

ALBERT RECKITT ARCHAEOLOGICAL LECTURE

Time as a Clue to Cause?

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Introduction

ARCHAEOLOGISTS HAVE FREQUENTLY ASSUMED that by studying archaeological sequences of considerable time depth they can uncover the 'causes' of culture change and cultural variability. One might, therefore, have expected the development of some productive techniques for using time and temporal patterning as clues to past organised structures that responded in different ways to the variables identified as producing 'causal' responses. Given such an expectation, it is reasonable to ask how have archaeologists made use of the intellectual advantage provided by significant, measurable time depth in their data?

When I first asked myself this question, I realised that most statements about archaeological sequences or time-related descriptions of the archaeological record are presented as if events occurring at a specified time in the past conditioned or caused subsequent events. I shall refer to this assumption, which provides the justification for claims that gradual culture change connects one component of a sequence with another, as causal principle A. Another common supposition, which I shall call causal principle B, is that if correlations between event sequences in two different observational domains can be established, then one set of these synchronous but independent changes can be cited as having caused the other. This is the customary rationale for claims that past environmental or demographic changes are responsible for

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particular changes in the domain of human culture, in the absence of any theory outlining the necessity of the suggested causal linkages.

The preceding principles are commonly used by persons who elevate systemic variables to the level of causes, as well as by those who postulate that the causal buck stops with human actors or agents. There is a difference, however, in the frequency with which archaeologists appeal to one or the other of these alternative causes. In my experience, persons who postulate agents¹ as causes are more comfortable with principle A and if they wish to deal with independent observational domains, they usually adopt the classic functionalist—essentially psychological—perspective that developed in Social Anthropology during the 1930s and continued through the early 1960s.²

When temporal patterning in cultural material varies in a regular way across a geographic region or regions, humanists or ‘action theorists’ postulate that human actors caused the pattern, either by influencing other actors—resulting in trait diffusion—or by migrating and transporting some or all aspects of their culture with them. Archaeologists—even those referring to themselves as archaeological scientists—have debated the probabilities of diffusion and migration since its earliest days, and, when they have observed geographically graduated temporal patterning, have tended to revert to their humanist roots by appealing to diffusion or migration to ‘explain’ the patterning they have observed. This is especially true when attempting to deal with the fact that in most places on earth in the past, hunter-gatherer groups experienced a transformation into agro-pastoralists, horticulturists, or some other societal form whose subsistence was not based on hunting and gathering.

I hope to demonstrate that the dynamics that are represented by the term diffusion do not constitute an explanation but rather, when diffusion appears to have occurred, it is itself a phenomenon that requires an explanation. The same standards apply to a radiation or temporally graduated geographic distribution of phenomena, which does not simply ‘happen’ but is the result of the interaction of sometimes numerous

¹ Arguments of this type usually hinge on assumed or generalised characteristics of the actors that permit one to imagine ‘human’ scenarios depicting how persons would behave either in general or under special conditions normally thought of as socially interactive. The locus of cause in such instances is vitalistic because it refers to essential properties of the actors themselves. Most humanistic causal arguments take this form.

² Structuralism took vitalism to an extreme by attempting to uncover structures of the mind that were postulated to underlie human behaviour and act as the vital causes of observable phenomena.

factors. I will also explore the idea that because causal conditions are likely to be distributed in a gradually changing pattern across geographic space, the results of causal processes will be similarly distributed. When I speak of ‘causal conditions’ I am referring to properties and conditions that influence, mould, or organise the actions of agents, particularly human actors, and as such, I am addressing myself directly to one of the fundamental and most contentious issues in archaeology—that is, does a humanistic view of history truly explain historical subject matter?

Arguments about Subsistence Change in Europe at the Close of the Pleistocene

The argument I will present here about the nature of causal processes is based on a large-scale, comparative study of hunter-gatherer groups drawn from the ethnographic record of the last several hundred years (Binford, forthcoming). I realise that some researchers dismiss the relevance of these cases to any discussion of hunter-gatherer groups that may have existed in the past, largely on historical grounds (e.g., Schrire 1984; Wilmsen 1989). This dismissal can be viewed as the negative side of historicism, which—in positive mode—presents itself as an attempt to organise the results of dynamic processes operating in the past by postulating event sequences (Marcus and Flannery 1996: 30–2) or thought transformations (Hodder 1990). The latter represents the essential and unique cognitive and volitional skills of human actors which are believed to underlie the behaviours that archaeologists cite in their attempt to accommodate, in human terms, the patterning observed in the archaeological record.

The different faces of historicism are well illustrated in the archaeological literature dealing with the spread of pottery and domesticated plants across Europe in the early Holocene. There are dramatically different views about what happened and why. Some discussions begin as examinations of dynamic processes but lapse into historical reconstructions as more details are introduced. I refer to schema of this type as local process, large scale historical arguments, an excellent example of which is the synthesis by Dennell (1983) of a variety of discrete arguments for regions in general (see also Smith 1994).³ For example,

³ Almost all of Dennell’s criticisms of demographic ‘wave of advance’ arguments are compelling and he has many good ideas.

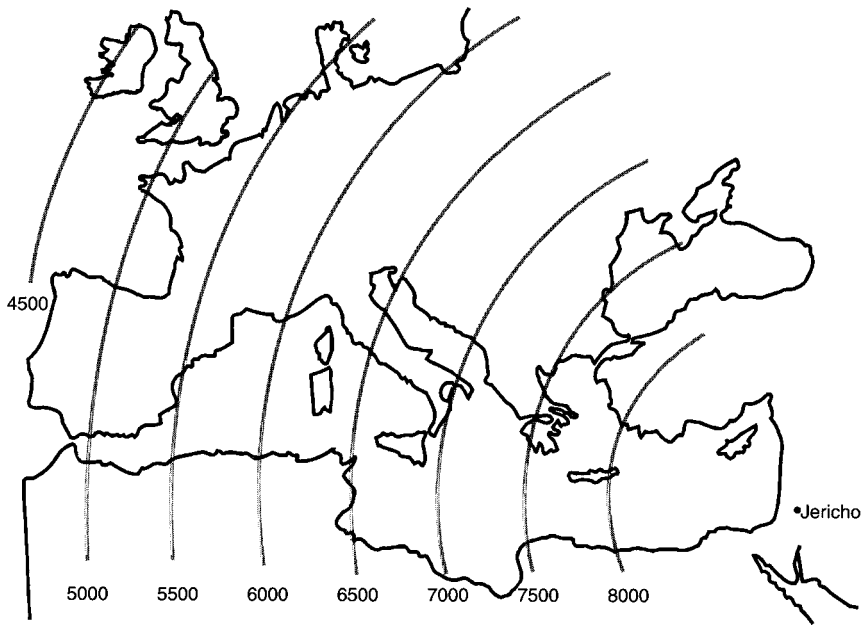


Figure 1. The 'wave of advance model' for the spread of agriculture. Redrawn from Ammerman and Cavalli-Sforza 1971: 685.

he explains why the postulated appearance of 'Neolithic colonists' is not very likely in many regions of Europe, but then he creates a series of 'micro-stories' that purportedly chronicle the events that occurred in various discrete locations. Dennell weighs the possibility that the domestication of plants and animals occurred independently in particular localities and considers the many, slightly different circumstances that could condition a variety of responses once domesticated plants and animals became accessible (see also Zvelebil and Rowley-Conwy 1986).

In marked contrast, the 'macro-argument' initiated by Ammerman and Cavalli-Sforza (1971, 1973, 1979, 1984)⁴ created a 'wave of advance' model, illustrated in Figure 1, to explain a documented geographic gradient of C-14 dates from agro-pastoral communities appearing first in Anatolia and spreading westward across Europe. The latest communities to appear were in northern Scotland and in the eastern Baltic region. Figure 2 displays a graphic summary of the data on which

⁴ The broad outlines of the pattern were documented earlier by J. G. D. Clark (1965).

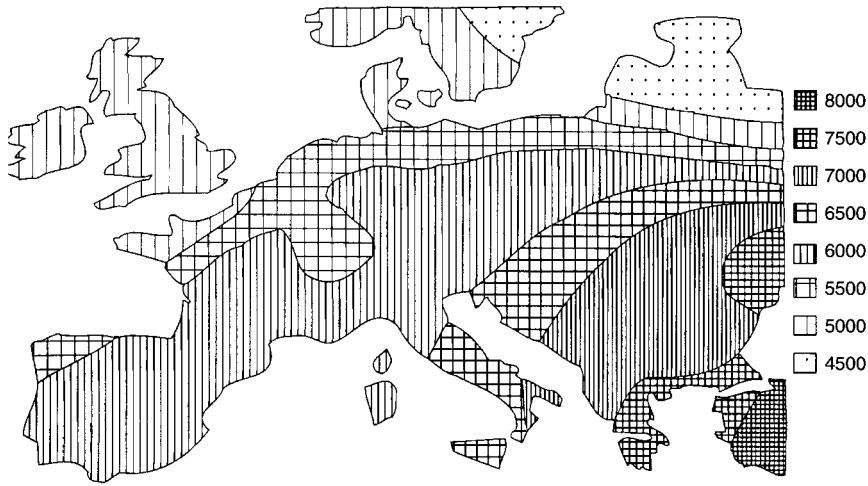


Figure 2. Radiocarbon dates for early domestication. Isopleths based on information in Ammerman and Cavalli-Sforza 1979.

Ammerman and Cavalli-Sforza (1984, Site list 4.1) based their claim that the archaeological record corresponds to their historical model, but it is obvious that their model and reality diverge in significant ways.

In the nearly two decades since this argument was elaborated, many new data have been accumulated and more sophisticated methods of data analysis have been developed. New domains of putatively supporting evidence from genetic studies have been amassed (Cavalli-Sforza 1988; Cavalli-Sforza 1991, 1996) and Renfrew (1987) has challenged the prevailing view of the spread of Indo-European languages by arguing forcefully that the distribution of these language groups coincided with the postulated spread of horticultural peoples during the 'wave of advance' modelled earlier by Ammerman and Cavalli-Sforza (1971, 1973, 1984; and Cavalli-Sforza 1988, 1991, 1996). The spread of 'Neolithic indicators' is certainly well documented and that this spread set in place conditions that remain evident in contemporary European populations also seems probable. What, then, caused this patterning? Cavalli-Sforza has argued that the practice of horticulture is responsible for increased rates of population growth and that excess population forced demographic expansion into new regions surrounding the growing population. The authors acknowledge that this process, referred to as 'demic diffusion', often operates together with trait diffusion and

results in the ‘wave of advance’ which is said to be supported, or at least not contradicted, by the chrono-geographic patterning.

I think it is clear that the traditional interpretative conventions that I discussed earlier are simply being applied to some fascinating archaeological patterning.⁵ I cannot detect any new components to the old arguments, except perhaps the sneaky introduction of post-domesticated driven population growth as a fundamental cause. Although there has been significant research documenting the archaeological patterning underlying the wave of advance scenario, it surprises me that the original arguments have not been widely challenged.⁶ Zvelebil (1986) emphasises the role of Mesolithic societies in modifying the paths to their ultimate transformation into horticulturists and agro-pastoralists. There is also a recognition that horticulture occurs in response to pressures to intensify the subsistence base and that in some Mesolithic settings, other responses occurred. This view is based on arguments by Harris (1977) that quite rightly shifted the discussion from the ‘origins’ of domesticates to the need to extract more and more resources from smaller and smaller segments of the landscapes, which is what I mean by intensification.

I think it is relevant at this juncture to ask whether the current historical narratives, which cumulatively describe chronological patterning, actually explain the way horticulturists and pastoral populations behave under conditions of population growth? We must also ask whether there is any reason to believe that agro-pastorales always fission and segment as the wave of advance ‘theory’ requires? I hope to demonstrate that the answer to both questions can be found by examining the responses of hunter-gatherer groups to population growth and associated pressures to intensify their subsistence base, which will, in turn, clarify the role played by domesticated plants and animals in processes of this kind.

⁵ I do not mean to imply that no excellent work exists on archaeological patterning at the close of the Pleistocene, with particular reference to the appearance of agro-pastoralism. Mithen’s work (1990) is provocative and informative and the long term publication record of Straus represents a constructive research program. The fascinating research by many Scandinavian researchers, as well as the analytical work of Rowley-Conwy, Zvelebil, Zilhão, Rozoy and others are all testimony to the progress made in recent years.

⁶ Except for Zvelebil (1988) and García (1997), most researchers have focused on the causal primacy of trait diffusion as opposed to demic diffusion or migration. To my knowledge, the demographic components of the argument have not been challenged.

Some Features of Process among Hunter-Gatherers

I first want to share some recent findings about the behaviour of hunter-gatherers (Binford, forthcoming) that support the view that demographic growth could have fuelled a wave of advance as hunter-gatherer populations moved into previously unoccupied lands capable of supporting their particular foraging niche. These findings do *not* support the view that a wave of advance would necessarily result from increased population within niche space already occupied. Even more provocatively, the findings provide no support for the argument that a segment-and-migrate process would occur among hunter-gatherer groups that might be exploring the use of horticultural techniques or even among early stage horticulturalists or agro-pastoralists that were not engaged in warfare or violent competition, unless a new niche had opened up. The full details of my argument are beyond the scope of this presentation but I will summarise the six basic components that are germane to this discussion:

1 Mobile hunter-gatherers live in small, self-organised groups that minimise the costs of mobility by limiting the number of participants in the group. When conditions favour population growth, the self-organising properties of mobile hunter-gatherer groups result in increased numbers of groups whose size remains relatively constant.

2 Once population density rises to the level of 9.098 persons per one hundred square kilometres, mobility is no longer a viable strategy for insuring subsistence security. I refer to this level as the 'packing threshold' and it occurs in a region as a result of the fission of parental groups into new filial groups which eventually 'pack' the landscape originally occupied by only parental groups. This process of replication eventually results in reduced mobility options for all groups. When a population density in a one hundred square kilometre area reaches the level of 9.098 persons, a group of minimal size can cover the area still available to them from a single central place location.

3 Given the preceding conditions, group sizes have been found to vary during the course of an annual subsistence cycle. During the annual cycle, most hunter-gatherers have been observed to maintain both very small groups that are engaged in regular subsistence activities as well as large subsistence-oriented groups. In the following discussion, these will be referred to as Group I and Group II units.

4 Optimal group sizes were found to vary with the trophic level of the primary sources from which foods were accessed. Significant differences were found among peoples who primarily exploited terrestrial plants,

terrestrial animals, and aquatic resources. The largest Group II units occurred among groups dependent upon terrestrial animals (Group II mean of 39 persons), while the smallest Group II units occurred among peoples dependent upon terrestrial plants (Group II mean of 22.91 persons). The group size of peoples primarily dependent upon aquatic resources differed depending upon the type of aquatic resources exploited but, more importantly, varied with the kinds of terrestrial alternatives that were available.

5 Consistent with the preceding statements, hunter-gatherers who were primarily dependent upon terrestrial animals exhibited important responses to a level of population density that was considerably lower than the 9.098 person threshold noted for groups dependent upon terrestrial plants. Among hunters, major changes in subsistence strategy occurred at a population density value of 1.57 persons per one hundred square kilometres. At that point, a bifurcation occurred in the strategies pursued; some groups concentrated on increasing their subsistence diversity and while others became more specialised. Once a population density level of 9.098 persons per one hundred square kilometres occurred, however, all hunter-gatherer groups that had once been primarily dependent upon terrestrial animals were forced to choose other subsistence options.

6 On the other hand, hunter-gatherer groups that were primarily dependent upon aquatic resources did not exhibit any thresholds in group size. In three different subsets of such cases, all experienced a gradual reduction in the mean size of their Group II units as population density increased, which represented a response to the segmentation and in-filling of subsistence ranges as populations increased. The reduction was the statistical result of the increasing number of small Group II units in the region, even as early settlements stayed the same size or increased in size but not in relative number. In settlement systems terms, this pattern represents the development of a settlement hierarchy within the subsistence range of each ethnic group.

In spite of the fact that, based on the food resources exploited, the three subsets behaved very differently with respect to the packing threshold of 9.098 persons per one hundred square kilometres, when group sizes were examined, all three responded dramatically to this threshold in terms of measures of sedentary settlement, various measures of social complexity and changes in the character of leadership, trade practices, the appearance of product specialists, and adjustments in kinship conventions and marriage practices. In fact, all of the indicators used to identify 'complex hunter-gatherers' only appeared

at or above the packing threshold, except for wealth differentials and storage. Wealth differentials may occur among groups that are dependent upon either aquatic resources or terrestrial animals at almost any level of population density while, other things being equal, storage scales inversely with the length of the growing season. Achieved wealth is, therefore, not an indicator of complex society nor is storage dependence in high latitudes.

Cases occurring on either side of the packing threshold are, however, very different kinds of systems when viewed from an organisational perspective. The overall character of the changes that appear at this threshold demonstrates that change tends to be punctuated, but this is not to say that gradual change is not correlated with increasing population densities prior to the packing threshold. As packing reduces the mobility options for hunter-gatherers, a sequential set of organisational accommodations to increases in intensification pressures certainly does occur. In fact, one might say that there are several indicators of intensification recognisable prior to the packing threshold, although the 'emergent' character of the appearance of new types of cultural systems at the packing threshold represents change of a different order. The break in continuity and the new forms that appear immediately after the threshold could not be anticipated, even if one had full knowledge of the systems extant prior to reaching the threshold.

At this point I want to focus on what is known about the diversity of responses to intensification leading up to the packing threshold. Hunter-gatherer groups that are primarily dependent upon terrestrial plants can only intensify their food procurement by increasing the yield from plants per unit area or by expanding their dependence upon aquatic resources in settings where this alternative exists. Groups dependent primarily upon animal resources, on the other hand, can shift to plants in settings where this is possible but most ethnographically known hunters have occurred in settings with mean effective temperature (ET) values of 13 degrees centigrade or less.⁷ This temperature value corresponds to approximately 42 degrees latitude in the contemporary world, where conditions are characterised by diminishing growing seasons as latitude increases, making plants an unreliable subsistence alternative. At locations with ET values of less than 13 degrees, the most productive alternative is to shift to aquatic resources, when these are available. It

⁷ ET has reference to the mean temperature in degrees centigrade at the beginning and end of the growing season (Bailey 1960).

is important to remember that shifting to alternative resources or increasing aquatic specialisation begins to accelerate at a population density of only 1.57 persons per one hundred square kilometres and that, once the packing threshold is reached, primary dependence upon terrestrial animal resources is no longer possible. Aquatic resource dependence appears to be primarily a density dependent response but it may, however, occur prior to the packing threshold as part of a general trend toward increased subsistence diversity stimulated by increases in population density. It may also provide the basis for a radiation into environments in which a purely terrestrial adaptation is not feasible.

I have now summarised what I have learned about some of the ways that hunter-gatherers cope with increases in their numbers relative to some important features of their environments, and how their basic subsistence-focused social units are organised. The implications of these observations are far reaching. For instance, if the argument standing behind the 'packing theory' is correct, we must imagine that every location on earth at which hunter-gatherer population densities exceeded 9.098 persons per one hundred square kilometres would have also experienced organisational changes making it possible to support many more people in the same area by pursuing primarily non-hunter-gatherer land-use and subsistence strategies. Archaeologists have traditionally referred to some of these changes as 'the appearance of domesticated plants and animals' but much more than that was involved. 'The appearance of complex hunter-gatherers' is a better descriptor of changes in some environments and a large range of new organisational variability took the form of agro-pastoral adaptations or 'hunter-gatherer-horticulturists' or other previously unseen cultural systems.

In addition to recognising population density and a habitat-driven diversity in accessible foods as major dimensions conditioning variability both before and at the packing threshold, my analysis of hunter-gatherer data identified two other conditioning dimensions: the niche breadth of the subsistence base and a scalar dimension (Johnson 1982) that only becomes a causal factor once the packing threshold is exceeded. These four dimensions were observed to interact causally to influence organisational variety among hunter-gatherer groups and direct trajectories of change, once population density levels increase beyond the packing threshold.

Niche breadth is a term that refers to the number of independently scheduled trophic levels or biotic communities from which a group regularly extracts food resources. I discovered that the hunter-gatherer

groups in my data set most often resorted to an expansion of niche breadth in response to increases in population density occurring prior to the packing threshold. Increases in the niche breadth tended to stabilise hunter-gatherer systems and provide subsistence security and there is some evidence that secure systems tended to change at slower rates after reaching the packing threshold.

Changes in the scalar dimension did not appear to impact hunter-gatherer societies at densities below the packing threshold. It did condition major changes after the threshold was reached, however, and these seem to relate primarily to integrative institutions as well as decision making bodies. In fact, ranking and ‘big man’ types of leadership hierarchies are demonstrably related to a scalar threshold in settlement sizes, in interaction with primary dependence upon aquatic resources.

Given the outline of the packing theory that I have presented, most would agree that whatever factors cause population density to vary from place to place or time period to time period would also directly condition the system state characteristics of hunter-gatherer groups and, in particular, the state of such systems relative to the packing threshold. Other things being equal, the packing threshold should appear across geographic space at different times depending upon the length of time that populations had been increasing in a region and the dynamics responsible for the differential rates of population growth. One would therefore anticipate culture change to be both chronologically and geographically patterned. I will now explore whether or not the knowledge gained from my analysis of a large hunter-gatherer data set contributes to an understanding of the archaeological patterning evident across Europe at the close of the Pleistocene.

Modelling Hunter-Gatherers’ Population Structure in Europe at the Close of the Pleistocene

It is well known that large regions of Europe were unoccupied at the time of the glacial maximum (Housley *et al.* 1997). In fact, other things being equal, the area of the earth covered by glaciers—which is illustrated in Figure 3—and the regions contiguous to the ice fields should have been uninhabited. Outside of this unpopulated zone, the distribution of human foragers between 20,000 and 18,000 BP can reasonably be thought of, other things being equal, as responding to climatic conditions which varied as a result of their distance from the centre of glacial



Figure 3. Ice distribution at 18,000 BP.

activity. The more impact the continental glaciers had on human habitats, the more reduced human populations in such regions were likely to be. I would also expect isopleth lines for population growth rates to increase gradually from zero as distance from the centre of the glaciers increased. Even in non-glaciated, mountainous regions, this model would anticipate that the one major feature that would change postulated conditions would be elevation: the higher the elevation, the less likely the occurrence of habitat conditions favourable for human occupancy. Similarly, we would expect a gradual reduction in the ability of habitats to support substantial population growth as a simple function of latitude: the higher the latitude, the lower the rate of population growth, other things being equal.

Although modelling the detailed geo-environmental pattern of variable rates of population growth is beyond the scope of this discussion,⁸

⁸ The time required to calculate reconstructed climatic estimates for a given location is considerable. At the time that I began work on this paper, estimates had been developed for forty-two weather stations as part of another research project, and these were mostly located in an east-west zone extending from Romania to Great Britain. As I began to prepare this manuscript, additional locations were calculated to provide a few points along the Mediterranean coast and near other key locations. In spite of this effort, only 11% as many locations were reconstructed as were used in making a base map for Europe, for which 404 sites contributed to the map features.

this does not mean that I cannot sketch the broad outlines of the factors conditioning such rates. In fact, a model already exists for technologically unaided humans which assumes that food was the only limiting factor on population growth and that all food comes from terrestrial species.⁹ For purposes of this presentation, I have used this terrestrial model as a minimalist estimate for the relative food limitation on population growth. Because I realised that 'man does not live by food alone', an additional model was developed, based on information recently summarised by Low (1988), to project the degree to which growth rates based on a limited food supply would be further depressed when the pathogen load was factored into the model. Low has demonstrated the existence of a strong relationship between the maximum number of potentially lethal pathogens and latitude. Translating this relationship into temperature estimates has allowed me to project the effects of pathogens on population growth rates at different locations. Once the bare bones model was constructed, it was used to calculate values for climatic sequences that were reconstructed for European locations using techniques developed by Reid Bryson (1989a; 1989b; 1992; 1997) at the Center for Climatic Research at the University of Wisconsin, who, together with colleagues (Bryson and Goodman 1980 and 1986; Bryson and Bryson 1995 and 1997), has formulated a high resolution, site specific method for reconstructing past climates. Using this method,¹⁰ mean monthly estimates of temperature and rainfall were produced for specific archaeological sites, although the technique is applicable to any location for which longitude, latitude, and elevation are known.¹¹ The summary mean monthly estimates of rainfall and

⁹ See Binford (forthcoming, chapter 6). This model does not include the use of aquatic resources since reliable, large-scale data on marine and aquatic productivity could not be obtained. This means that estimates of aquatic dependence should relate strongly to residual differences between modelled and observed case values.

¹⁰ In December 1997, the Brysons conducted an archaeoclimatological workshop at Southern Methodist University during which interested faculty and students were taught how to use their method of climatic reconstruction. Following this introductory tutorial, my colleague, Amber Johnson, consulted with the Brysons at the University of Wisconsin in order to clarify some technical aspects of their procedures. A follow-up visit by the Brysons to SMU, scheduled for the summer of 1999, will focus on linking my efforts to calculate derivative values for a variety of ecologically relevant variables such as net above-ground productivity to their reconstructive procedures.

¹¹ The procedure is straightforward for locations where there are modern weather stations but it is more complicated for archaeological sites and other locations of interest, such as where pollen samples have been taken, for which extrapolations for contemporary weather summaries become necessary.

temperature are generated continuously in two hundred-year intervals from the present to 14,000 BP and in five hundred-year intervals thereafter until 40,000 years ago. These basic data are needed to utilise many equations that transform climatic data into useful environmental information such as net above-ground productivity, as well as to project data about ethnographically documented hunter-gatherers onto any environmental landscape (Binford, forthcoming). In turn, the Brysons' synoptic climate reconstructions provide the basic data for modelling reproductive rates. All of these recently developed techniques are certain to stimulate some interesting debates initially at the methodological level. In this context, however, I am primarily interested in their potential to produce high resolution temporal sequences outlining the climatic conditioners of habitat variability as a way of generating useful ideas about the causes of observable patterns in the archaeological record.

Some results of our modelling efforts are presented in Figure 4, which displays the reproductive rates that are projected to have occurred across Europe 12,000 years ago. The overall pattern supports my earlier expectation that growth rates at this time period should grade dramatically from south to north in Western Europe. I had expected that the isopleth lines would depict an analogous distribution, but one with different configurations relative to the accumulation of

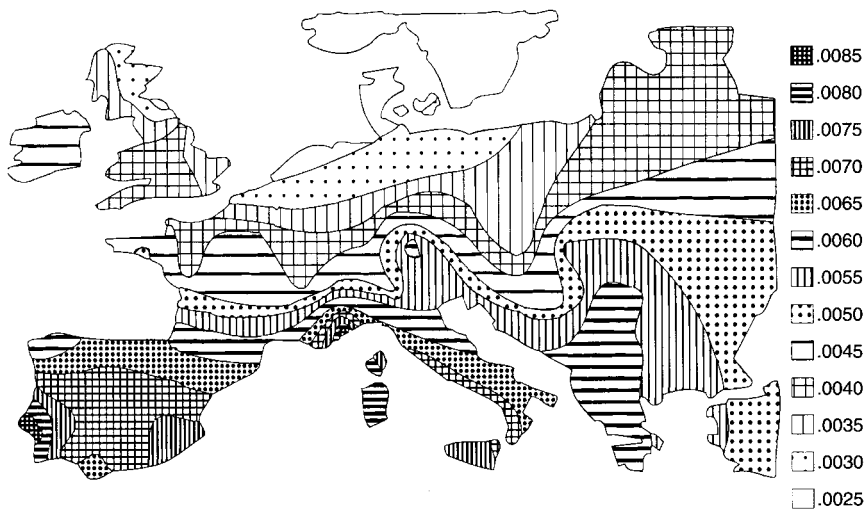


Figure 4. Modelled reproductive rates at 12,000 BP.

ice fields that resulted from continental effects on temperature and decreasing rainfall as contemporary, winter rainfall dominated, eastern Mediterranean habitats began to emerge. The pattern in Figure 4 essentially confirms my expectations for the period during which populations had recently re-entered zones that had formerly been uninhabited during the glacial maximum (Housley *et al.* 1997). Figure 4 illustrates that there are three northern lobes of higher growth rates and a western lobe centered on northern France that coincides with the concentration of well documented Magdalenian reindeer hunters located on the Paris Plain (Audouze 1987). The central lobe in south central Germany also corresponds to a focus of well documented Magdalenian reindeer hunters (Weniger 1987; 1989), while the larger area of the eastern European lobe includes areas of eastern Czechoslovakia, eastern Hungary, western Belarus, and western Romania (Dolukhanov 1996; Montet-White 1994: 488–9). This area also supported Magdalenian reindeer hunters in the west and Epigravettian hunters in the east. Given the climatic conditions prevailing at 12,000 BP, northward-moving hunter-gatherer populations should have had their antecedents in these three centres of higher growth (see Dolukhanov 1996: figure 11).

Conditions at 12,000 BP are explored further in Figure 5 in which a projected primary dependence upon terrestrial animals and plants is mapped. During this time, Scandinavia, the northern part of the Netherlands, and western Germany are projected to be uninhabited and all of Europe, except for areas of Spain and Portugal, Sardinia

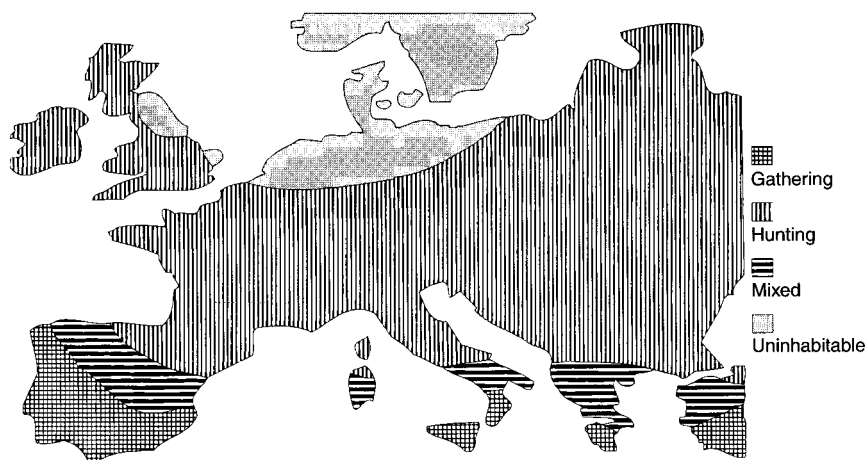


Figure 5. Modelled initial conditions for subsistence at 12,000 BP.

and Corsica, southern Italy, Sicily, southern Greece, and southern Turkey, is projected to be primarily dependent upon terrestrial animals for subsistence. The Mediterranean locations are expected to have been primarily dependent upon terrestrial plants and separated from more northern regions by a zone of mixed resource exploitation. It must be realised, however, that all of the islands situated in the northern Mediterranean were uninhabited at this time.¹² In light of the aspects of my hunter-gatherer research that I have previously summarised, I would expect very different trajectories of intensification in the geographical zones in which terrestrial plants, as opposed to terrestrial animals, were primarily exploited. Intensification leading to greater niche breadth in the diet occurs at population density levels of 1.57 persons per one hundred square kilometres¹³ and is expected in areas in which an aquatic alternative is available to hunters. Among plant dependent peoples, further increases in plant dependence, increased exploitation of smaller body-size animals, and an expanded use of aquatic resources in locations in which an aquatic alternative is available is anticipated. Consistent with these expectations, it is notable that a shift occurred from the exploitation of large mammals to the increased use of rabbits, hedgehogs, and birds along the central Mediterranean coast of Spain and there is also evidence of the exploitation of marine resources (Villaverde, Aura, and Barton 1998: 178). In regions in which aquatic resources were not accessible, a marked intensification in the use of plant resources should be accompanied by a very dramatic reduction in dependence upon moderate to large body-size terrestrial animals and a slow pattern of change. In zones of mixed subsistence, the pattern of exploited resources should resemble patterns in plant dominated zones.

Figures 6 and 7 illustrate projected changes at 9,000 BP in reproductive rates and subsistence indicators, reflecting the shifts in environmental conditions that began after 12,000 BP. The simulated conditions are roughly coincident with the beginning of the Boreal period in the European bioclimatic sequence. By this time, northward expanding

¹² Controversial data from Sardinia (Lewthwaite 1985: 546) documents faunal specimens dated to 13,590 BP that were excavated and reported by Sondaar *et al.* (1984). I was fortunate to have been able to examine these specimens shortly after their discovery and, although the modified bones of *Megaceros cazioti* were interpreted by the discoverers as evidence of butchery by humans, I saw no evidence of human involvement. While the modifications, particularly to skulls, were distinctive, I believe they were attributable to relatively small canid-like creatures.

¹³ This density value corresponds to a situation in which a single economic group of hunter-gatherers has easy, uncontested access to six ranges, each equal to approximately 225 sq. km.

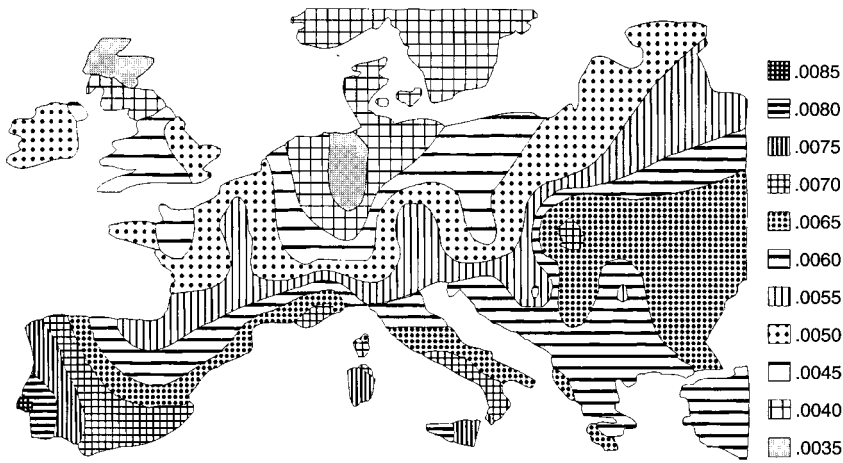


Figure 6. Modelled reproductive rates at 9,000 BP.



Figure 7. Modelled initial conditions for subsistence at 9,000 BP.

populations, among whom aquatic resource exploitation was already important, were approaching sections of Finland, and even though ice fields remained in the mountains of northern Sweden and Norway, hunter-gatherers were extending their range into parts of these areas at the same time that, further west, populations were appearing in Scotland and highland Wales. Further to the south, red deer and other forest-dwelling species replaced the reindeer that had been present in France during the Younger Dryas. As Figure 6 indicates, reproductive

rates increased more rapidly on both the western and eastern margins of the northern parts of the map and are projected to occur in Ireland and in eastern coastal regions of England, although Ireland was not yet inhabited. Comparable increases in reproductive rates project northward into sections of Estonia, Latvia, and Lithuania.

The three bulges in reproductive rates in mid-latitude Europe at 12,000 BP, which are illustrated in the map in Figure 4, are still visible in Figure 6. The bulge in central France appears to have extended into eastern portions of England and there is no change in the bulge in southern Germany. The bulge in central Europe is still observable in eastern Czechoslovakia and Hungary and western Romania and the higher rates have now extended eastward to the shores of the Black Sea. The west central portion of this bulge includes the region in which, at a later time period, the earliest 'complex Mesolithic' systems such as those at Lepenski Vir (Srejović 1972) occur, followed by a precocious use of domesticated plants and animals. In Figure 6, southern Europe looks much like it did at 12,000 BP. High rates of population growth are centred on areas of Portugal and a pronounced increase in the use of aquatic resources is noted after 10,000 BP (Aura *et al.* 1998: 90). Comparably high rates of population increase are distributed along the northern Mediterranean coast with high rates occurring in Sardinia, Sicily, southern Italy, and the Greek islands although, with the exception of Sicily, all of these regions continue to remain uninhabited.

Figure 7 indicates that substantial changes in environmental conditions occurred across major regions of Europe at 9,000 BP, resulting in greater usable plant biomass that, in general, is linked to increases in the length of the growing season. The region in which hunter-gatherers are primarily dependent upon plant resources now includes all of Spain and Portugal as well as a diagonal slice across the southwestern corner of France. In those areas of southern Sardinia, Italy, Sicily, Greece, southern Albania, and some regions in Turkey in which hunter-gatherers are present at this time period, dependence upon terrestrial plant resources is anticipated. This pattern indicates that resource intensification can be expected across the entire northern Mediterranean area at a relatively early date. After 9,000 BP, the major differences in responses to intensificational pressures in this area should arise from (1) the availability of an aquatic alternative and (2) the actual levels of population packing that occurred among hunter-gatherers in different localities in the region. Shell mounds appear for the first time in the archaeological record of the northern coast of Spain at approximately

9,000 BP (Straus 1979: 318), although an earlier occurrence of small-scale salmon exploitation dates to the Magdalenian (Hayden, Chisholm, and Schwarcz 1987), as does evidence of the inclusion of shell fish in the diet (Straus 1991: 100). Similarly, recent research has placed shell mound occupations along the coast of Portugal at 10,000 BP (Zilhão, 1993: figure 1).

At 8,000 and 7,000 BP, the geographical distribution of centres of high and low population growth projected to have occurred at 9,000 BP—and presented in Figure 6—continues in roughly the same locations. There are, however, changes in the absolute value of the growth rates, which are higher as one approaches the present, indicating the presence of increasingly more ‘user friendly’ environments. Shifting conditions result in the northward extension of the zone of terrestrial plant dependence so that by 7,000 BP, hunter-gatherers in Greece, the former Yugoslavia, and Bulgaria would have been primarily dependent upon plant resources. At 6,000 BP, continuity in the locations with high reproductive rates is clearly represented in the maps in Figures 8 and 9. The geographical distribution of modelled reproductive rates for terrestrially adapted hunter-gatherers has stayed essentially the same except for the tendency at 9,000 BP, noted in Figure 6, for the north-eastern and northwestern edges of the distribution to converge toward the centre of the region of low growth rates situated along the Baltic coast. By the eighth millennium, the archaeological record of this region contains spectacular Mesolithic cemeteries in northern Russia

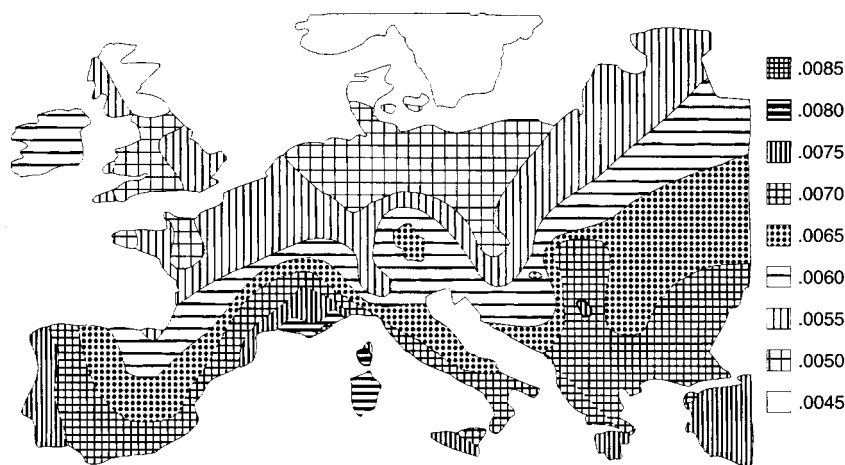


Figure 8. Modelled reproductive rates at 6,000 BP.

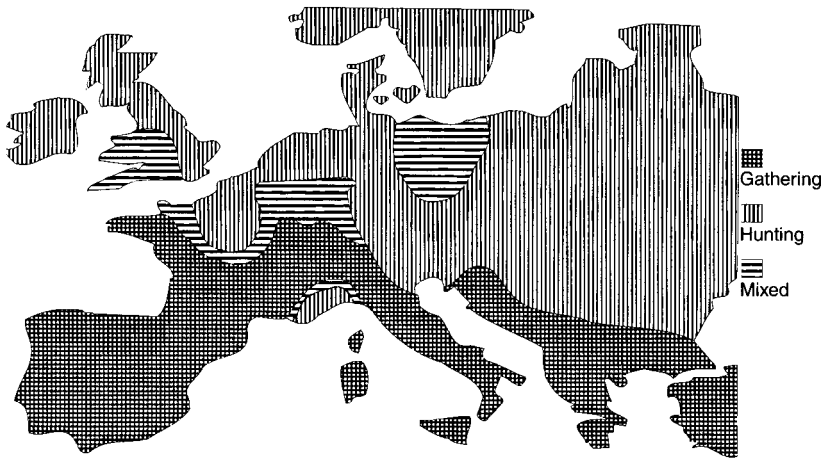


Figure 9. Modelled initial conditions for subsistence at 6,000 BP.

and into Estonia (Dolukhanov 1996: 47–60). Higher rates of growth continue in southern Germany and in areas of the Hungarian-Romanian plain between the Carpathian mountains and the Alps. The only difference between this and previous patterns is that higher reproductive rates now extend southward across Greece and Bulgaria. This new distribution represents a marked change from previous patterns, including those projected to have occurred at 7,000 and 8,000 BP, but the highest rates of population growth continue to be projected for the islands along the northern Mediterranean coast and Turkey, southern Italy, and western Mediterranean coastal areas extending to the Atlantic coast of Portugal. These mainland localisations remain provocative centres of European population expansion.

The recurrent features of the maps from different time periods have consistently identified a number of centres of potential population growth across Europe. Except for the Mediterranean islands, the major patterns of radiation are described by a series of isopleth lines trending southeast to northwest with higher values in the east that fall into a depressed lower arc extending from Scandinavia into the northern European plain (Figure 8). When this pattern is compared to the pattern of isopleth lines based on the C-14 dates used by Ammerman and Cavalli-Sforza (1984) to warrant their argument for a wave of advance model of Neolithic indicators, a striking similarity is observable. It is worth repeating that this wave was thought to have been



Figure 10. Updated isopleth map of radiocarbon dates for early domestication. Isopleths based on information in Ammerman and Cavalli-Sforza 1979 and Renfrew 1996.

initiated and driven by demic diffusion fuelled by higher rates of population growth in areas already utilising domesticated plants or animals.¹⁴ A swamping or displacement of Mesolithic occupants by advancing agro-pastoral peoples is implicit in this argument. It is important to note that a detailed set of similarities exists between the reproductive rates projected by my model for hunter-gatherer populations at 6,000 BP and the dates for Neolithic indicators.

These two complementary patterns are illustrated in the maps in Figures 8 and 10 and it is clear that the patterns on both the eastern and western sides of the two maps are remarkably similar. Given the differences in the scaling of the isopleth lines, this comparison provides a remarkable fit between the dated sequence in Figure 10 and the environmental conditions standing behind the projections of reproductive rates in Figure 8, which must have fuelled differential responses to intensificational pressures among the hunter-gatherer groups. The major difference between the two patterns occurs in the bulge of relatively early dates in Figure 10 that extends into the north central zone of

¹⁴ There is no question that the authors believed it was possible for Neolithic traits to spread from *either* demic or cultural diffusion. The mechanisms most frequently discussed, however, related almost exclusively to demic processes. It is also true that 'changes in population densities often took place concurrently with the shift to agriculture' (Ammerman and Cavalli-Sforza 1984: 63).

projected low reproductive rates and was a recognizable feature of all of the maps projecting population growth since the glacial maximum. In terms of archaeological features, the bulge corresponds to dated deposits that document the spread of the 'Linear Pottery Culture' typified by long houses and unequivocal dependence upon domesticated plants and animals (Milisauskas and Kruk 1989). I will discuss this fascinating pattern in more detail later, but at this juncture I want to point out the fit between the projected distributions of hunter-gatherer reproductive rates at the close of the Pleistocene and into the Holocene and the dates of the spread across Europe of Neolithic indicators.

Examination of the Exceptions

Although the overall fit between the patterns in Figures 8 and 10 is impressive, a significant opportunity to learn more about the dynamics underlying these patterns would result from an examination of the exceptions and situations in which there appears to be a lack of fit. The first important contrast is found in the late dates of Neolithic indicators relative to the pattern of simulated reproductive rates along the Atlantic coast of Portugal and the Mediterranean coast of Spain. For instance, on the map in Figure 4 of projected population growth rates at 12,000 BP, higher anticipated rates of population growth were projected for the Iberian peninsula than for Greece or Turkey. This projection is inconsistent with the C-14 chronology and contradicts the expectation that packing related intensification would be synchronous with early indications of high rates of population growth in the Iberian peninsula. The inconsistency is clarified, however, by the pattern in Figure 11, which presents a series of modelled reproductive rates for Lisbon in the last 20,000 years. Rates of population growth are depressed during the glacial maximum during which the archaeological record contains widespread Solutrean industries in the region. At approximately 17,000 BP, the rates increase, reaching a high point at approximately 11,400 BP and then dipping again during the Younger Dryas. A short period of recovery immediately thereafter coincides with the appearance of shell mounds along the northern coast of Spain and—at 10,000 BP—along the coast of Portugal (Zilhão 1993: 9). The projected date for regional packing of terrestrially based hunter-

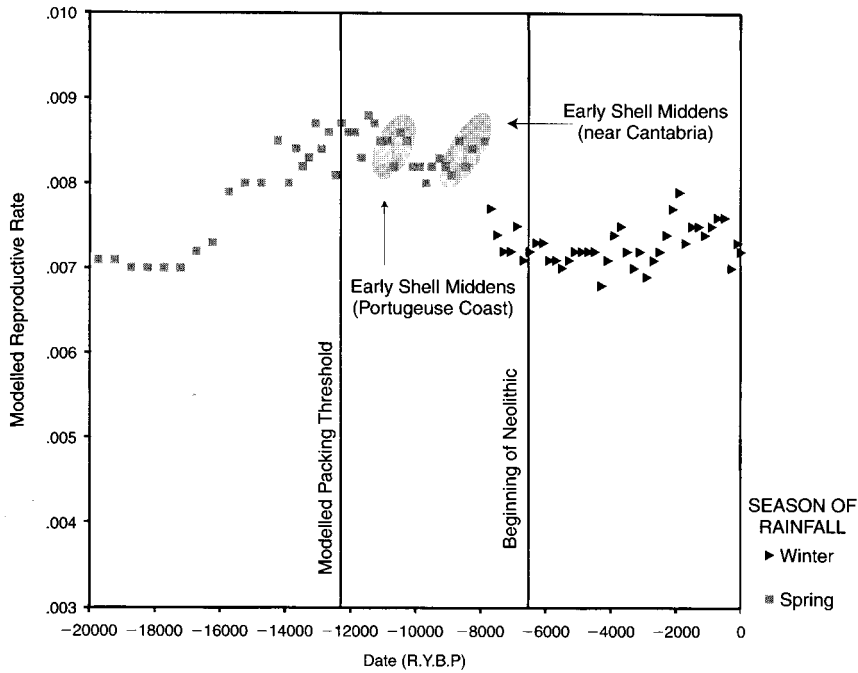


Figure 11. Reconstructed reproductive rate sequence: 20,000 years BP to present at Lisbon.

gatherers at Lisbon is 12,300 BP, which is long before sea levels approached contemporary levels, making the degree of correspondence to the evidence difficult to assess. The early, systematic exploitation of marine resources in the region is, however, consistent with the projection that populations in the region crossed the packing threshold at a relatively early time.

Following the short-lived environmental recovery at the end of the Younger Dryas, population growth rates are progressively lower, in association with a shift to primarily winter rainfall, which signals a drier climate and the onset of more typically xeric Mediterranean vegetation. Standing behind the apparently inflated growth rates along the Portuguese coast is the simple fact that our model does not permit negative rates. It is quite likely that already intensified populations exploiting aquatic resources decreased along the coast for a period after 8,000 BP, which would produce an oscillation in growth rates and result subsequently in populations approaching and crossing the packing threshold for a second time.

The graph in Figure 12 illustrates the more normal pattern derived

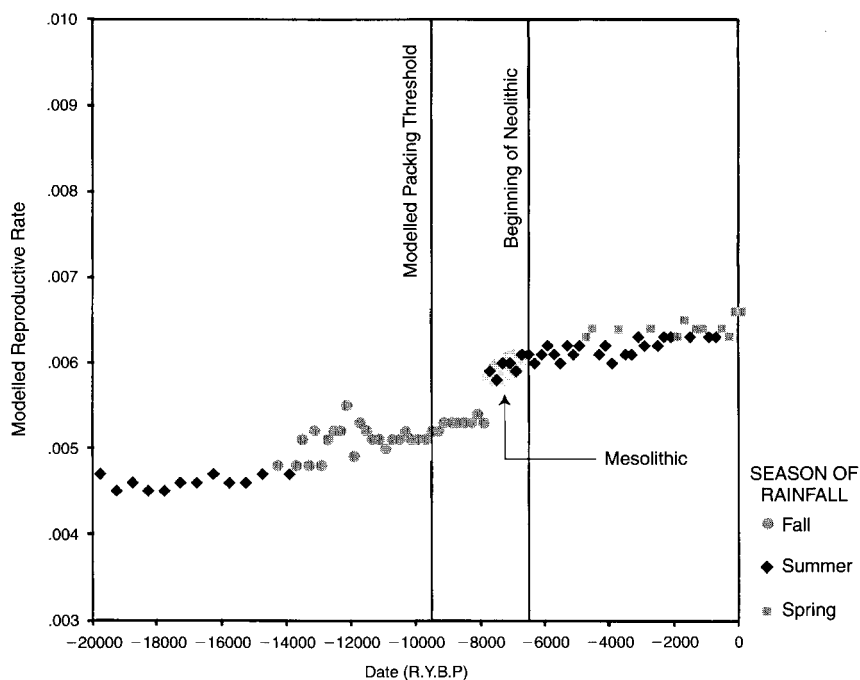


Figure 12. Reconstructed reproductive rate sequence: 20,000 years BP to present at Lepenski Vir.

from the model using data from the Iron Gates region near the Mesolithic site of Lepenski Vir. Here the packing threshold is reached at 8,300 BP but the rates of population growth remain relatively flat thereafter until approximately 8,000 BP, when there is a big jump corresponding to the initial occupation by complex hunter-gatherers who were exploiting aquatic resources. The archaeological sequence at Lepenski Vir contains a Neolithic occupation dated to approximately 6,500 BP, which fits nicely with the modelled rates of population growth.

I have now presented two examples of European locations at which projected levels of population density exceeded the packing threshold, either just before or roughly coincident with archaeological indications of major organisational changes. Among the ethnographically documented peoples in my global sample of hunter-gatherers these changes are associated with reaching and exceeding the packing threshold. The next example is interesting because it represents the appearance of Neolithic traits in the Paris Plain just north of the Magdalenian site of Verberie, including a dependence upon domesticated species that

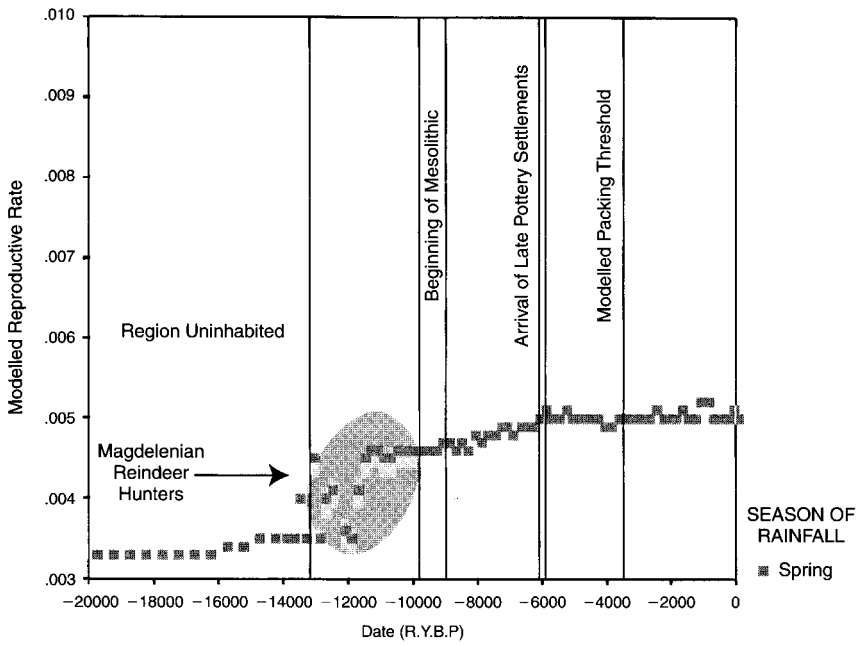


Figure 13. Reconstructed reproductive rate sequence: 20,000 years BP to present at Le Marais.

predates the packed conditions projected by my model of reproductive rates. The rates of population growth projected by the model are almost perfectly consistent during the early part of the sequence which, as Figure 13 illustrates, begins with an almost static period between 20,000 and 13,250 BP during which the region was apparently uninhabited. The first obvious jump in projected rates coincides with the archaeological record left by the Magdalenian reindeer hunters at the sites of Pincevent and Verberie, who dominated the region until approximately the end of the Younger Dryas. The archaeological record indicates that bow-using Mesolithic peoples next occupied the region, leaving lithic evidence of the stability of their scale of land use (Rozoy 1998: 82) that persisted until the apparent intrusion into the region by the Linear Pottery Culture and the establishment of settlements dated to approximately 6,000 BP (Ilett 1983: 9). This so-called intrusion occurred more than two thousand years before the model of reproductive growth rates anticipates that packing would occur in the region, prompting me to ask why is the model so inaccurate?

If I did not know the answer to this question, an additional clue

could be found in the isopleth maps in Figures 8 and 9 that—taken together—make it possible to compare the projected reproductive rates and the distribution of C-14 dates across Europe at 6,000 BP. The major difference in the overall patterns presented in the two maps is the dramatic westward extension, north of the Alps and generally south of the northern European Plain, of uncharacteristically early dates (see Figure 9), given the projected low reproductive rates in the same region (see Figure 8). This area is defined by the westward extension of Linear Bandkeramik pottery and associated settlement and house types that have been linked to the use of domesticated animals and plants and is probably the least controversial example of a population or niche expansion in the European archaeological sequences. In fact, the Linear Bandkeramik has been used by Ammerman and Cavalli-Sforza (1984: 73–6) to illustrate and warrant their model for a wave of advance fuelled by demic diffusion. In a previous analysis (Binford, forthcoming: chapter 7), I have presented new evidence to support the view that the spread of Linear Bandkeramik materials was correctly modelled by Ammerman and Cavalli-Sforza (1984), in spite of recent scepticism (Whittle 1996: 205). I will shortly discuss this fascinating phenomena in greater detail, but before I do, I need to clarify what is meant by the term niche in relation to cultural systems.

Is a new niche created when consumers add a new source of food to their list of previously exploited foods? Does the use of domesticated plants indicate the appearance of a new niche in those situations in which the previous subsistence base consisted primarily of terrestrial plants? In other words, can a new niche be said to have appeared when a change has occurred in the subsistence base? One source of guidance can be found in the biological sciences where the idea of niche originated. In the biological literature it is quite clear that niche is not defined by what one eats but by the tactics of exploitation. For example, two species may consume the same range of plant species, but one eats young plants while the other eats the same plants when they are more mature. This tactical difference signals that the predator species occupy different niches. Applying this rule of thumb to cultural systems, we can ask what kinds of changes can be said to signal a new niche? In the case of the Linear Pottery culture, why are the chosen subsistence options thought to represent a new niche while the alternatives selected by other Neolithic cultures are not, or are interpreted as ambiguous? Two criteria that are helpful in deciding when a new niche has appeared are: (1) there is a clear tactical contrast between the

parental and the filial niche; and (2) there is an ability to exploit a new biotic zone in ways that were not possible using the tactics of the parental niche. In addition, the stability and security of the occupants of the new niche should exceed the stability and security of the prior occupants of the same niche space, and the overall supportable biomass must increase across the niche space in question.

I will now explore the utility of these principles by focusing first on the example of the occupants of a terrestrial niche who are embarking on their initial exploitation of aquatic resources. If, for instance, the hypothetical occupants of a terrestrial niche simply begin to pick up previously unutilised aquatic species at low tide along a rocky beach, does this constitute evidence of a new niche? If walking and directly accessing such resources requires no new tactical behaviours than were involved in picking fruit or digging roots, then this example does not represent the development of a new niche.

If we now return to the Linear Bandkeramik example, its parental antecedent is usually considered to have been the Körös culture centered on the Hungarian plain (Whittle 1987), which is situated in the easternmost bulge of high reproductive rates first identified in Figure 6. During the parental era, horticulture consisted largely of flood plain cultivation (Kosse 1979: 147) in a region in which there was insufficient rainfall to practice rainfall horticulture exclusively. Typical settlements were located directly on river levees and a considerable percentage of the occupants' diet came from wild species, including aquatic resources and forest animals (Kosse 1979: 149). Domesticated animals consisted primarily of sheep and goats, although cattle and pigs were also exploited, but to a lesser degree. In marked contrast, the filial Linear Bandkeramik niche was based on rainfall agriculture and the exploitation of wild species was greatly reduced. At this time, cattle and pigs were the most extensively utilised domesticated species. The subsistence strategies of the Linear Bandkeramik period were obviously very different from its parental Körös culture and there here is little doubt that these new strategies made a much higher level of human biomass possible in the region, which is reported to have supported very few Mesolithic societies and, in many locations, none at all (Tringham 1971: 63). The subsistence security of Linear Bandkeramik peoples was undoubtedly much greater than the Mesolithic cultures it superseded and I think the Linear Bandkeramik clearly represented a new niche.

The emergence of a new niche is frequently followed by a relatively rapid filling of the niche space—that is, the geographic region in which

the essential habitat conditions necessary to the success of the new niche are distributed—which results from either increased reproductive rates within the new niche space or in-filling by adjacent and local populations that adopt the new niche strategies. These demographic dynamics occur because population levels in the parental niche have risen in response to the vital security provided by the old niche and reached intensification response mode as a result of density dependent pressures building within the niche space. At such a juncture, the niche has become habitat limited and it is not possible to expand the niche space. It is in this context that huge advantages accrue to groups that experiment with new adaptive strategies. Successful innovations allow the practitioners to escape the environmental limitations of the parental niche, as well as the limitations that demographic packing have placed on earlier populations living in the former niche space.

The best known ethnographic example of this niche-related process is the recent, well-documented history of the occupation of the Great Plains of North America. Quite early in the history of American anthropology it was established that the occupants of the Plains environmental zone shared a basic cultural inventory, even though all of the culturally similar peoples came from different ethnic backgrounds and spoke different languages (see Binford, forthcoming: chapter 9). In the eighteenth and nineteenth centuries, most of the sedentary groups that had previously practiced horticulture along the margins of the Plains acquired horses and shifted to a mounted hunter subsistence strategy that was highly mobile. As such, Plains dynamics represent an empirical challenge to the assumptions of stylistic similarity underlying cladistic syntheses, as well as the fundamental assumptions standing behind most historical reconstructions of cultural, linguistic, and genetically based social units (see Moore 1994). Although it is possible to explain variability in cultural systems and to recognise and explain the appearance of new niches, this one example makes clear that patterns appearing to represent cultural continuity or breaks in tradition must not be interpreted as reliable clues to either ethnic identity or continuity.

What, one might ask, are the consequences of having developed a model of reproductive rates that is tied to the effects of climate change on the abundance and availability of terrestrial resources as tempered by pathogen load? Clearly, any conditions that make aquatic resources accessible should increase reproductive security and result in increased rates of growth. This means that all groups that responded to intensification pressures at the close of the Pleistocene and during the early

Holocene by shifting to increased exploitation of aquatic resources should be situated in regions in which the reproductive rates presented here exhibit values that are depressed below the 'real' values for at least some portion of the time sequence. In such circumstances, other things being equal, populations in regions of the world in which hunter-gatherers intensify by increasing their dependence upon aquatic resources should reach the packing threshold somewhat earlier than is anticipated by the reproductive rates presented so far.¹⁵ Additionally, populations should have increased in Brittany and some regions of the British Isles, Denmark, and the Netherlands as sea levels rose and the newly flooded regions were abandoned in favour of higher ground by the occupants of lowland terrestrial regions during glacial periods. The relatively few locations for which complete environmental reconstructions have been developed and to which the early stage reproductive rate models have been applied are summarised in Table 1.

Conclusion

In this presentation I have tried to demonstrate that population growth rates will exhibit different temporal patterning in response to differences in the trajectory of climatic change and that they will be differentially distributed geographically under conditions of environmental stasis as well as during periods of climatic change. Patterning of this

¹⁵ Calculation of the population growth rate begins at the glacial maximum of 18,250 BP unless there is clear evidence that the region was uninhabited at that time, in which case the C-14 date of the initial reappearance of humans in the region is used. If clear evidence of a viable population exists prior to the glacial maximum established for Western Europe, and if it was sustained throughout the glacial maximum until after the appearance of domesticated plants and animals, then that date is used. A constant of twenty persons was assumed to be the initial group size at all locations. A value of 120 persons was interpreted as an indication of packing in each location and represents the point at which the ancestral group has produced five additional groups of the same size that fill in the area originally used by the founding group. This pattern has been determined empirically by studying ethnographically documented hunter-gatherers.

If one is interested in anticipating when local groups might arrive at a critical state of intensification-driven change, it is necessary to know the starting date for population growth, since the number of compounding intervals (generations of 25 years, in this instance) must be known in order to calculate a population at a given point in time relative to the size of the originating population. (The actual dates at which populations can be said to begin to grow during the close of the Pleistocene will be explored later.) The equation for this calculation is $y = x(1 + r)^n$ when y = size achieved at a given time, x = size of population at the starting date, r = the rate of growth, and n = the number of temporal intervals between x and y .

Table 1. Date of initial Paleolithic occupation and anticipated packing date of sites in Europe and the Middle East.

City	State	Date of Initial Occupation (BP)	Anticipated Packing Date (BP)
Jerusalem	Israel	20,500	10,100
Palermo	Italy	18,250	12,900
Almeria	Spain	18,250	12,300
Lisbon	Portugal	18,250	12,300
Volos	Greece	18,250	9,900
Sparta	Greece	18,250	9,700
Beograd	Yugoslavia	18,250	10,100
Budapest	Hungary	18,250	9,900
Bucharest	Romania	18,250	9,500
Drobeta	Romania	18,250	8,900
Osijek	Yugoslavia	18,250	8,100
Muenchen	Germany	14,250	6,300
Ampoix	France	13,100	3,900
Cambridge	United Kingdom	12,900	3,900
Le Marais	France	12,900	3,500
Oostende	Belgium	12,900	2,900
Exmouth	United Kingdom	12,900	3,100

kind insures that any formal characteristics of cultural systems that may be linked to differential rates of population growth, such as density, will also be linked to temporal and geographical patterning. I have argued that at least two distinct thresholds are density dependent and that when hunter-gatherer systems reach or exceed these population levels, predictable intensificational responses will result, depending, of course, upon a group's subsistence strategies prior to reaching the thresholds. Since the models of population growth used in this demonstration were based exclusively on the accessibility of terrestrial resources, I have noted that in regions in which hunter-gatherers are shifting to aquatic resource exploitation, the packing threshold would be reached prior to the dates listed in Table 1. This expectation is met in coastal locations such as Oostende and Exmouth, where, using the terrestrial rates of growth, packing would not be expected until the Bronze Age.

I began this presentation with a question regarding the degree to which archaeologists use time and temporal patterning as a clue to cause. During my discussion of this issue I said that I would try to demonstrate that diffusion is not an explanation, nor is radiation or demic diffusion, since these terms, at best, refer to events or the consequences of events,

which are the phenomena that require explanation. I have argued that two basic processes have explanatory potential: intensificational processes and expansive processes associated with the development of new niches. Once intensification is more completely studied, archaeologists should be able to identify regular temporal sequencing associated with intensificational trajectories in different settings. The appearance of new niches is, however, a different story. New niches represent punctuated changes marking major reorganisations of cultural systems. As such, they may appear in the archaeological record of hunter-gatherers and other small-scale societies as discontinuities relative to earlier niche-based responses to pressures to intensify subsistence. New niches ensure that there will be major contrasts between the archaeological remains of former and subsequent niches. In contrast, accretional changes within an intensificational trajectory look more like a gradual series of changes, although within such a trajectory, major disjunctive reorganisations may occur which ensure that a full knowledge of the prior system will not permit one to anticipate the features of the new emergent system nor identify it as a descendant of the earlier, well known parental niche.

Archaeologists have for too long assumed that ethnicity can account for the differences between assemblages when a simple measure of formal similarity is used to arrange variants in cladistic or even more unrealistic, linearly-linked schemes across a temporal frame of reference.¹⁶ Sequences of formal properties have been assumed to be surrogates for a temporal sequence and, in turn, a temporal sequence was considered to be a clue to cause if it diverged from the customary pattern of a graduated temporal series. The consequence has been more than one hundred years in which a logical tautology has served as the justification for postulated event sequences that are interpreted in causal terms from patterning in the archaeological record.

Note. The author wishes to thank Michael Bletzer for his literature search and help with map design, Joseph Miller for preparing climatic reconstructions and

¹⁶ This procedure has been used to devise evolutionary sequences in archaeology and is the method of choice of postmodernists postulating ideological linkages across long temporal sequences in which major changes occur (e.g., Hodder 1990). The only difference between the approaches is that evolutionists have focused on chronologically undetermined empirical phenomena while postmodernists have applied their interpretative inferences to warranted chronologies.

illustrations, and Nancy Medaris Stone for her editorial contributions to the manuscript.

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