Figure 7.64.

Figures 7.64-7.66 show that organic artefacts remain extremely rare in the Middle Pleistocene, and spread across Europe with the Lower Palaeolithic, rather than forming any discernable regional cluster of occurrences. However, as the sample of sites containing organic material is so small it is impossible to determine whether the use of organic artefacts was more prevalent than usual in any region.

Figure 7.63. Map showing the definite hominid sites containing organic artefacts, probably dated to the early Early Pleistocene.

Figure 7.64. Map showing the definite hominid sites containing organic artefacts, probably dated to the early Middle Pleistocene.

Figure 7.65. Map showing the definite hominid sites containing organic artefacts, probably dated to the middle Middle Pleistocene.

Figure 7.66. Map showing the definite hominid sites containing organic artefacts, probably dated to the late Middle Pleistocene.

The behavioural implications of the Lower Palaeolithic artefact data.

Choppers, debitage and flake tools were found to be ubiquitous to Lower Palaeolithic assemblages, hence the following discussion will focus on the other tool types that present uneven spatial and temporal distributions, which may be related to the processes of movement.

The appearance of the Acheulean.

Figure 7.48 and Figure 7.49 reveal that handaxes and cleavers appear later in Europe than its surroundings, and that these tool forms are not present in the earliest sites in Europe. Thus, a pre-Acheulean phase of European occupation is confirmed, fitting the models of Carbonell and Rolland. However, several explanations of this phenomenon are possible. Carbonell and Rolland explain the pre-Acheulean occupation of Europe by the initial colonisation involving a group that did not possess the Acheulean before entry into the continent, followed by a later phase of movement of handaxe bearing groups. In this scenario the groups possess distinct technology that can be used to trace their route into Europe, and which is not transferred between groups.

Foley interprets the patterning in the appearance of artefact types in a more extreme manner by linking technologies to hominid species. The results of the analysis of the potential relationship between the species of hominids and tool forms refuted this hypothesis. Moreover, the lack of physical differences between hominids found in association with different tool forms undermines the possibility of distinct groups of hominids with unique technologies as the explanation of the pre-Acheulean phase because it is unlikely that groups could maintain cultural isolation over a period of 0.5 Myrs without also undergoing speciation. Nevertheless, the scarcity of the hominid fossil record and the uncertainty over species attributions in the late Early and the Middle Pleistocene, discussed in the previous chapter, result in these findings remaining provisional.

It is possible that the lack of Acheulean sites during the initial occupation of Europe is explained by the movement into Europe occurring in two phases, with the Acheulean associated with the second wave of migration. The second group of hominids would not have been in contact with the initial non-Acheulean occupants, and their movement could be treated as entirely separate, forming a second colonisation event. This scenario differs from the models proposed by Carbonell and Rolland because it does not assume that the non-Acheulean initial population of Europe was either incapable of learning the techniques of manufacturing handaxes and cleavers, or that the two groups continued to exist in isolation from one another after the second dispersal. However, given the small size of the initial population indicated in site numbers and assemblage sizes, it is possible that groups had failed to survive, and that the second wave of migrants entered a relatively or completely empty landscape. The appearance of the Acheulean coincides with the increase in site numbers in Europe during the Middle Pleistocene, which may indicate that both phenomena are linked and explained by fresh movement into Europe.

The alternative explanations to the two-phase model of movement for the lack of handaxes or cleavers in the early sites in Europe are that a sampling effect renders these artefacts archaeologically invisible, or a lag effect relating to the processes of movement prevented the spread of the full range of technologies until later stages of movement. The sampling effect argument relies on the rarity of handaxes and cleavers in assemblages, which can result in reattribution of sites as excavation produces larger assemblages. The weak tendency for larger assemblages to date to the later parts of the study period, shown in Figure 7.1, would support the contention that handaxes have simply not yet been recovered from early assemblages in which they did exist. However, the relationship between assemblage size and date is very weak, especially in the high-resolution data, undermining this potential explanation. Nevertheless, as sites are rare in Europe in the Early Pleistocene, and handaxes and cleavers are rare tools within those sites, it is possible that these tools have not yet been recovered from assemblages that are Acheulean. However, the trend towards an increase in the proportion of sites that contain handaxes or cleavers over time, shown in Figure 7.50 and Figure 7.51, suggests that these tools were absent from a larger proportion of sites during the Early Pleistocene. Furthermore, the absence of any definitely Acheulean sites in Europe in the Early Pleistocene implies that the pattern is more than a sampling problem.

The complete lack of handaxes and cleavers from the early sites in Europe is supported by the spatial patterning over time of these tools. Figures 7.53-7.59 suggest that spread was initiated by hominids without the use of handaxes, followed by the spread of handaxes and finally by cleavers. The more restricted occurrence of cleavers could also be explained by their rarity; for example, the absence of cleavers in Eastern Europe could result from archaeological sites being rare, and cleavers being an unusual aspect of assemblages. The finding that cleavers are only located in sites that contain handaxes suggests that cleavers represent a rare variant of handaxe technology, rather than a distinctively different tool form. This is reinforced by the association between large assemblage sizes and the presence of cleavers, seen in Figure 7.52, which can be interpreted as cleavers being a rare form of handaxe that appears when assemblage size is sufficiently large to include a wide range of variants in technology.

In all regions occupied a pattern of initial assemblages characterised by flake tools, debitage and choppers is seen, followed by the appearance of handaxes and finally cleavers. Handaxes and cleavers are never present in the initial phases of exploration of a region. Therefore, it is possible that these tools are associated with a more substantial phase of occupation, supported by their appearance once sites become relatively numerous. The low levels of incidence of Acheulean assemblages in Central and Eastern Europe can therefore be explained by the later occupation and lower concentration of population in these regions, as the process of population expansion was still occurring at the end of the study period in Northeast Europe. In contrast, Southern and Western Europe show evidence of more substantial occupation that had a greater time depth, and is associated with Acheulean assemblages.

This patterning provides tentative support for an exploratory phase in each region, marked by the absence of Acheulean assemblages, followed by established settlement with a broader range of tool forms, including those that demand a higher degree of investment of time in their manufacture, fitting the expectations of initial ephemeral occupation followed by later less mobile and more substantial settlement. The arrival of the Acheulean in Europe could therefore be interpreted as the spread of larger and less mobile groups, including a greater diversity of demographic groups, creating a more balanced population undertaking a wider variety of behaviours. This exploration-establishment model is distinguished from the two-phase model of movement by there being continuous movement of a single population into Europe, with the later establishment building on the knowledge gained in the initial exploration. The increased diversity of environments occupied during the Middle Pleistocene, discussed in the previous chapter, supports the model of increasing familiarity with the environments of Europe, which can be linked to longevity of occupation and exploration, potentially supporting the exploration-established settlement model over the two-phase model.

The appearance of organic tools.

The late appearance of tools made from organic rather than lithic materials in Europe could be linked to the emergence of the Acheulean in the Middle Pleistocene. However, these materials are extremely rare and are subject to major taphonomic biases. The distribution of wooden, bone and antler tools shown in Figures 7.63-7.66 reveal no spatial patterning or trends in regional occurrences over time, as were seen for the Acheulean assemblages. There is an association between the size of an assemblage and the presence of organic artefacts, shown in Figure 7.52, which can probably be attributed to the better chances of recovery of organic materials in major excavations compared to chance finds of small assemblages. Therefore, taphonomic explanations probably account for the patterning of the organic artefacts, and these tools cannot be used to determine the patterning of hominid behaviour during the population movements into Pleistocene Europe. Nevertheless, the lack of bone tools in northwestern Europe throughout the Middle Pleistocene may be indicative of their genuine absence, in contrast to the material from central Europe.

The appearance of prepared cores.

Prepared cores appear in Europe during the Middle Pleistocene and are also rare and associated with large assemblages. It is possible that some of these artefacts have been incorrectly identified, and their presence in large assemblages is a result of sampling effects among the cores, thus among a large sample of cores some may appear to have been prepared, whereas in a small sample it is unlikely that appearance of preparation will occur. Moreover, the prepared cores may be incorrectly dated, and actually derive from the period immediately following the study, during which core preparation is accepted to have developed. The rarity of these tools results in a lack of spatial patterning to their occurrence, as seen in Figures 7.60-7.62. The appearance of prepared cores seems to match the prevalence of sites in each region during each period.

Comparison of the tools in Europe and its surroundings.

Comparison of Figure 7.48 and Figure 7.49 reveals that the tool forms recovered in European sites are the same as those in the surrounding areas of the Near East and North Africa. The only difference between the tools recovered in Europe and beyond its borders is the time delay in the appearance of handaxes, cleavers and organic tools. Therefore, there is no evidence that innovation in behaviours, predicted by the biological and sociological models, accompanied movement during any of the three periods of potential movement in the Lower Palaeolithic.

Rolland, Carbonell and Foley suggest that the source of the populations moving into Europe can be traced through similarities in manufacturing technology, hence the pre-Acheulean phase must have an origin in a non-Acheulean region, and the later appearance of the Acheulean must be explained by movement of handaxe using groups. However, as Mode 1 industries are an intrinsic aspect of all lithic technology, it is possible that loss of other elements could produce a non-Acheulean technology from areas that did contain handaxes, and thus the spatial patterning of tool forms cannot shed light on the region of origin of the pre-Acheulean occupation of Europe. Nevertheless, as independent invention of handaxe technology seems unlikely, the appearance of the Acheulean in Europe implies a movement either of people or of ideas from an Acheulean region. However, in the early Middle Pleistocene, when Acheulean assemblages first appear in Europe, both the Levant and the Maghreb contain handaxes and cleavers, shown in Figure 7.56 and Figure 7.57; therefore, either of these regions could have formed the source of the European Acheulean. Thus, the spatial patterning of the tool forms cannot be used to determine the source of population movements.

Conclusions.

In conclusion, the data regarding the existence of an exploratory phase of occupation of Europe are ambiguous, and the proxy data sources of increasing local knowledge proved to be poor indicators of the processes of knowledge acquisition at the current state of their recording in archaeological publications. The environmental and landscape data presented in the previous chapter suggest that experience and knowledge of the conditions in Europe did develop slowly during the Early and Middle Pleistocene, but still do not provide conclusive evidence of exploration and learning underlying the processes of movement during the Lower Palaeolithic.

However, the artefacts show that a phase of pre-Acheulean occupation existed, which may be linked to processes of exploration. Furthermore, the existence of behavioural innovations preceding and driving movement has been shown to be an inappropriate model, as the assemblages in Europe contain the same kinds of artefacts as those in the Levant and North Africa, after a time delay for the arrival of handaxes and cleavers. This suggests that the temporal patterning in artefact occurrence in Europe is related to the longevity and density of occupation, rather than innovations before the initiation of the movement. The appearance of the Acheulean in the Levant and North Africa during the early Early Pleistocene, contemporary with the beginning of the pre-Acheulean phase of European occupation could support Carbonell's contention that the Acheulean drove the movement of Oldowan groups through competition. However, the consistent trend during the occupation of each region of non-handaxe assemblages, followed by the arrival of handaxes and ultimately cleavers suggests that processes of movement, rather than an external forcing mechanism created this pattern. Furthermore, there is no technological development in the late Early and Middle Pleistocene in the Levant and North Africa that could have driven the movement of Acheulean groups into Europe.

There are no artefacts unique to Europe during the Lower Palaeolithic, and unless the appearance of the Acheulean in the Middle Pleistocene is treated as an independent indigenous development, there is no evidence of behavioural changes following the occupation of Europe, contrary to the expectations of the ecological and sociological models presented in Chapter 2. Thus, hominids were able to occupy Europe without any substantial behavioural changes that can be detected through the archaeological record.

The following three chapters will present the Upper Palaeolithic data, and will discuss whether the findings concerning the Lower Palaeolithic are also seen during the movement of the Aurignacian. Chapter 11 will then review the similarities and differences between the two study periods, and will discuss the linkages between the findings of both studies and the models presented in Chapters 2 and 3.