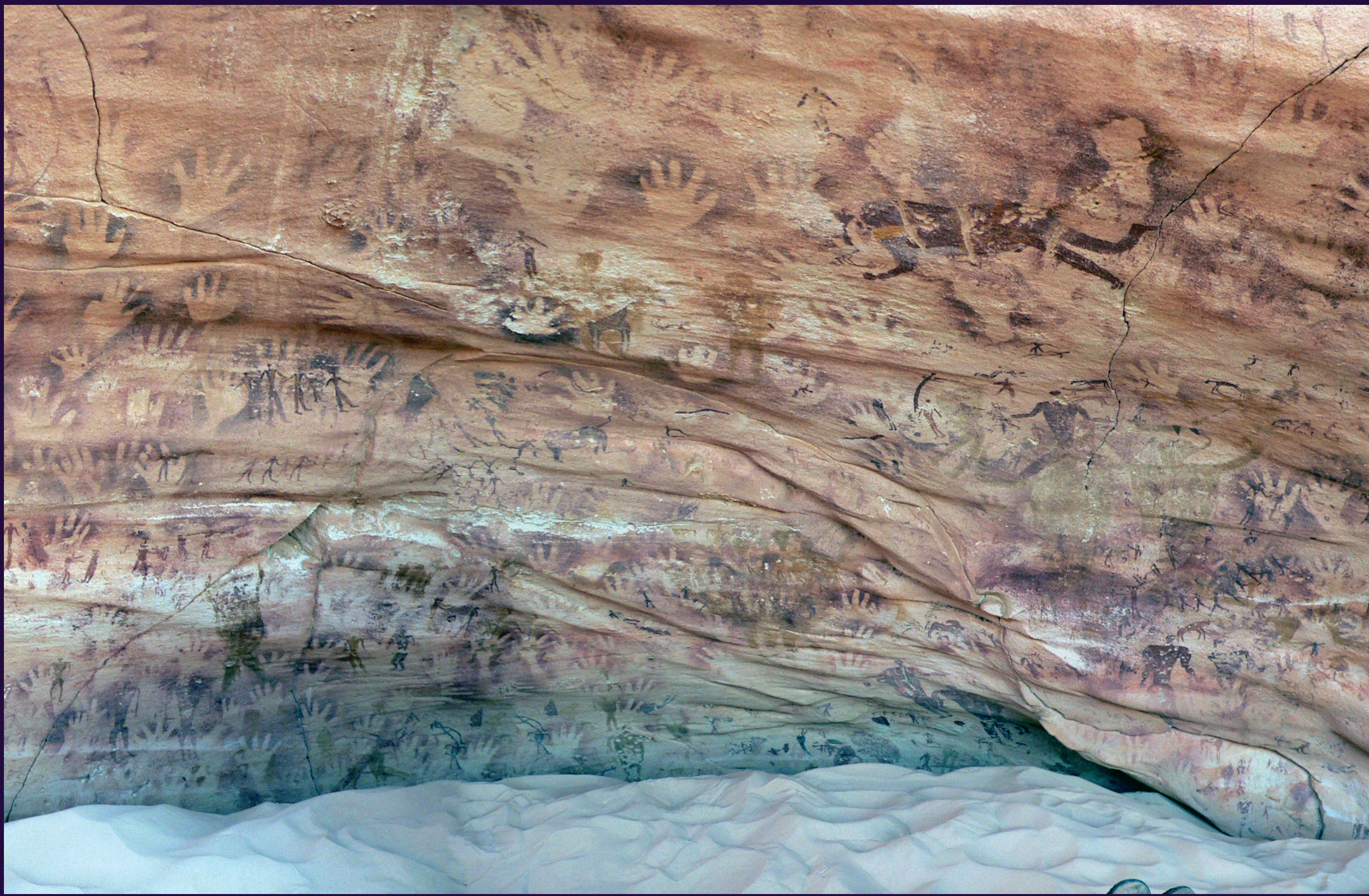
McDONALD INSTITUTE CONVERSATIONS

Social inequality before farming?

Multidisciplinary approaches to the study of social organization in prehistoric and ethnographic hunter-gatherer-fisher societies

Edited by Luc Moreau



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with contributions from
Hervé Bocherens, Alberto Buela, Andrea Czermak, Christophe Darmangeat, William Davies, Mark Dyble, Kate Ellis-Davies, Ben Fitzhugh, Douglas P. Fry, Mietje Germonpré, Matt Grove, Emmanuel Guy, Brian D. Hayden, Rowena Henderson, Emmanuelle Honoré, Joe L. Jeffery, Charles A. Keith, Marta Mirazón Lahr, Noa Lavi, Robert H. Layton, Martina Lázničková-Galetová, Julia Lee-Thorp, Sheina Lew-Levy, Paul Pettitt, Rachel Reckin, Paul Roscoe, Mikhail V. Sablin, Rick J. Schulting, Patrik Söderberg, Duncan N.E. Stibbard-Hawkes, Ilga Zagorska, Gunita Zarina

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Contents

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Figures

Tables

Preface

I write this preface from the state of Wyoming in the US, a state where COVID-19 has not (yet) struck as hard as it has struck other parts of the world, but where we nonetheless have been under stay-at-home orders. Those orders have given me plenty of time to think about where we went wrong, which in the case of the US is a long list. Coincidentally, I also recently re-read Machiavelli's sixteenth-century book, *The Prince*, a manual of how to ruthlessly crush opponents while administering (apparent) generosity to acquire the 'love' of the masses.

It was in this context that I read the papers in this volume. In doing so, I was struck by two facts. First, inequality's origin, development and operation are difficult to understand and yet the actions that lead to inequality are easy to implement. This shouldn't surprise us: no American baseball player mathematically calculates the arc of a fly ball, but he's still able to position himself in the right place to catch it. You can be utterly uneducated and still know how to manipulate a system to maintain exert, and abuse power. Many world leaders today are proof.

Second, I think that the papers in this volume could be some of the most valuable published in anthropology in many years. Philosophers and social thinkers have tried to understand inequality for a century; indeed, efforts to understand it precede Machiavelli. We bemoan its existence, and yet we have felt unable to grasp it, and, unable to grasp it, unable to do something about it. We muddled through the useless ramblings of nineteenth- and early twentieth-century evolutionists, who, reflecting their colonial environment, often thought that inequality was a good thing, and, if not good, an inevitable thing. Marx tried to shake them out of that complacency, but his brilliance was largely wasted during his 'second coming' in the second half of the twentieth century with so much hand-wringing about how a theory intended to explain early capitalism should also apply to hunter-gatherers (because, it must… right?), and so much politically correct posturing that led to no action – and all but disappeared when the Berlin Wall (thankfully) came down and the Soviet Union collapsed. 'Intensification' and 'complexity', words that should be stricken from anthropology's vocabulary for their uselessness (and that are thankfully rare in this volume), masked what was really going on: exploitation, oppression, slavery… inequality in all its manifestations. Finally, I think, we have reached the point, through analyses of archaeological and ethnological data, that we might actually understand inequality.

We've passed a Rubicon. And this really matters.

The calamity that is COVID-19 has pulled back the curtain on modern society, exposing the weaknesses of its structure, laying bare the inequality between and within countries that Machiavellian leaders exploit and exacerbate for personal gain. Doing something about inequality is the challenge that will remain after COVID-19 dissipates.

These papers help by seeking the origin of inequality in a kind of society, that of nomadic hunter-gatherers, that we once considered 'the original affluent society', a classless society, or 'primitive communists'. Some argue that inequality must be there (as Marxist analysts argued in the 1980s) since it is present in our closest primate relatives, and therefore is in humanity's genetic foundation. Some see evidence of social and/or political inequality among Palaeolithic hunters, in the evidence for secret societies and in the violence of cave art. I am not convinced by this 'grimdark' vision of Palaeolithic society, and see an enormous gap between difference and inequality, between a situation where one person has more than another who nonetheless has enough and one in which society gives a person permission to enslave another.

Nonetheless, these chapters remind us that hunter-gatherers are not angels, and the same self-interest that guides an Iñupiaq man to become a *umialik*, or that gave privilege to those men allowed to gather in the torch-lit gallery of Lascaux, guides Machiavelli's anonymous prince. People have different skills, and for some, those skills are political. Under the right conditions, those individuals can consolidate power, convince others to go to battle, and make their personal aggrandizement seem reasonable to the people paying its price. Palaeolithic society had its Hitlers and Stalins, its Caesars and Trumps.

But it didn't have imperialism, or empires, or palaces, or wealth hidden in tax havens. So other chapters here look for the conditions under which those 'selfish' individuals can gain power. High population density (pressure), localized and hence controllable resources, the ability to build a coalition, which requires a sufficient concentration of population and social institutions that are conducive to creating coalitions, lack of trust in institutions, including sharing networks, to provide in times of stress – these are the conditions that permit those with political skills to pursue self-interest through the manipulation of others.

These conditions are as relevant to understanding the world of today as they are to an understanding of the Palaeolithic world. Today, however, conditions can be manipulated, for example 'localized' in off-shore bank accounts. Population pressure is high and will become worse as the world approaches the projected population of 11 billion by 2100. And competition is worsened by a capitalist economy that encourages ever-increasing amounts of consumption and conversion of needed resources, such as food, into higher profit margin items such as crisps and alcoholic beverages. Information is a resource, and technology makes information more available but less trustworthy. Unbelievably expensive displays of potential force – multi-billion-dollar aircraft carriers, atomic weapons, a Space Force – signal a lack of trust in non-violent institutions to resolve the inevitable disputes that arise when people, or countries, pursue their self-interests with little regard for others. Building trust in institutions – in the UN, in voting, in the media, in government itself! – is an integral part of stopping and even reversing the arms race before it drives the world to the poor house.

Inequality is an old story, and one that we understand much better due to the efforts of anthropologists and archaeologists. It hasn't been easy to arrive at this point. But the really hard work – implementing our knowledge – still lies ahead for us. This volume, and our prehistoric hunting and gathering ancestors tell us what needs to be done. And it is the most important work anyone could be doing in the world today.

Robert L. Kelly
University of Wyoming

Chapter 9

Responses of Upper Palaeolithic humans to spatio-temporal variations in resources: inequality, storage and mobility

William Davies

Recognizing and quantifying degrees of inequality, storage and mobility in the Upper Palaeolithic is not a straightforward process. How long-lived were any instances of Upper Palaeolithic inequality, given the climatic and environmental instability of the period? Such environmental changes were significant, affecting the types/variety and abundance of resources within human lifetimes (e.g. van Andel & Davies 2003; Gamble et al. 2005). Thus, what were the potentials for establishing long-lasting inegalitarian socio-economic systems based on control of rich, predictable resources? 'Resources' include not just food resources, but those needed to fuel heat and light and make artefacts. People, in the form of labour and expertise (social knowledge), can also be seen as resources (Gamble 1999). Resources themselves can thus be mobile, stored and controlled. However, not all resources (e.g. secular skill and knowledge) were finite, temporally restricted or easily controllable, and thus not hoarded in some 'zero-sum' situation, whereby someone benefited at the expense of another.

Definitions of 'stratified societies' generally conflate social, economic and political inequalities, which are closely linked, but distinct, phenomena (Hayden 2008: 18). Socio-economic control can be exerted over resources and/or stored produce, or goods and exchange networks, while political control (over the work of individuals, etc.) can operate through many strategies (marriage/bride prices, exchange, extortion, war, rituals, feasts) (Hayden 2008: 22). Inequality is multi-scalar, from temporal to long-lasting (multi-generational), and from individuals to metapopulations. Long-lasting inequalities, operating at large (metapopulation) scales would only be sustainable if social institutions that could maintain consistent aims were present. Without such institutions (including communal belief systems), stability could not be sustained or coerced, and every action or plan would need to be negotiated, or renegotiated in the case of unforeseen events.

The long-term socio-economic basis for structural inequality, even transegalitarianism (Table 9.1), has often been linked to resource predictability and abundance (e.g. Dyson-Hudson & Smith 1978; Marean 2015, 2016; Hayden 2003). Foragers located in areas with predictable and abundant resources are, according to this model, more likely to be sedentary and territorial, e.g. Pacific Northwest Coast groups that rely on obtaining and storing large quantities of fat-rich anadromous fish (primarily salmon). Some authors, e.g. Bordes & de Sonneville-Bordes (1970), have suggested that the environmental conditions of Northwest North America *might* have been analogous to those in Upper Palaeolithic Europe. In this paper, I will examine the following questions:

- Can we be sure that the productivities of Upper Pleistocene European environments resembled those known for forager societies today (cf. Hayden 2008: 81)? (The implications of 'non-analogue' ecological communities will also be considered.)
- Could socio-economic complexity have existed without a resource base that generated consistent surpluses?
- Was cosmological or ritual knowledge directly founded/dependent on productive biotic resources, and might it have been easier to control than technical knowledge?

Control of ritual knowledge can be found in extant forager groups, often based on gender and age, without necessarily leading to clear patterns of inegalitarianism or transegalitarianism, e.g. Kalahari San or Australian Aborigines (Cashdan 1980; Woodburn 1982, 2005; Testart 1989; Boehm 1993; Layton 2005; Hayden 2008).

The spectre of equifinality (several possible explanations for a pattern) thus haunts our interpretations: what can our data tell us unequivocally, and how should we incorporate ethnographic parallels into our analyses?

Testing for inegalitarianism in the Upper Palaeolithic record

The key egalitarian and transegalitarian categories (Table 9.1) form a continuum of variation (through to full structural inequality), though they should not be interpreted as an evolutionary succession. Societies within each broad category vary in the intensity and expression of their traits, and all have their own contingent history. We shall explore the extent to which we can, and should, generalize from both ethnographic and archaeological data, and how we should link the two lines of evidence (if possible or desirable). Table 9.2 outlines how transegalitarian social traits might be tested archaeologically. It is important to identify possible sources of *equifinality* in our evidence: how confident can we be in asserting that specific traits (or combinations of them) are diagnostic of structural inequalities, or can they be explained in other ways? Are some traits better at indicating inequality than

Table 9.1. *Defining key terms of reference.*

Egalitarian societies (Testart 1982; Woodburn 1982; Zubrow 2010)	Active and systematic elimination of distinctions (except those of sex) based on wealth, power and status. Individuals have influence, but no power, and hierarchies (e.g. of knowledge) can exist in egalitarian contexts. Zubrow (2010: 113–14): equality has different scales (proportional/ relative vs. quantitative/absolute) and dimensions (horizontal vs. vertical distinctions (or not) in treating individuals in a group). He identifies five models of equality (pp. 114–16): 1. Equal treatment for all (no preference of provision or receipt; blind equality in how an individual relates to others/groups/social institutions; all expected to have same baseline abilities, even if they do not). 2. Equal outcome (initial conditions are not important, but results should be equal: egalitarianism of ends, not means; assumed that individuals are diverse, and have variable opportunities – often from no control over circumstances; different preferences might influence the equality outcome; difficult to organize beyond the local scale). *Reduces the differences among households and individuals over time.* 3. Equal opportunity (for everyone to develop their own talents; equal rewards for equal performances – the 'opportunity to try,' not the 'opportunity to succeed'; permits a divided and hierarchical society, predominantly organized around individualism; accepts that not all talents are equally valued by society; socially conservative, in that there is prior acceptance of a social order of value). *Over time, inequality will increase, by following meritocratic principles, even though no-one is denied the opportunity to participate.* 4. Equality of resources (all individuals treated as equal – no further transfers of resources will make them more equal; there is a potential difference between private and public resources, and no division of resources is equal if, after division, anyone would prefer someone else's portion of resources, goods and services). The market is needed to recognize one's socio-economic position, but it can also lead to individuals monopolizing/maximizing their position (though not always at the expense of others). 5. Equality of welfare (all are equally successful, with equal, though heterogeneous, enjoyment from life; goal is to achieve the greatest average welfare, as long as this does not detract from the fair shares of others, but it is unclear how this model allows resource provision for those with disabilities). If anyone develops more expensive tastes than others, or is pessimistic rather than optimistic, more resources will be needed for equal success or enjoyment.
Transegalitarian societies (Owens & Hayden 1997; Hayden 1995, 1998, 2008)	Between egalitarian and inegalitarian societies, and equivalent to 'complex' hunter-gatherers, e.g. Pacific Northwest Coast (cf. Table 9.2). Created by 'aggrandizers', who range in intensity from **Despots** (relatively egalitarian: no stratification as the position is ephemeral; duplicated across settlements and households; some surplus-based corporate kin groups; feasting used to build alliances; compensation payments made to allies for death in conflict; operative in only one or two realms, e.g. warfare and production), to **Reciprocators** (overtly non-egalitarian: leaders competing within the community, so some stratification within corporate groups; moderate heredity of positions; strategies for creating debts, surpluses and power, including bride-wealth, more elaborate feasts, and perhaps child growth payments; minor public, feasting or ritual community architecture; surplus-based corporate groups, whose aggrandizers have increased wealth, more wives and larger social networks), to **Entrepreneurs** (clear evidence of institutionalized inequality; strong heredity and stratification within corporate groups; non-monumental community architecture; some community cult architecture; duplicated corporate monumental architecture; surpluses used in competitive feasts to create contractual debts, involving interest payments; loans and investments are the primary means of obtaining wealth and power; warfare is less important, as it interferes with generation of surplus and exchange; marriage used to transfer wealth through bride-payments; aggrandizers consolidate control of a wide range of leadership roles, e.g. military, ritual, financial/economic).

Table 9.2. *Characteristics of 'Generalized' (egalitarian) and 'Complex' (transegalitarian) hunter-gatherers (modified and augmented from Hayden 2003: 125 & 2008: 15-16; also Owens & Hayden 1997, Testart 1982). Reference to archaeological indicators given by numbers in parentheses for relevant characteristics; my additions (numbered) given in italics.*

	'Generalized' hunter-gatherers	'Complex' hunter-gatherers
Resources	• Limited (1–3, 5, 6); • Fluctuating & vulnerable (1–3, 5, 6); • No storage (2, 3, 6); • No small or secret/concealed resources (3, 4)	• Abundant (1–3, 5); • More stable (2, 3) & invulnerable (1–3, 5, 6); • Storage (2, 3, 6); • Small or secret/concealed resources are important (3, 4)
Population density (person/100 sq. km)	1–10 (5, 6)	10–1000 (5, 6)
Annual mobility	Nomadic foraging (6–9)	Full or semi-sedentism (6–10)
Social & ideological adaptation	• No individual ownership (2, 4, 7, 11); • Sharing; no economic competition (1?, 7, 11?, 13); • Egalitarian society (1–4, 9–11, 13); • Alliances (11?, 12); • Sporadic revenge raiding (14)	• Private property/resource ownership (1, 4, 7, 8, 12, 13, 14); • Economic competition, and specialization (1–3, 4?, 7); • Hierarchical society, and poor vs. wealthy (4, 7, 8, 10, 12?, 14); • Economic trade (13); • Slavery (14?); • Increased warfare (15)
Archaeological indicators	1 *Little/no evidence of resource intensification;* 2 Generalized technology; 3 Few/no storage features or resources (pits, caches, smoking/drying hearths, filleting using blades; grease extraction); 4 No remains from small secret/concealed resources, and little/no technology for them; 5 Simply structured, small sites, with thin deposits; 6 Fine-grained spatial distribution of sites; 7 No permanent architecture; 8 *Seasonality indicators (plants & animals), including fruits/seeds, tooth cementum, etc.;* 9 *Isotopic and skeletal signatures of dietary status, activity and mobility by age and sex;* 10 *Ancient DNA evidence of effective population structure.* 11 No primitive valuables; 12 *Informal exchange items;* 13 No rich burials; 14 *Individuals with perimortem injuries.*	1 *Management and intensification of favoured resources;* 2 Specialized, complex technology; 3 Significant storage features (pits, caches, smoking/drying hearths, filleting using blades; grease extraction); 4 Remains of small concealed/secret resources, and specialized technology for them; 5 Large, structured, sites with thick, dense artefact deposits; 6 Patchy spatial densities of sites; 7 Permanent architecture, *e.g. monuments, terraforming, restricted private spaces*; 8 Ancestor cults: mortuary practices, body-part 'talismans,' body modification, secret art; masks; 9 *Seasonality indicators (plants & animals), including fruits/seeds, tooth cementum, etc.;* 10 *Isotopic and skeletal signatures of dietary status, activity and mobility by age and sex;* 11 *Ancient DNA evidence of effective population structure.* 12 Primitive valuables (status items, jewellery, etc.); 13 Regional trade networks; 14 Rich vs. poor burials; 15 Cemeteries with high levels of violent deaths.

others, or is the evidence from a particular trait more convincing than from *combinations* of traits (as listed in Tables 9.1 and 9.2)? If either of those situations could be demonstrated, what are the implications for our reconstructions of Upper Palaeolithic inequality?

It is worth noting that the simple linear transition sequence of control ⇒ power ⇒ wealth ⇒ inequality ⇒ hierarchy (with power deriving from varying control of natural resources, property, labour and production, ritual, exchange networks, etc.) is tautologous. '*Control is power* rather than simply a means to power', as Clark (1998: 501) observed, so how did emergent control/power arise in the first place? Egalitarian societies actively squash any attempt to monopolize resources, labour, ritual, etc. (Cashdan 1980; Woodburn 1982, 2005): what, therefore, might prompt group members to tolerate an appropriation of communally held rights? Could it have arisen through elaboration of ritual knowledge and rights, as postulated by Woodburn (1982, 2005) for delayed-return societies (Appendix A),[1] or were the causes economic or socio-political (e.g. Cashdan 1980; Hayden 1998, 2003; Zubrow 2010: 117)? The option of group fission would surely have been available to Palaeolithic foragers as a means of conflict-resolution, or for escaping the dictates of a despot (Table 9.1), unless something were to restrict that option (e.g. population packing in adjoining areas or topographic barriers: Boone 1992: 312–13). The concept of 'motility' (Weig 2015: 423) is key to this discussion (see p. 145).

As will be discussed below, it is not clear that either topographic or environmental barriers, or population packing, were significant factors in the Upper Palaeolithic. The major basis of the assertion that transegalitarianism was present in the Upper Palaeolithic, and indeed drove many of its innovations via the whims of 'Big men,' is that resources were rich in western Eurasia, allowing the production of surpluses that could be controlled (Owens & Hayden 1997: 123; Hayden 2003, 2008). However, the term 'surplus' is a slippery one: are we discussing the stockpiling of abundant, but temporally restricted, resources to provide essential subsistence in periods of dearth (Layton 2005), or a constant withdrawal and storage (probably monopolized) of superfluous resources throughout the year, which could then support a non-producing class? Zubrow (2010: 117) has argued that unequal status began in the Upper Palaeolithic, owing to the way resources were distributed within and between groups, rather than through the richness of resources generally or the nature of production. Different ways of sharing, and of using space, would also potentially cause the development of inequalities (Zubrow 2010).

Woodburn's (1982, 2005) immediate- and delayed-return systems form two poles of a socio-economic continuum (Appendix A), and some forager societies (notably in Australia) have traits from both extremes (Woodburn 1982, 2005; Riches 1995). This led Layton (2005: 140) to sub-divide the delayed-return pole by separating seasonal fluctuation in productivity from territorial patterning. Layton reminds us that while highly seasonal distributions of resources may require complex technology and storage of food to equalize food supply across the year, they do not of themselves always lead to elaborate social organization. Inuit may have complex technology, but are essentially egalitarian: there is flexibility of movement within communities, and no descent-group claims over particular parts of the group's territory. Meat-sharing is restricted to family groups in summer and co-operating hunters (only in winter is food shared throughout the co-resident extended family); levelling transactions enforce the redistribution of material goods between households if some are thought to have too much (Layton 2005: 139). While some (mostly central and northern) Australian Aborigines practise clan totemism and strategic inter-clan marriage alliances (Woodburn 1982, 2005; Riches 1995), their technology is generally simple, and there is flexible movement between bands (Layton 2005: 139). Inherited membership of a totemic clan only gives exclusive rights (through initiation) to enter sacred sites, wear totemic paintings during restricted ceremonies and curate its sacred objects; it does not confer exclusive hunting and gathering rights (Layton 2005: 140). Water is the resource that governs logistical movement in desert conditions (e.g. southern Africa and much of central and western Australia), with predictable sources being localized and uncommon; otherwise, reciprocal access to clan territories is practised, to reduce risk from unpredictable resources and rainfall (Layton 2005: 140). If no transfer of resources from seasons of surplus to ones of shortfall occurs, then maximum populations must lie below the lean season's minimal productivity (Layton 2005: 133): effectively Liebig's law of the minimum. Inter-season transfers of resources allow maximal populations to rise slightly (up to the median productivity between the seasonal extremes) (Layton 2005).

These should all be borne in mind when evaluating the environmental impact on European Upper Palaeolithic societies, which covered a wide range of often rapidly changing environmental types, from drier conditions in the Mediterranean to more temperate and colder conditions at higher latitudes. Climatic fluctuations also affected the distribution of resources (including water); it is worth noting that the Last Glacial Maximum was not just relatively cold, but that levels of precipitation declined in many regions (Clark et al. 2009; Heyman et al. 2013; Monegato et al. 2015).

Environmental contexts of late Pleistocene western Eurasia

The assumption that environments in the European Upper Palaeolithic were richly resourced is key to the argument that the production and accumulation of surpluses (owing to the nature of resources and technological improvements in hunting and processing equipment) enabled the development of socio-economically complex, transegalitarian societies in this period (Owens & Hayden 1997: 123; Hayden 1998; 2003: 123, 129–30). The plains of western Europe comprised prairies of unequalled richness,[2] with abundant prey (Hayden 2008: 82, after Bordes 1969: 128). By analogy with Pacific Northwest Coast Indians, whose economies are founded on large salmon migrations, Hayden (2003: 81) argued that large reindeer migrations were the equivalent seasonal surplus resource harvested and stored by transegalitarian Upper Palaeolithic foragers. The supposed rich hunting grounds of southwest France, northern Spain, northern Italy and the Russian Plain are used to explain the high development of art, wealth, complexity and ritual (Hayden 2003: 129–30; 2008: 82). These generalizations, though, conceal considerable variation in the nature of food resources in those four regions. The Upper Palaeolithic records of northern Spain and northern Italy are not marked by (significant) reindeer remains; most of the ungulates were relatively sedentary and territorial, e.g. red deer.

In addition, reindeer are not a simple terrestrial analogue for salmonids. While the extent to which salmonids are r-selected (Hayden 1981) is debatable – while they reproduce once, followed by the catastrophic mortality of the reproducing generation, they also live several years, develop slowly, reproduce late, have relatively large size, and are affected by competition – reindeer are clearly at the K-selected end of the spectrum (Pianka 1970: 593; Parry 1981). Modern *Rangifer* have two main ecotypes, and studies of Upper Palaeolithic specimens are needed to establish which reindeer ecology was targeted at each Upper Palaeolithic site. Woodland reindeer form relatively small herds and undertake restricted seasonal migrations, while tundra reindeer form much larger aggregations and migrate extensively (Burch 1972). The latter type migrate in long files of individuals that do not follow the same routes each year (Burch 1972: 351): they are thus unpredictable. This unpredictability is compounded by the dynamics of reindeer populations, which can fluctuate greatly in size over cycles of 25–100 years (Burch 1972: 359), owing to factors such as food supply, climatic and local weather conditions, and parasites (Solberg et al. 2001; Albon et al. 2002; Uboni et al. 2016). Reindeer movements might be consistent and well-patterned for a few years, and then suddenly shift (within a year), perhaps by 800 km, owing to changes in snow conditions *en route*: good news for hunters in the new destination, but disastrous for those in the previous location, expecting a reindeer bonanza (Burch 1972: 354). A limited series of isotopic studies have been carried out so far, indicating presence of reindeer of the aggregating and migrating ecotype at Jonzac, southwest France (Quina Mousterian: 68–81 ka) (Britton et al. 2011; Niven et al. 2012; Richter et al. 2013), and Stellmoor, north Germany (Hamburgian, *c.* 15.0–14.0 ka, and Ahrensburgian, *c.* 12.8–11.4 ka) (Price et al. 2017).

These strontium results might appear to support Hayden's (2003) assertion that reindeer in southwest France ('Dordogne') were intercepted and harvested in bulk during their autumn aggregation migration to their wintering grounds. However, a combination of antler, dental development and wear, and foetal long bone evidence (Fontana 2017) indicates that during the Gravettian, Solutrean and Magdalenian (at the well-known sites of Abri Pataud, Laugerie-Haute, Badegoule, Fourneau du Diable, La Madeleine, and possibly Combe-Saunière), reindeer were hunted throughout the year in the period *c.* 30–15 ka. Magdalenian IV and V layers at La Madeleine indicate reindeer hunting in at least five periods of the year, across all four seasons (Fontana 2017: 353). This pattern contrasts with the evidence from the Aude basin (winter/spring hunting) and the Paris Basin (autumn hunting) for the Magdalenian.

The evidence for relatively sedentary reindeer in the Périgord region forces reinterpretation of the proximity of several Magdalenian sites to natural fords (White 1985). Reindeer crossings near La Madeleine and Laugerie-Haute (White 1985: 125) would have occurred several times a year, and in small herds rather than in large aggregations. Modern reindeer can swim extended distances (at least 6.5 km: Burch 1972), and unless the Vézère was particularly fast-flowing during the classic Magdalenian, it is unlikely that reindeer were restricted to natural fording places in the river (cf. Burch 1972: 347; White 1985: 129–30). Thus, *contra* Hayden (2003), it is difficult to argue for mass intercept kills of migrating reindeer aggregations in southwest France on current evidence; instead of labour-intensive processing and storage of large quantities of meat in a few short periods during the year, annual supply of reindeer seems to have been more evenly distributed. Did that obviate the need for storage, as temporal fluctuations in supply were not pronounced? The lower quantities of reindeer available in the Périgord would restrict the amounts that could have been harvested and stored, but perhaps there might have been targeted exploitation of reindeer in August, when hides and meat were in prime condition (Burch 1972: 359)? Fontana's (2017: 355) estimates of seasonality indicate July and August hunting events for La Madeleine levels 27 (Magdalenian IV) and 25 (Magdalenian V), respectively.

Elsewhere, e.g. the North European Plain Magdalenian, and at other times, e.g. the Weichselian Middle Palaeolithic of southwest France, seasonal intercept hunting of reindeer herds was practised (Price et al. 2017; Britton 2011). Whether the reindeer in those two examples were long-distance migrants, or moving between different biomes within the same broad region, is more debated (cf. Britton et al. 2011; Price et al. 2017: 384). The large reindeer assemblages from the lateglacial sites of Meiendorf and Stellmoor (north Germany) appear to mix different ecotypes: some had relatively restricted ranges, and others moved long distances between distant summer and winter ranges (implied by larger inter-tooth $\delta^{18}O$ differences and more strontium variation than seen in less-migratory individuals) (Price et al. 2017). Given the essentially homogeneous strontium values for the North European Plain, which are matched by values seen in the reindeer teeth and antlers (implying reindeer did not stray from the region), it is the $\delta^{18}O$ and $\delta^{13}C$ values that give some indication of climatic conditions and dietary intakes. On that basis, Price et al. (2017) argue that summer grazing pastures were east of Meiendorf and Stellmoor, with hunters intercepting them as they shifted westwards in late summer/early autumn. The variable isotopic values between and within Stellmoor reindeer suggest varying herd densities (and compositions) in the vicinity, and that the site might have been positioned centrally within a herd range during the lean season(s), rather than on a migration path (Price et al. 2017; cf. Burch 1972: 351).

The evidence considered so far would imply that the migratory patterns of late Pleistocene reindeer were more variable than those seen in modern populations (Price et al. 2017: 388–9), and this would have implications for Hayden's interpretation of reindeer as a rich, storable, resource in the Upper Palaeolithic, not just in terms of their migratory predictability, but also in their seasonal availability/quantities. Hayden's (2008: 82) two exploitation models for large-scale hunting – intercept hunting of big migrations versus hunting of less-mobile, spatially restricted prey – can thus both be applied to late Pleistocene reindeer. Given shifts in prey behaviour over time and space, both strategies can sometimes be found at the same sites, e.g. Stellmoor, where small-scale hunting of reindeer is recorded (drives or stalking of small groups, whose carcasses were then intensively exploited) in the Hamburgian (Magdalenian), while in the Ahrensburgian, large-scale ambush hunting (taking many individuals while they were in the water, and butchering the carcasses selectively) occurred (Bokelmann 1991; Bratlund 1991, 1996; Price et al. 2017). Burch (1972: 363) estimated a processing time of several days for up to 12 people to process kills from the huge aggregations at Meiendorf or Stellmoor. The Ahrensburgian layer at the latter site had a Minimum Number of Individuals (MNI) of 302 reindeer, which were selectively filleted (perhaps to save time – cf. Burch – and to minimize interest of other carnivores) (Bratlund 1996), plus another 12 almost complete skeletons (Price et al. 2017). Late summer/early autumn would have been a good time for quickly air-drying thin strips of filleted meat for later consumption, as well as processing prime-condition hides (Burch 1972). The unused portions of most carcasses, plus the 12 that were not exploited at all, seems to argue against the controlled production of surpluses by individuals or families: why were returns not maximized? However, it is possible that these carcasses might have been anchored to the bottom of the lake with rocks to store them for a future need that ultimately did not arise (Speth 2017: 60). This large-scale hunting of reindeer can still be explained as an aggregation of hunters designed to produce a seasonal surplus (either filleted or stored underwater) to mitigate shortages during lean seasons. Similar patterns of indiscriminate slaughter in strategic parts of the landscape, followed by selective butchery, have been documented for Neanderthals (synthesized in White et al. 2016), so there seems little to distinguish Neanderthals from modern humans in this regard (cf. Hayden 2003). Firm evidence of controlled access to surpluses in the Middle and Upper Palaeolithic eludes us at present, and it is not clear what this evidence should look like, or how it could be measured: hearths can be used for multiple purposes over their use-lives, and no drying rack evidence has been recovered.

The economic alternative to storage based on specialization in migratory species is resource-spectrum broadening (both plants and animals), seen in both Neanderthals and Upper Palaeolithic modern humans (e.g. Freeman 1981; Berganza et al. 2012; Pétillon 2016; Pryor et al. 2013; Costamagno & Laroulandie 2004; Stringer et al. 2008; Hardy et al. 2013; Henry et al. 2014). The taxa exploited, and their relative quantities, are highly spatio-temporally variable, but all show evidence of cut-marks, disarticulation, burning/cooking and human tooth marks. Often taxa were used for products (feathers, talons, bones, teeth, fur/hides, etc.), as well as being consumed: were such resources (particularly mammalian and avian carnivores) consumed more for symbolic purposes than nutritional ones? If the former, then who was involved in the consumption (the whole group, or a sub-section of it)? Fish consumption evidence is present in both late Middle Palaeolithic and Upper Palaeolithic assemblages, seemingly becoming more economically important in the lateglacial (Magdalenian) (e.g. Costamagno & Laroulandie 2004). To what extent did the collection of such resources dictate the positioning of sites, perhaps near fording places (e.g. White 1985: 131)?

Marine mammals, such as whales, also seem to attain a new importance in the Magdalenian of Franco-Cantabria, being not only depicted in art (Fritz & Roussot 1999: 82–3), but also turned into bone tools (Pétillon 2016). The fat and meat content of these beached whales would have been a great bonus to groups living near the Atlantic coast, although we cannot know if the blubber was stored/matured in bogs and streams, as it was in Tierra del Fuego (Moore 1980; Jackson & Popper 1980). Fuegian Yaghan groups could expect one or two whale beachings per year, and groups would aggregate to process the carcass (Jackson & Popper 1980). The circulation of whalebone projectile tips far inland from the Atlantic coast in Magdalenian France (Pétillon 2016) might have been the result of exchange, or direct procurement by a variety of groups.

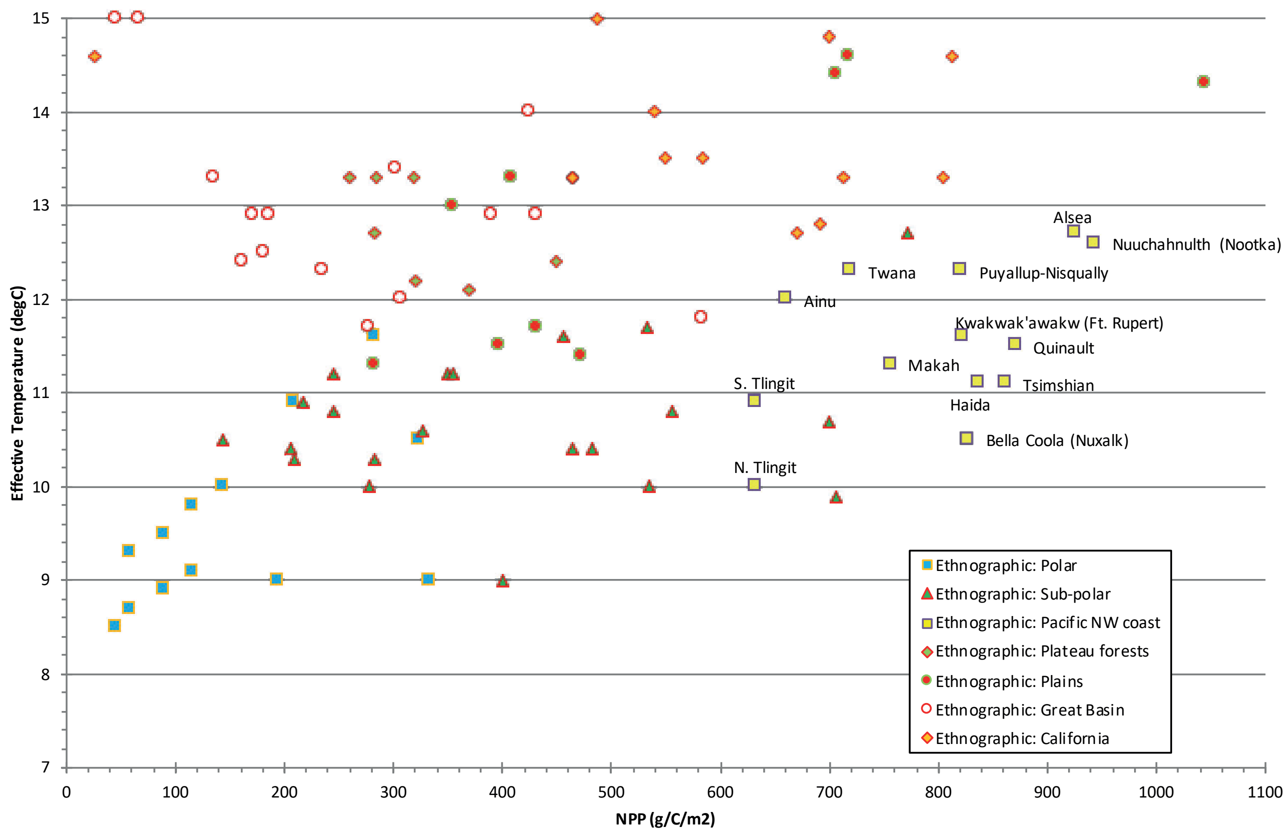
Environmental productivity

While Upper Palaeolithic foragers appear to have had a wide range of exploitation strategies (from relatively specialized to broad-spectrum), it is still not clear whether any surpluses stored were for anything more than time-scheduling of resource extraction and consumption to account for fluctuations in supply (Ingold comment, in Testart 1982: 532), or alternatively to augment or provide variety to an otherwise monotonous diet (Moore 1980; Jackson & Popper 1980). We should note that species exploited, and the quantities recovered for each taxon, do not of themselves tell us about environmental productivity. Instead, they tell us about the broad choices and preferences of the occupants of a particular locale, though occupation duration and palimpsest activity will have an effect on patterning. To this end, we should consider environmental primary productivity from regional models of Marine Oxygen Isotope Stages (MOIS) 3 (*c.* 59–25 ka) and 2 (*c.* 25–11.5 ka) (periodization and models will be based on Stage 3 Project data (van Andel & Davies 2003), as they were available for analyses). There have been several such projects over the last twenty years (van Andel & Davies 2003; Allen et al. 2010; Huntley et al. 2013; Tallavaara et al. 2015; Burke et al. 2017), and they allow us to use climatic and environmental models to compare productivity over time and space with uniform data and methods.

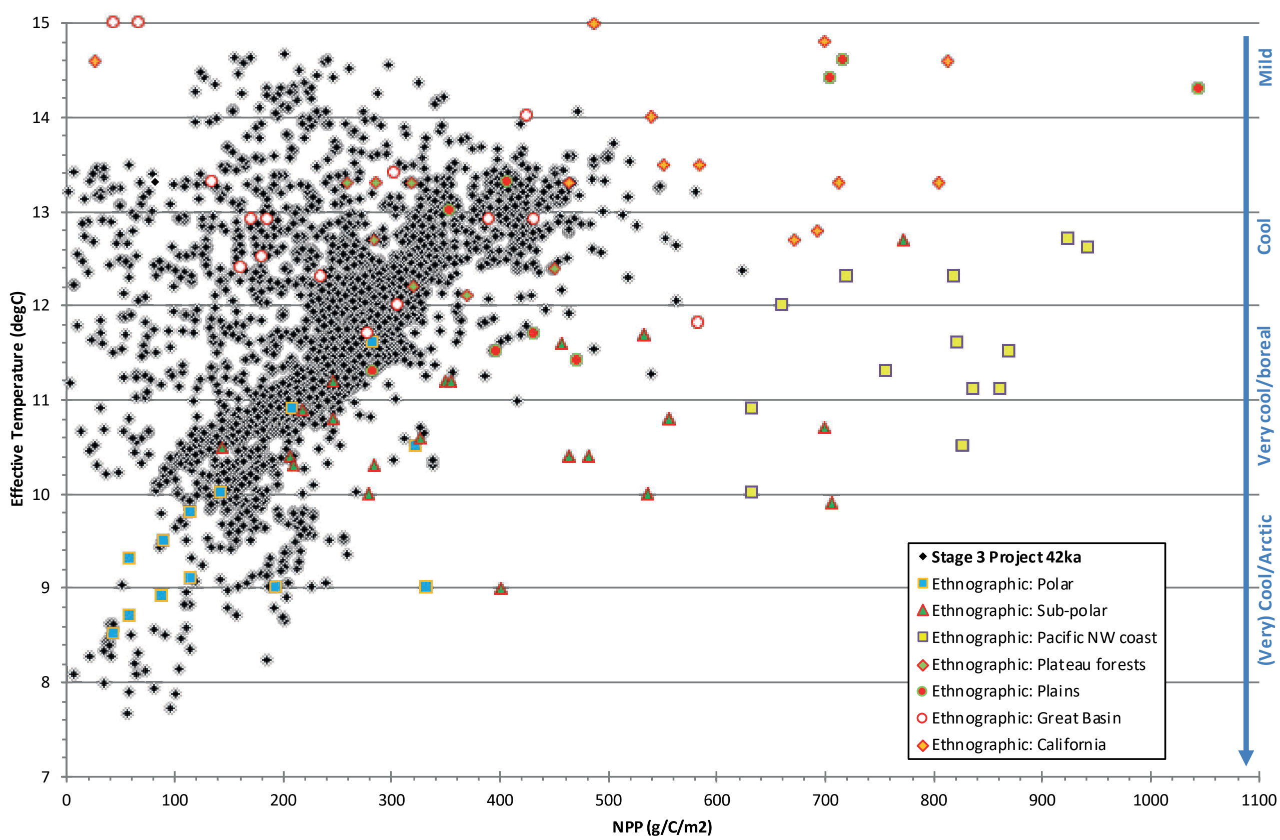
Binford (2001) and Kelly (2013) have both plotted modern fisher-hunter-gatherers against local Net Primary Productivity (NPP: estimating the amount of new plant growth within a given area over time (grammes of carbon per sq. m per year)) and Effective Temperature (ET: a measure of the length of the growing season in a location, and its intensity of solar energy (Bailey 1960; Binford 1980, 2001)). The ETs seen in Figures 9.1 and 9.2 (and Appendix B) comprise values for ethnographic groups (Binford 2001; Kelly 2013), and for each 60 x 60 km cell in the Stage 3 Project Regional Climate Models for 42 ka ('Stable Warm'), 30 ka ('Cold') and 21 ka (Last Glacial Maximum ('LGM')) (see van Andel & Davies 2003). Given that the ethnographic values presented here mainly derive from mid-to-high latitudes, it is unsurprising that their levels of seasonal insolation are similar to those estimated for similar latitudes in late Pleistocene Europe. The boxplots for the three Pleistocene simulations cover a wide range of ET values, from 'very cold' (Bailey)/'Arctic' (Binford) to 'mild' (Bailey)/'warm temperate' (Binford) (Bailey 1960: 7–8; Binford 1980: 14), although the interquartile ranges for 42 ka and 30 ka perhaps most resemble those for the Pacific Northwest Coast, partially overlapping also with ETs for the North American Plains, Great Basin, Plateau forests and Sub-polar environments. The LGM simulation ET interquartile range shows clearer similarities with the Pacific Northwest Coast and Sub-polar environments. At face value, this would support Hayden's (2003, 2008) contention that the Pacific Northwest Coast is an analogue for the European Upper Palaeolithic. However, the situation becomes more complex when we focus more on ET values for key regions of the European Upper Palaeolithic (e.g. Cantabria, southwest France and Moravia), and when we consider NPP. The cells in the Stage 3 Project simulations containing key Cantabrian Upper Palaeolithic sites have surprisingly low ET values (tending to Bailey's 'very cool,' or Binford's 'boreal,' category, shifting towards 'cold'/'Arctic' at the LGM (21 ka)). Only the similarly westerly and maritime-influenced site of Paviland shows similar values (akin to those seen today for Polar and Sub-polar foragers). Further to the east (southwest France, Moravia and the site of Sunghir), ETs are generally higher, falling within the 'cool,' or upper range of Binford's 'boreal,' category. Any similarity in ET values to those seen in today's Pacific Northwest Coast from the selected regions in this paper (southwest France, Moravia and Sunghir) is terminated by the LGM, when ET values drop (Fig. 9.2, Appendix B).

NPP, as can be seen in Figures 9.1 and 9.2, does not show such a clear latitudinal and longitudinal pattern. Overall in Europe, there is a slight drop in mean and median NPP between 42 ka and 21 ka, but what is most striking is the lack of productivity overlap between late Pleistocene Europe and present-day Pacific Northwest Coast (Figs. 9.1, 9.2; Appendix B). As indicated in the ET values, Cantabria and Paviland also show depressed NPP values (similar to those for current Polar foraging groups), which perhaps are the result of relatively consistent temperatures: while most days each year seem to have been above 0°C (Cantabria, 42 ka: 11–12 months; 30 ka: 9–12 months;

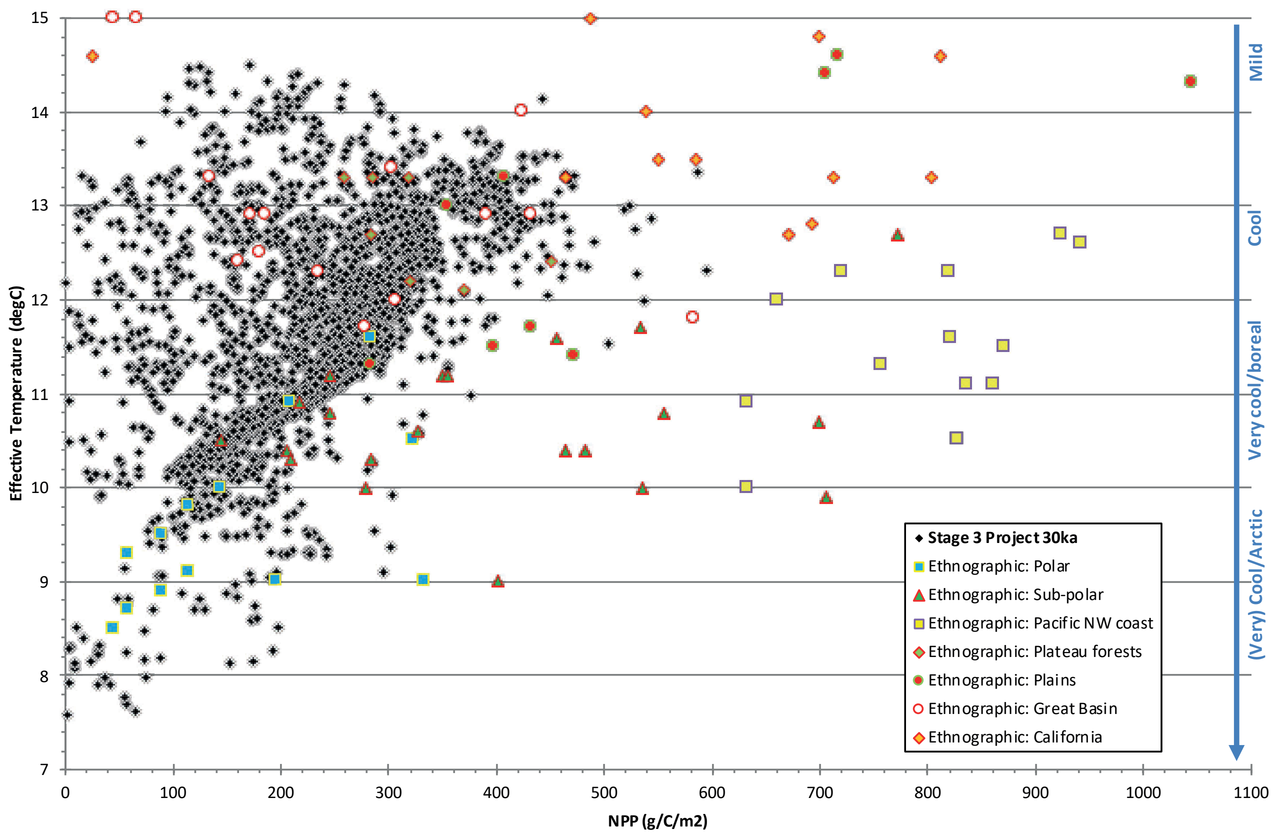
Figure 9.1 *(overleaf). Net Primary Productivity (NPP) and Effective Temperature (ET) conditions for extant fisher-hunter-gatherers, in comparison to reconstructed NPP and ET values for Upper Palaeolithic Europe (42 ka [stable warm conditions], 30 ka [cooling conditions] and 21 ka [LGM]). ET categories (Bailey 1960: 7–8): Mild (13.4–15.5 °C), Cool (11.6–13.4 °C) and Very cool (10.0–11.6 °C) (cf. Binford's (1980: 14) 'Warm temperate' = 14.0–15.9 °C, 'Cool' = 12.0–13.9 °C, and 'Boreal' = 10.0–11.9 °C); Cold (8.6–10.0 °C), Very cold (7.5–8.6 °C) and Glacial (below 7.5°C) (cf. Binford's (1980: 14) 'Arctic' = 8.0–9.9 °C).*

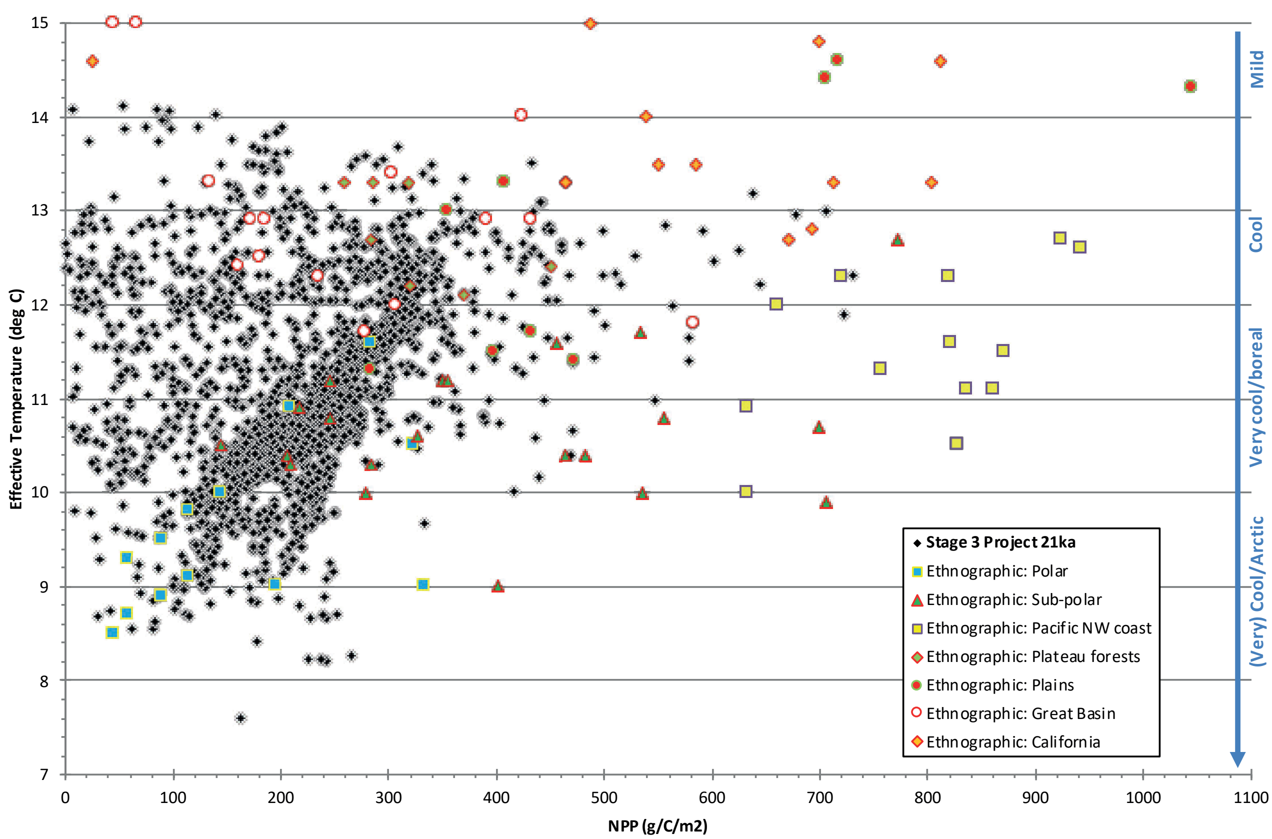


Effective Temperature (degC)
NPP (g/C/m2)
Alsea
Nuuchahnulth (Nootka)
Twana
Puyallup-Nisqually
Ainu
Kwakwak'awakw (Ft. Rupert)
Quinault
Makah
S. Tlingit
Tsimshian
Haida
Bella Coola (Nuxalk)
N. Tlingit
Ethnographic: Polar
Ethnographic: Sub-polar
Ethnographic: Pacific NW coast
Ethnographic: Plateau forests
Ethnographic: Plains
Ethnographic: Great Basin
Ethnographic: California



Effective Temperature (degC)
NPP (g/C/m2)
Mild
Cool
Very cool/boreal
(Very) Cool/Arctic
Stage 3 Project 42ka
Ethnographic: Polar
Ethnographic: Sub-polar
Ethnographic: Pacific NW coast
Ethnographic: Plateau forests
Ethnographic: Plains
Ethnographic: Great Basin
Ethnographic: California


Effective Temperature (degC)
NPP (g/C/m2)
Mild
Cool
Very cool/boreal
(Very) Cool/Arctic
Stage 3 Project 30ka
Ethnographic: Polar
Ethnographic: Sub-polar
Ethnographic: Pacific NW coast
Ethnographic: Plateau forests
Ethnographic: Plains
Ethnographic: Great Basin
Ethnographic: California


Effective Temperature (deg C)
NPP (g/C/m2)
Mild
Cool
Very cool/boreal
(Very) Cool/Arctic
Stage 3 Project 21ka
Ethnographic: Polar
Ethnographic: Sub-polar
Ethnographic: Pacific NW coast
Ethnographic: Plateau forests
Ethnographic: Plains
Ethnographic: Great Basin
Ethnographic: California

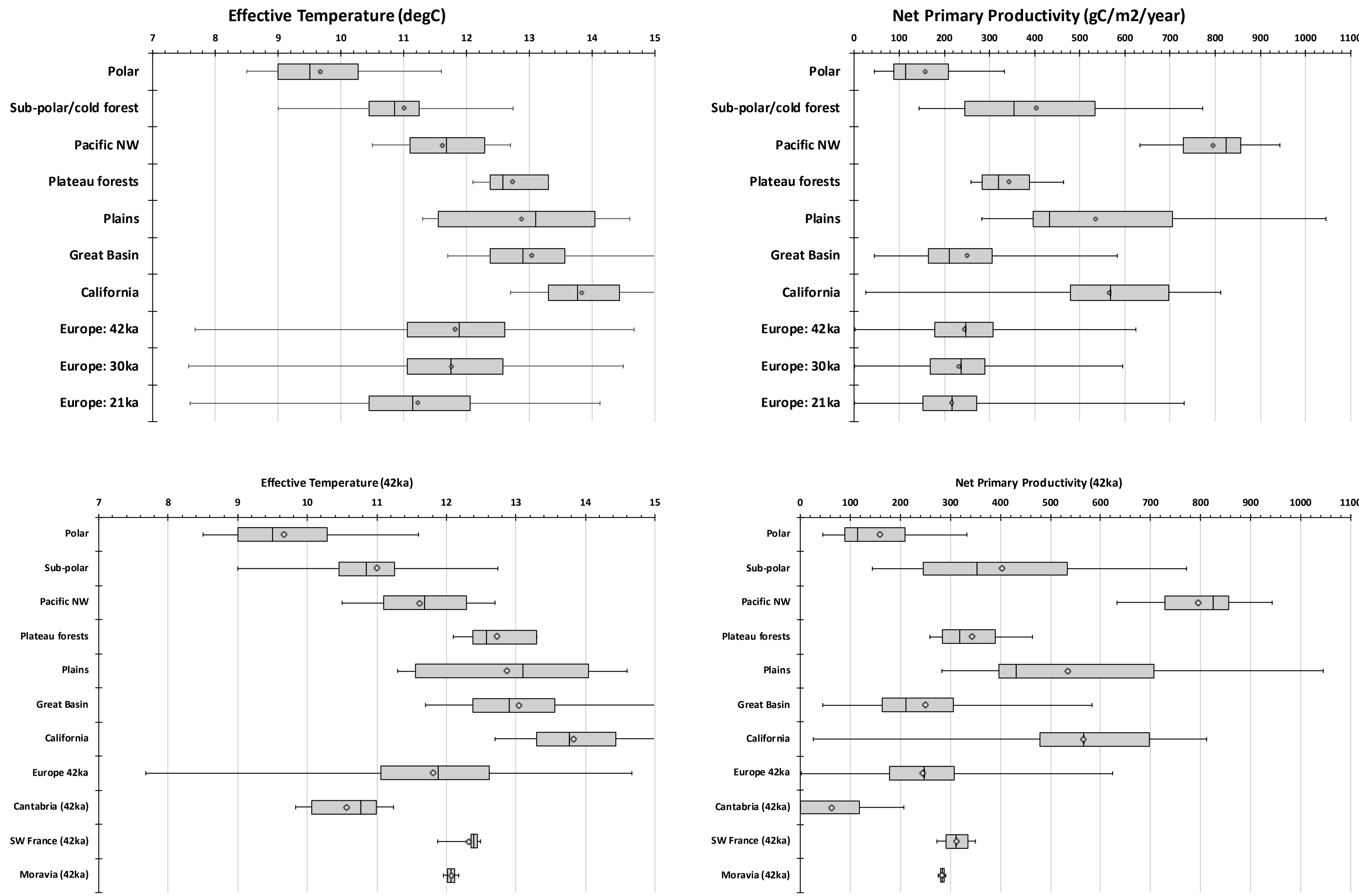


Figure 9.2 *(cont. opposite). Spatio-temporal distributions of NPP and ET in Upper Palaeolithic Europe, and by region/site: Cantabria, southwest France, Moravia, and two key isolated sites (Paviland and Sunghir). Mean values denoted by white diamonds.*

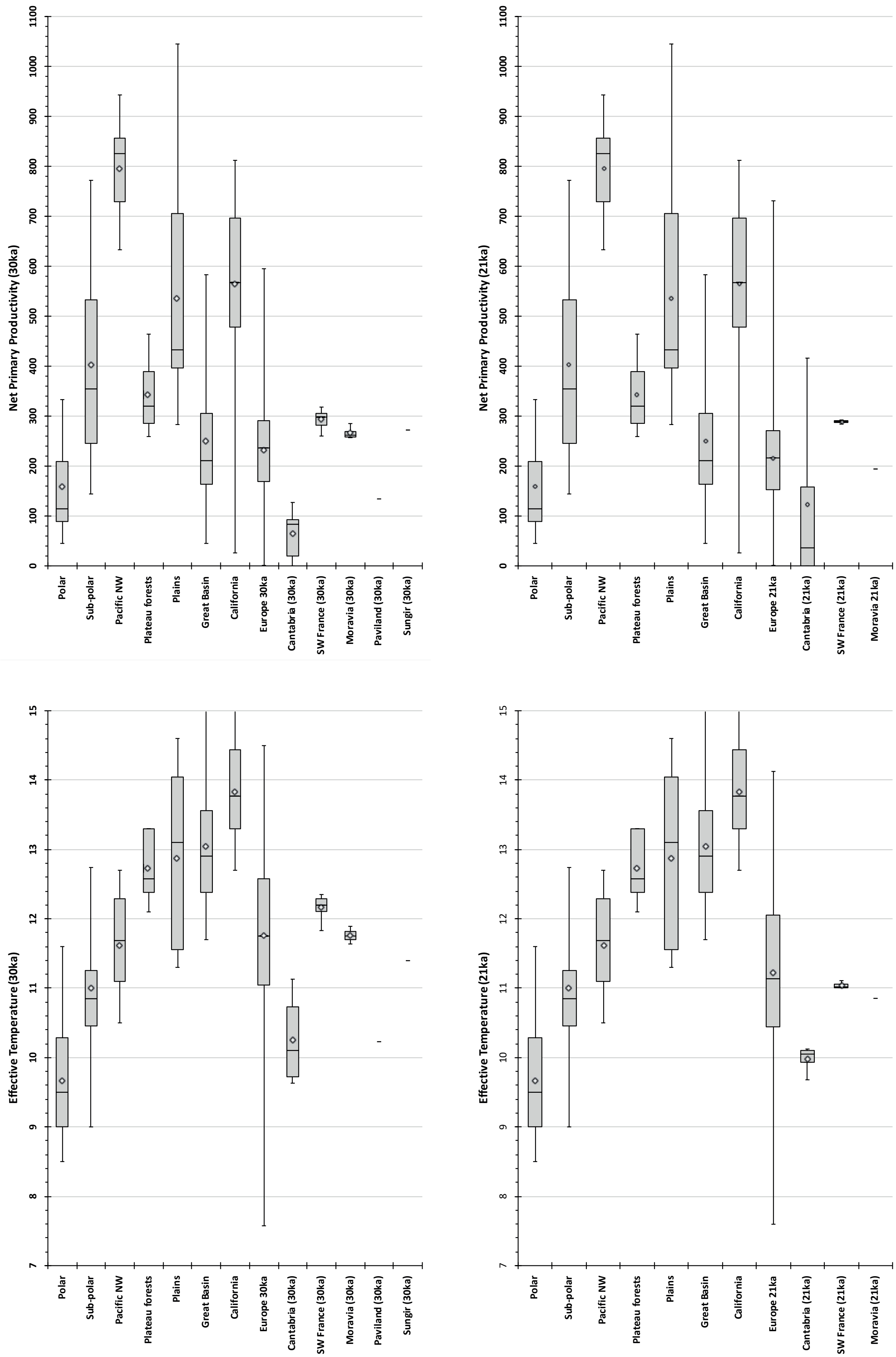


Figure 9.2 *(cont.)*.

21 ka: 10–12 months; Paviland, 30 ka: 6 months), temperatures above 10°C (42 ka: 2 months; 30 ka: 1–2 months; 21 ka: 0–1 months) are rather less common, unlike the situation seen in southwest France, Moravia and at Sunghir (Fig. 9.3). With NPP values generally lying below 320 g carbon per sq. m per year for the key European Upper Palaeolithic regions/sites (Figs. 9.1, 9.2; Appendix B), rather than the Pacific Northwest Coast's range of 633–943 g carbon per sq. m per year, it is hard to see how the latter could be seen as an analogue of resource richness for the former. Instead, Upper Palaeolithic Europe's productivities seem to have been much lower: more akin to those from current Great Basin environments, as well as those from Polar, Sub-polar and Plateau biomes (Fig. 9.2). More recent NPP estimates by Allen et al. (2010) and Huntley et al. (2013) have done little to alter our preceptions of relatively low productivity European Upper Palaeolithic environments.

Different methods of estimating NPP privilege different aspects of plant growth: not just growing temperatures, precipitation and potential evapotranspiration (e.g. Kelly 2013; Tallavaara et al. 2015), but also (in some models) carbon dioxide concentrations and forest canopy structure (Huntley & Allen 2003; Allen et al. 2010; Huntley et al. 2013). These simulations thus need testing against other lines of evidence. Dated plant macrofossils can yield useful productivity data if well-enough preserved. Analyses of growth rings in carbonized wood from Upper Palaeolithic sites corroborate low productivities in the late Pleistocene: the Gravettian sites of Pavlov, Dolní Věstonice and Krems-Wachtberg show clear growth-ring evidence for slow-growing, dense wood in the environs of these sites, and also implying delayed springs, cool summers and early, cold, autumns (Beresford-Jones et al. 2011; Pryor et al. 2016; Opravil 1994; Damblon 1997; Cichocki 2000; Cichocki et al. 2014). Slowly growing trees and shrubs would have affected the productivity of firewood, raising the key question of how long high-latitude groups could remain in an area before fuel became exhausted, enforcing displacement of people for decades until the supply was replenished (Pryor et al. 2016). The shortage of fuel would not only affect the ability to provide heat (for warmth, cooking and manufacturing) and light, but also for smoking

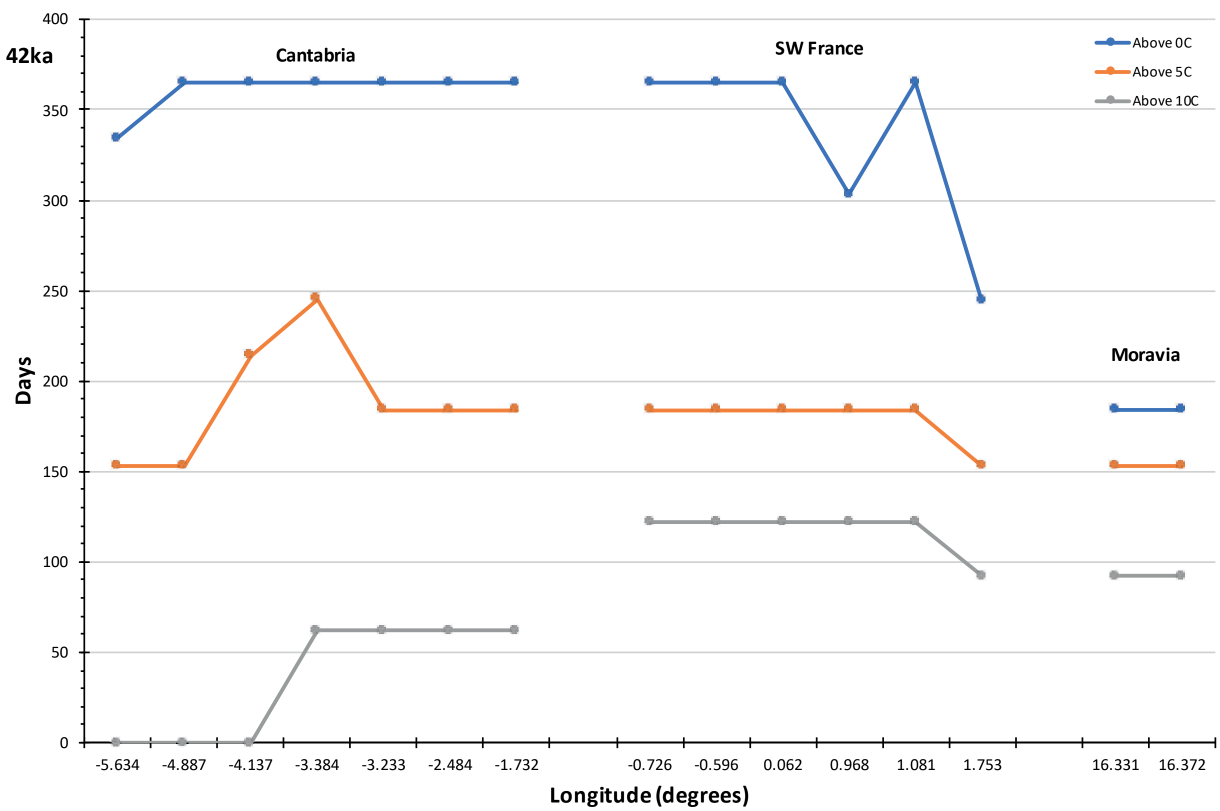
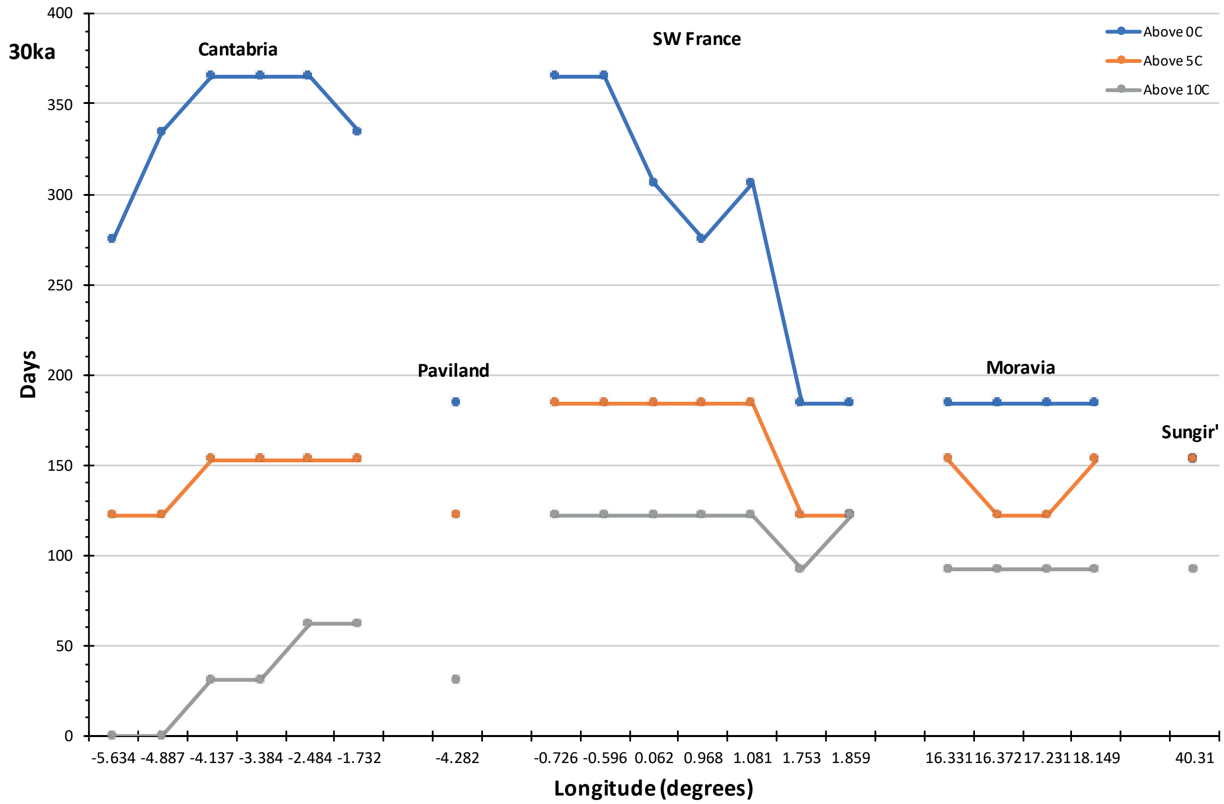
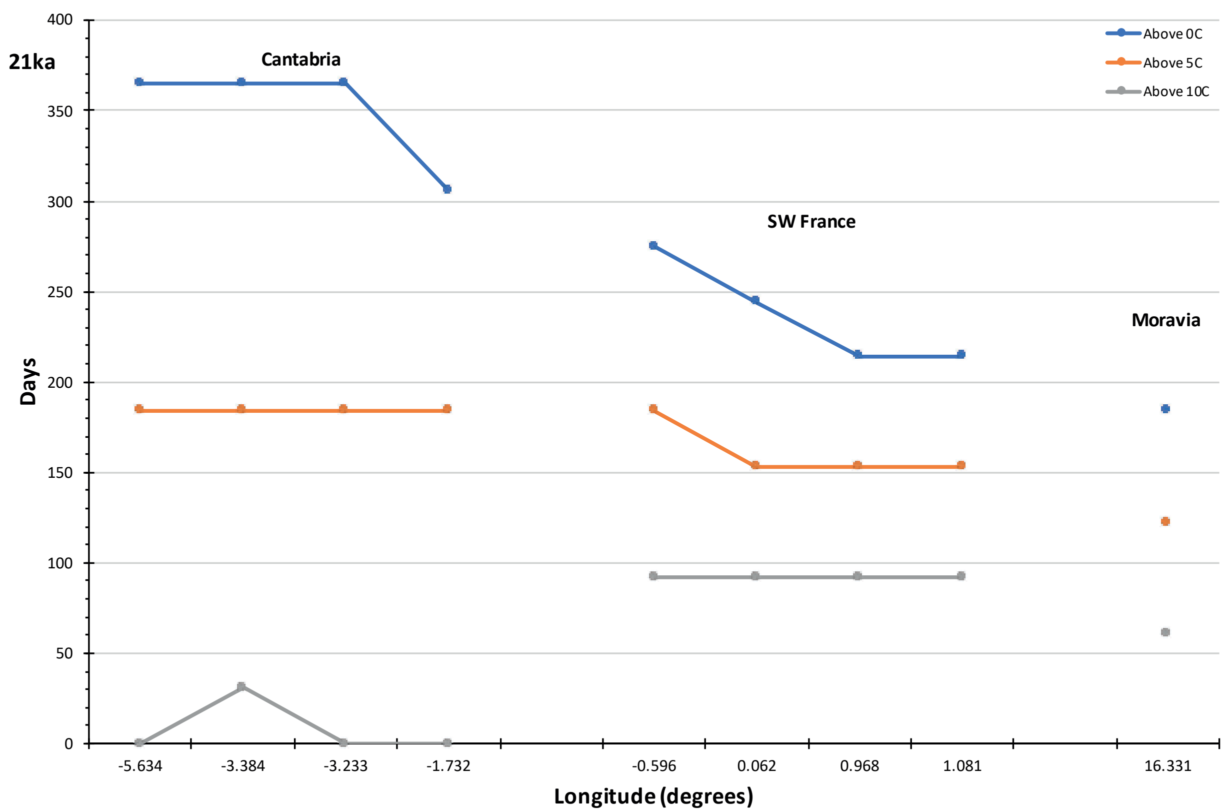


Figure 9.3 *(opposite and above). Number of days per year with (growing) temperatures above 0°C (blue), 5°C (orange) and 10°C (grey) at 42 ka, 30 ka and 21 ka.*


30ka
Cantabria
SW France
Paviland
Moravia
Sungir'
Above 0C
Above 5C
Above 10C
Days
0
50
100
150
200
250
300
350
400
-5.634 -4.887 -4.137 -3.384 -2.484 -1.732
-4.282
-0.726 -0.596 0.062 0.968 1.081 1.753 1.859
16.331 16.372 17.231 18.149
40.31
Longitude (degrees)


21ka
Cantabria
SW France
Moravia
Above 0C
Above 5C
Above 10C
Days
0
50
100
150
200
250
300
350
400
-5.634
-3.384
-3.233
-1.732
-0.596
0.062
0.968
1.081
16.331
Longitude (degrees)

surplus meat for storage. Slow growth also would affect the suitability of locally available wood for production of wooden tools (e.g. projectile shafts: see p. 150). The structure of *c.* 8–10 cm thick spruce logs over the Dolní Věstonice Triple Burial (Trinkaus et al. 2006: 16) presumably required wood of suitable dimensions, rather than of a particular structural quality.

Glacial aridity and – by extension – clear skies have been seen as a driving force of Guthrie's 'Mammoth steppe' (Guthrie 1982, 2001; Guthrie & van Kolfschoten 2000), creating large areas of mid-latitudinal steppic (mostly herbaceous) vegetation that supported megafauna such as mammoth, woolly rhinoceros, reindeer, musk ox, saiga antelope, cave lion, wolf and fox, in non-analogue combination with horse, red deer, hyaena and aurochs. The rapid Dansgaard-Oeschger climatic cycles would help to create changing environmental compositions and productivities in a given location, and these fluctuations operated at much larger spatio-temporal scales (and with much more unpredictability) than those acknowledged in Owens & Hayden (1997: 123). This unpredictability would have made it difficult for structured socio-economic complexity to arise in much of the Upper Palaeolithic (next section). Soil micromorphological studies of the 2005 excavations at Dolní Věstonice II, and at the contemporaneous site of Předmostí, have indicated that the Gravettian occupation was on the surface of an incipient soil (with evidence of grassland vegetation and some (coniferous) trees): periodically saturated, but otherwise showing evidence of low soil moisture (Beresford-Jones et al. 2011; Paine 2012). The small quantities of micro-debitage at Dolní Věstonice II (2005 excavations) might indicate ephemeral occupation, and the agglomerated, deep series of hearth deposits suggests use, interspersed with 'significant periods of disuse' (Beresford-Jones et al. 2011, 1959) when loess covered the hearth. This sequence of use and disuse might have lasted some six centuries (Beresford-Jones et al. 2011, 1954). It could be that the disuse reflected relocation to another part of the Pavlovské Hills where preferred conditions arose or survived, but overall, the association of many Moravian and Austrian Gravettian sites with periods of soil formation is intriguing (Paine 2012): where did human groups go when conditions deteriorated, preferred plants and animals were displaced, and aeolian sediments began to accumulate? Occupation at Dolní Věstonice II might cover a single Dansgaard-Oescheger event, perhaps situated in the GS-5b oscillation in NGRIP (*c.* 32.04–30.84 ka) (Beresford-Jones 2011, 1962; Rasmussen et al. 2014). Such apparent lack of stability in regions with highly developed Upper Palaeolithic material culture would surely have ensured that only relatively ephemeral socio-economic inequalities might develop.

Issues of seasonal availability and quantities of resources are beginning to be more clearly articulated, although our knowledge of environmental productivities is in its infancy: NPP simulations need greater detail and testing against environmental proxies (including tree growth rates) from archaeological sites or their environs. It is currently difficult to estimate aquatic productivities, so our picture of *total* primary productivity (including underground storage organs from aquatic plants and marine algae) for the European Upper Palaeolithic is by no means complete. Archaeological evidence of marine and freshwater resources exists, e.g. in Cantabria and Moravia (Freeman 1981; Pryor et al. 2013), though a more holistic environmental productivity model (incorporating both aquatic and terrestrial biomes) would enable us to assess the extent to which aquatic resources might have been used to mitigate lower terrestrial productivities. Evidence for exploitation of marine algae has been inferred from molluscan evidence at just two late Upper Palaeolithic Iberian sites: Parpalló (Solutrean) has six *Neritina* sp. shells, claimed by Freeman (1981: 151) to be too small to be food, though they could have served as potential beads/pendants), while Santa Catalina has *Rissoa parva* (Final Magdalenian: level II) and *Bittium reticulatum* (Azilian: level I) shells (Berganza et al. 2012: 178–9). It is unclear whether seaweed was used for packing marine fauna to maintain freshness, and/or as food.

To return to the quotation near the start of this section, rather than 'unequalled richness,' the evidence instead suggests intermittent resource bounties. Climatic and environmental fluctuations might have permitted the intermittent occurrence of individuals with competitive and aggrandizing tendencies (Hayden's (1995, 1998) 'despots': Table 9.1). The problem of equifinality makes it difficult to see any evidence of Upper Palaeolithic storage as indicating long-lasting, structural inequalities: the general indications of variable, and often depressed, productivities in the late Pleistocene, together with the nature of the available resources, suggest that storage was practised to mitigate fluctuations in supply (household self-sufficiency). It is therefore hard to see how other community members could be persuaded to surrender control over any temporary surpluses they might have accumulated; certainly, clear surpluses could not be continually accumulated over lifetimes (unless more durable materials were selected: see pp. 150, 153). The whole chain of inference (generation of surpluses that allow development of inter-individual/-familial competition and prestige, and then the formation of secret societies that control relationships of political, economic and supernatural support (Owens & Hayden 1997: 124)) thus lacks a firm foundation: resources are not demonstrably 'rich' and 'reliable.'

Upper Palaeolithic demography

Population estimates are generally relatively low for Upper Palaeolithic Europe, using a variety of proxy evidence (Appendix Table 9.C1). Maximal estimates generally lie below six figures for the whole of Europe, with late Magdalenian/final Pleistocene populations being the largest. When we consider population densities, recent modelling does not suggest any densities above Hayden's (2003) threshold of 10 persons per 100 sq. km (Table 9.2). Most reconstructed Upper Palaeolithic densities lie well below six people per 100 sq. km, which is below the modelled transitional threshold from band-organized societies to more tribal/chiefdom-based ones: 6.3–63.1 persons per 100 sq. km (Fig. 9.4; Newell & Constandse-Westermann 1986). Simulated population densities are higher for some regions and periods, but there is little to suggest more tribally or chiefdom-based societies in the Upper Palaeolithic. The nearest example to the latter is the Franco-Cantabrian Upper-Final Magdalenian, where multiple authors have modelled the densest Upper Palaeolithic populations in Europe: perhaps reaching maximal estimates of 17–20 persons per 100 sq. km (Appendix Table 9.C1), or third quartile values of 7.8 persons per 100 sq. km in southwest France (Kretschmer 2015). Similar densities were reported for two Inuit groups that specialized in aquatic and small game resources, with some reindeer exploitation (18–19 persons per 100 sq. km: Burch 1972: 350). Such densities suggest that social population units [bands] would have permeable boundaries, situated within bounded ethnic groups and exogamous breeding populations (cf. Sikora et al. 2017). The estimated low regional population densities and occupation areas (e.g. Maier & Zimmermann 2017) would have placed greater emphasis on the location of individuals within a territory in Newell and Constandse-Westermann's model, creating a system of overlapping mating networks. Densities scarcely attain those seen for Pacific Northwest Coast societies (mostly 10–96 persons per 100 sq. km: Kelly 2013, Appendix Table 9.C1). As discussed earlier, we have little evidence, even in Franco-Cantabria, for consistent production of surpluses that would sustain transegalitarian societies and the subordination of bands to tribal/chiefdom social structures.

The Upper Palaeolithic evidence for broad-spectrum consumption has demographic implications. While there is no clear evidence of predominant exploitation of small fauna and plants, their presence is consistent enough to suggest they were a significant economic resource for some groups. The restricted mobility of such resources might imply sedentary or semisedentary human economies, allowing persistence in a location and the practice of activities that required reduced mobility. However, evidence for population packing in the regions with clear evidence of broad-spectrum economies is unclear. Demographic estimates for Upper Palaeolithic populations are missing for much of the Mediterranean region, but those for southern Iberia, southern France and parts of Italy are relatively low (Kretschmer 2015; Maier et al. 2016). Exploitation of a wide range of food resources may have been needed simply to support groups in relatively arid environments, where large herbivores were also rarer than on the mammoth steppe. Even in that habitat, sites such as Pavlov and Dolní Věstonice do not show clear evidence of long-term occupation, despite the range of species exploited (Wojtal et al. 2012, 2018). It is possible that long-term intensification at the latter sites was limited by local environmental instability (Paine 2012) and restricted productivity of key resources like firewood (Beresford-Jones et al. 2011; Pryor et al. 2016). Thus, there might have been transient 'big men' (Cashdan 1980) or despots (Table 9.1) at these sites, but nothing more structurally inegalitarian.

Archaeological evidence for group sizes at Upper Palaeolithic sites is limited. Many estimates depend on the sizes of features and assemblages (artefactual and faunal) at sites, which may have been contingent on local spatio-temporal resource availability (Appendix C). The Middle Magdalenian at Maszycka (Poland) has yielded what is argued to be a catastrophic death assemblage for a household (several related families?), thus providing a rare indication of group size and composition. However, even this assemblage cannot be seen as a direct reflection of group demography, as the bone fragments are highly modified and were probably selectively deposited. Their fragmentary condition has made it difficult to calculate the number of cave occupants: initial estimates of at least 16 individuals (one male and seven indeterminate infants, three female juveniles, three female and two male adults) (Kapica & Wierciński 1993) have since been revised as a minimum of nine individuals (four adults (one sexed as male); five children) (Orscheidt et al. 2017). Empirical evidence of Upper Palaeolithic site demography (size and organization) is thus rare and variable, making it difficult to relate directly to resource consumption.

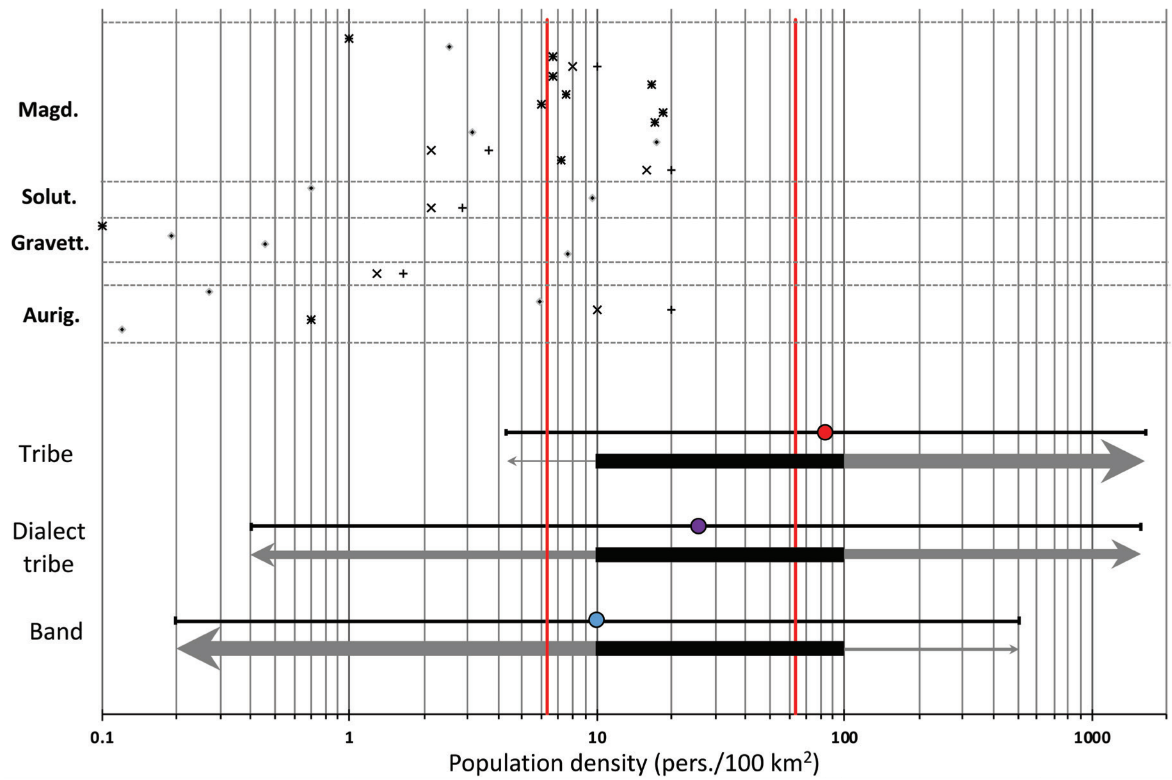
Mobility and motility have been recognized as key aspects of Palaeolithic demography for several decades (Dyson-Hudson & Smith 1978). Motility is the '*the capacity or potential to be mobile*' (Weig 2015, 423), setting the choices and limitations that precede movement into a temporal dimension. Zubrow's (2010) equality of opportunity (Table 9.1) can be used to evaluate intragroup motility options and constraints: was motility connected to age, sex and social ties, with resulting differences in potentials for interaction and transfer of knowledge (Weig 2015: 428)?

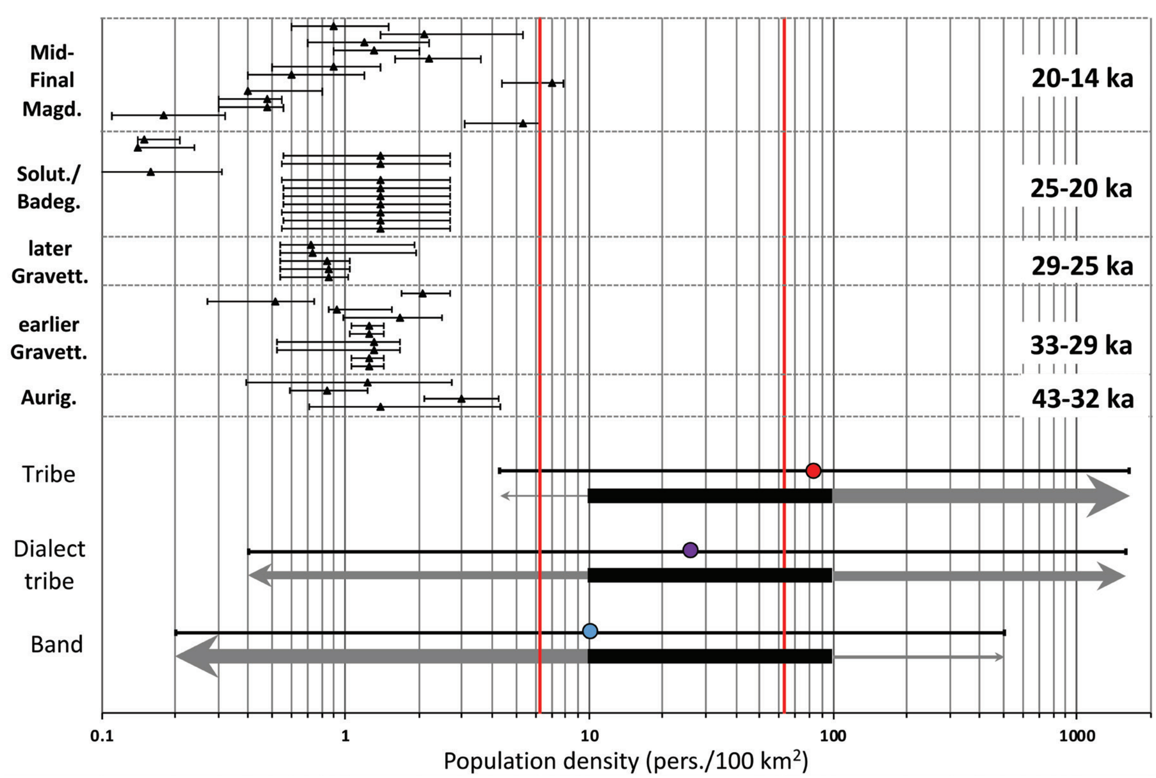
Aggregation to exploit high-density (and predictable) resources would be one example of motility, and another would be constraints on group fission, e.g. population 'packing,' topographic barriers or warfare, that might restrict options for movement (Hayden 2008: 22; Boone 1992). Most European Upper Palaeolithic contexts were in areas with not particularly abundant or predictable resources. Options A, B and D (Fig. 9.5) are therefore more likely than geographically stable territorial systems with resource contests. 'Contests' are a form of resource competition where available patches are restricted by prior occupancy or despotic control; pairwise competitions between individuals over particular resource patches result in success or failure in winning or holding a patch (Boone 1992: 315–16). Individuals' fitness thus correlates with unequal patch qualities (and differential access to them); the fitness of those holding desirable territories is not necessarily lowered by the addition of other people. Social hierarchy can therefore develop around resources that are defendable and divisible, if the costs of defence can be maintained. The alternative competitive strategy for resources (Boone 1992) is the scramble: all individuals are equally empowered and informed to choose the best-available resource patch or strategy, but in sparse and unpredictable patches that are not economically defensible, every additional participant lowers the fitness of other group members. There is little evidence of resources that were predictable or dense enough to be defendable or divisible, and thus there is no clear socio-economic development throughout the European Upper Palaeolithic. Potential examples of resource division do exist, but not on a scale where we can generalize for a whole region or technocomplex: a wide variety of habitat sizes and structures can be found within each major Upper Palaeolithic technocomplex.

Environmental fluctuations during the Upper Palaeolithic would have affected economies (resource abundance, distributions and predictability; technology) demography (population sizes, densities and mobilities) and knowledge exchange (density and structure of networks). Fluctuations and changes are seen in all the major Upper Palaeolithic technocomplexes (Davies 2001; Maier & Zimmermann 2017; Maier et al. 2016; Appendix Table 9.C3). Technological change may be more indicative of motility and mobility than increasing intensification and surplus-production (Appendix Table 9.C2). Habitat-tracking (targeting particular biomes) underpins both human demic dispersal and contraction/refugiation. Dispersal processes operated at multiple spatio-temporal scales, not just happening at the start of the Upper Palaeolithic and the Lateglacial; likewise, contraction/refugiation processes were not restricted to the LGM. Late Pleistocene spatio-temporal shifts in the mosaic of biomes and resource attractors created corresponding shifting potentials for motility in Upper Palaeolithic societies. The durability and nature of any resource 'hot-spots' would determine whether they would generate contests rather than scrambles. High-density networks would be more resilient to environmental perturbations, as they have a high capacity for information transmission, unlike low-density ones with few connections or ones with a few highly connected hubs (Fitzhugh et al. 2011).

Information exchange is key to adaptations in areas with scarce and often unpredictable resources (Fig. 9.5). It operates at two main social and spatial scales (local/inter-band; supra-/multi-band), tracking environmental productivities and changes with different levels of adaptive depth (Fitzhugh et al. 2011: 91). Mobility

Figure 9.4 *(opposite). Reconstructed population densities compared against the modelled transition (6.3–63.1 persons per 100 sq. km: between the two vertical red lines) from band-organized societies to tribal/chiefdom-organized ones (Newell & Constandse-Westermann 1986). Means for the three social groupings are shown with log^{10} double standard deviations (95 per cent confidence): band-level societies (mean: 10.1 persons per 100 sq. km; range: 0.2–504.3 persons per 100 sq. km at two standard deviations; N=93), dialect tribes (mean: 26.1; range: 0.4–1586.3 persons per 100 sq. km; N=169), and tribal/chiefdom-level (mean: 83.9 persons per 100 sq. km; range: 4.3–1646.0 persons per 100 sq. km at two standard deviations; N=76). Thickness of grey and black lines beneath each mean reflects the relative proportion of groups in that category (<9.9 (grey), 9.9->99.1 (grey) and 99.1 (black) persons per 100 sq. km). (a) Aurignacian, Gravettian, Solutrean and Magdalenian population estimates: means (◆) (Bocquet-Appel & Demars 2000); minimal (×) and maximal (+) estimates (Hahn 1977; Straus 1986; Biraben 1988; Zimmermann 1996; Rozoy 1996, 2001). (The Hahn (1977) estimate of 10–20 persons per 100 sq. km for the Central European Aurignacian is uncertain, as it is based on very few, widespread, sites.) (b) Earlier and later Gravettian, Solutrean/Badegoulian, and Middle-Final Magdalenian median (▲) and interquartile ranges for key occupied areas in Europe (from Kretschmer 2015; Maier et al. 2016; Maier & Zimmermann 2017).*


Magd.
Solut.
Gravett.
Aurig.
Tribe
Dialect tribe
Band
0.1
1
10
100
1000
Population density (pers./100 km²)


Mid-Final Magd.
Solut./Badeg.
later Gravett.
earlier Gravett.
Aurig.
20-14 ka
25-20 ka
29-25 ka
33-29 ka
43-32 ka
Tribe
Dialect tribe
Band
0.1
1
10
100
1000
Population density (pers./100 km²)

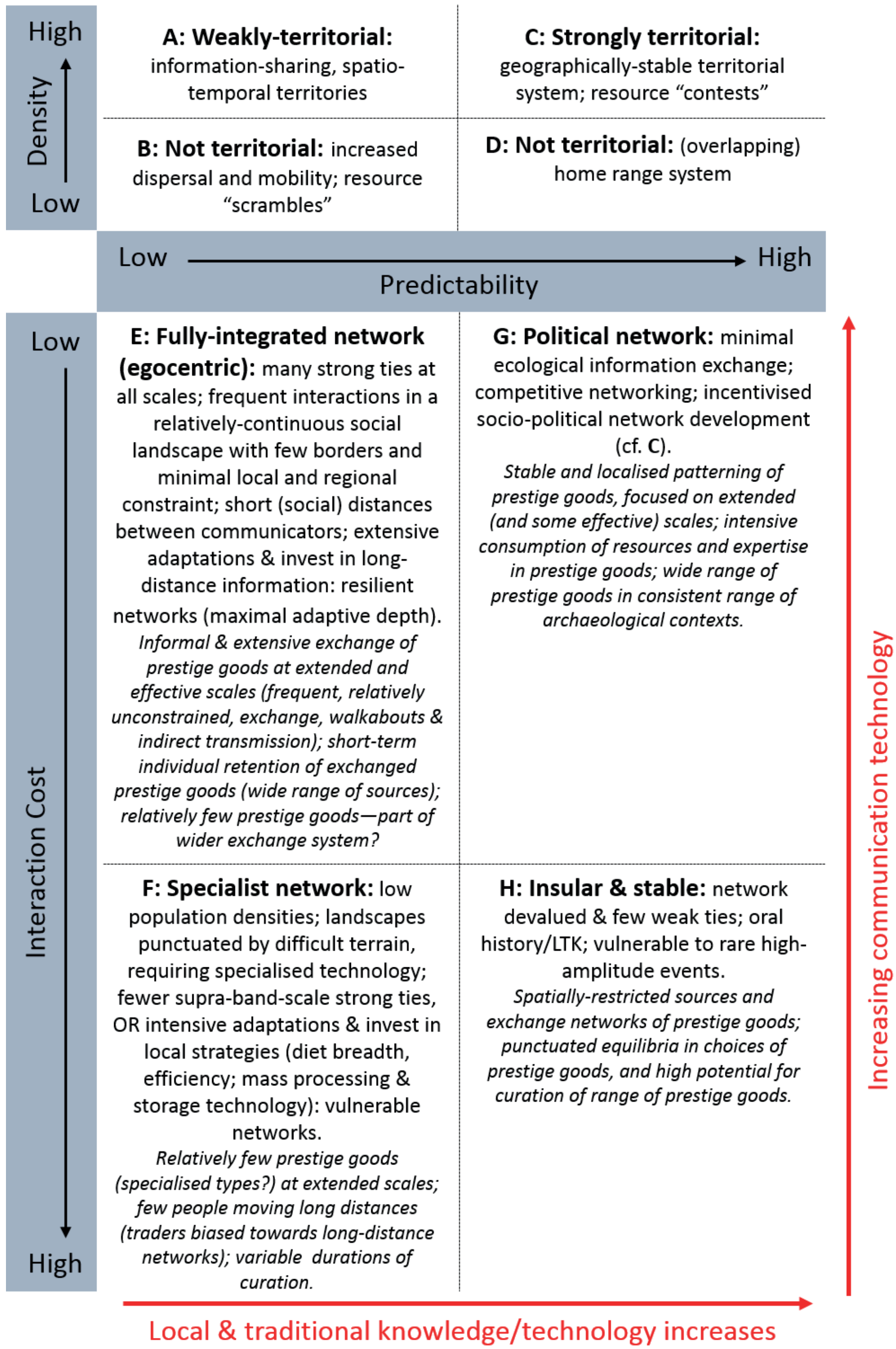


Figure 9.5. *The effects of resource predictability and abundance on territorial organization and exchange networks (after Dyson-Hudson & Smith 1978; Boone 1992; Marean 2015; Fitzhugh et al. 2011). The y-axes of both grids are different, which ensures that they do not directly map onto each other; resource productivity is taken to be sufficient to support population density, and therefore omitted by Fitzhugh et al. (2011). 'LTK' = Local and Traditional Knowledge. Categories E–F are all assumed by Fitzhugh et al. (2011: 97) to be founded on sufficient environmental productivity for the local population density. 'Effective' and 'extended' scales taken from Gamble (1999: 50–3). E–H: hypothetical prestige exchange patterns in italics.*

Table 9.3. *Information transmission types (Fitzhugh et al. 2011) compared to demographic (including longevity of units) and spatial attributes from forager societies (Newell & Constandse-Westermann 1986; Wobst 1974). ('Half-life' reflects longevity and relative stability of social units in equilibrium conditions, and gives a* minimal *indication of the time taken for half the original existing units to become extinct, e.g. half of families survive a single generation (Wobst 1974).)*

Social Unit	Population			Spatial extent (sq. km)			Duration (yrs) ('half-life')	Information transmission type
	N	Mean	Range (2 SD)	*N*	Mean	Range (2 SD)		
Language family	*23*	4514.09	165.2–124,165.23	*23*	18,801.82	537.03–657,657.84	2000–8000	Oral history (millennial scale). Inter-regional (>320 km) & regional (160–320 km) networks
Tribe/Chiefdom	*193*	897.18	112.7–7142.0	*215*	3303.62	46.78–233,287.79	691-716	Local & traditional knowledge (centennial scale). 'Supra-band' (64–160 km) & local band (<64 km) networks
Dialect tribe								
Band	*113*	297.21	43.76–2018.53	*69*	1926.95	19.45–190,883.33	>180	
Household/ family							*c.* 25	Partnerships (decadal), e.g. hxaro networks & task groups, and local adaptive mechanisms (annual/sub-annual scales)
Individual							30–34	

facilitates multi-scalar transmission of information, from highly detailed local knowledge (containing redundant information collected during everyday activities), more cursory and infrequent regional information exchange (loss of detail between bands over distance: susceptible to down-the-line bias), and inter-regional exchanges between minimal bands (supra-band aggregations, informal long-distance travel/'walkabouts,' inter-individual partnerships and marriage-alliances) (Fitzhugh et al. 2011: 91). If the network is fully integrated over varying social and spatial scales, lower-amplitude, often frequent, shifts in resource attributes (productivity, diversity and distribution) can be closely monitored. Larger-amplitude fluctuations require more extensive information networks or greater mobility if groups are to survive, to mitigate the effects of any deterioration. Informal regional networks (Fig. 9.5: E) are resilient to environmental change, having a greater range of adaptations at different scales ('maximum adaptive depth' (Fitzhugh et al. 2011: 96)) and frequent, unconstrained, local and regional interactions. They are further characterized by 'a relatively continuous social landscape, with few social or physical barriers' and short interaction distances (Fitzhugh et al. 2011: 96). Fluidity of group membership, via fission-fusion processes, could reduce the costs of information transmission over longer distances (Table 9.3, Fig. 9.5), though the range of material culture transmitted at the supra-band scale is more restricted (Gamble 1999: 49–63).

The social construction of resources in the Upper Palaeolithic

As stated at the start of this paper, 'resources' are not self-evident entities. They include not only food, but also those needed to make artefacts and fuel heat and light; people, in the form of labour and expertise, can also be seen as resources. Selection of particular resources, the manufacture of artificial materials, and the social value placed on them (as reflected in procurement, transport, processing and storage) will all be examined in this section. We shall consider the extent to which activities and processing of resources can affect motility, and the potentials for secrecy in the use of materials or the control of know-how. If the resource patterning discussed so far provides no clear support for structural inegalitarianism in Upper Palaeolithic societies, can we identify inequalities in resource usage?

The extent to which dedicated specialists were required in the sourcing and processing of technical resources in the Upper Palaeolithic is unclear: we have no *unambiguous* archaeological evidence to suggest secret workplaces or controlled access to technical knowledge. Reconstructed Upper Palaeolithic group sizes suggest that what might have been small activity areas (e.g. the rear of Hohlenstein-Stadel cave, Germany (Aurignacian) (Kind et al. 2014)) could in fact have contained the whole group, not just a fraction of it. That is not to state that all Upper Palaeolithic people were equally talented or experienced in every technical skill, but archaeologically it is difficult to distinguish equality of opportunity in acquiring skill from more hierarchical control of knowledge and expertise by specialist craftspeople (Table 9.1). Human skeletal remains can show evidence of persistent behaviours, e.g. heavy manual labour, repetitive manual actions, but are difficult to link to *specific* activities and tool-types, and so cannot be used to demonstrate inequality in the technical sphere. However, *artificial* materials (e.g. composite pigments, mastics, ceramic) have greater *potential* for specialist, secret (or *ad hominem*) knowledge than those that are common and require relatively straightforward processing (e.g. stone, bone). Some natural materials, such as antler, ivory and wood, may have been commoner and more accessible in some parts of Europe than elsewhere, leading to variation in potentials for unequal access within technocomplexes: in areas where they were scarce or unknown, exchange or long-distance procurement would be needed to provide them, with better-connected individuals benefiting more than others.

Intra-site spatio-temporal patterning of resources and associated technologies has potential for evaluating Upper Palaeolithic inequalities, e.g. the combination of comminuted and heat-altered resources into specific artificial compounds (pigments, mastics, ceramics, and even some foods). Concealment of such materials or the knowledge of their ingredient proportions and processing (Table 9.2) needs to be demonstrated case-by-case, and is not exclusively diagnostic of structural inegalitarianism. We should not rely on similarities of form, when the resource ingredients, *technological* styles and archaeological associations can be much more varied. Generalized traditional analyses of Upper Palaeolithic art, focusing on similarities of form, have begun to be tested by studies of the varying *chaînes opératoires* used to produce the pigments (e.g. Leroi-Gourhan 1982; Lorblanchet et al. 1990; Clottes et al. 1990). Today's egalitarian forager societies display inequalities of knowledge, particularly relating to craft-specialization and ritual involvement (Woodburn 2005: 26). Clottes et al. (1990) emphasize differences in pigment 'recipes' between Magdalenian sites; the same images were even painted with different 'paint pots' (varying pigment recipes and sources of constituent ingredients). Were such differences the results of different artists and their individual preferences, or of artists of different status (or place of origin)? Other artificial materials display similar heterogeneity: ceramic figurines from the earlier Gravettian (Pavlovian) sites of Dolní Věstonice and Pavlov show different ways of shaping the form and surface features, varying between site locales, and also within the same artefact type (Farbstein & Davies 2017). It has also become apparent that Pavlovian knapped stone assemblages were heterogeneous at the same sites (Polanská & Novák 2014), implying household-based or diachronic variations in lithic and ceramic *chaînes opératoires* for assemblages that have tended to be seen in monolithic terms.

The fluctuating population histories of many Upper Palaeolithic regions of Europe probably ensured loss and reinvention of technical knowledge and use of raw material sources over time and space. Clottes et al. (1990) identified significant chronological gaps in image production at Niaux, based on pigment recipe variation, while Lorblanchet et al. (1990, 7) argued for similar gaps in production (millennia) in Cougnac. This irregularity would appear to support a model of ritual knowledge inequality that was individualized, rather than structural and consistent. Such resource use was thus not transegalitarian, but consistent with the variation seen in generally egalitarian extant foragers. If production of pigments and art were part of transegalitarian status and regular initiation ceremonies, would we not expect more consistent 'recipes' for pigment production?

Natural distributions of resources were not homogeneous across Upper Palaeolithic Europe, affecting the ability to deliver equality or opportunity or outcome (Table 9.1) at anything greater than the local scale. Technological options to maximize available resources, and social ones to obtain suitable materials from elsewhere, were evident in the Upper Palaeolithic from its inception, allowing people to mitigate fluctuations in supply to some extent. In regions where such materials might be in short supply, e.g. wood suitable for artefact manufacture in higher latitudes, technology would have to focus on maximizing the productivity and conservation of scarce resources. Compositing suitable sections of scarce material (e.g. slow-growing, dense, locally available wood), or protecting them with commoner resources (stone/antler projectile tips), might have helped to prolong the lifespans of tools, e.g. the Ahrensburgian pine arrowshafts of Stellmoor (Price et al. 2017: 213; Bokelmann 1991: 79).

The ability to create artificial resources, often from materials not reliant on biological productivity, seems to have been relatively spatio-temporally restricted: ceramic and pigment production was intermittent, and highly localized. It is premature to say whether such materials were exchanged, or whether they were restricted to households or certain members of the group. During manufacture, artificial (plastic) resources would have constrained motility, requiring episodes of intensive time-budgeting, unlike more durable materials (bone/antler/ivory, stone) that could be carried round the landscape while being worked. Proximity to fire would have governed production of ceramics, mastics, etc., and ceramics could not be moved even short distances before they were dry enough (Farbstein & Davies 2017). This variation in temporality of different resource types would surely have affected household motility, unless people were prepared to abandon such objects between production stages.

Many resources are socially constructed; there are no *a priori* reasons why they should be needed, rather than desired, by people. In extant acephalous foraging societies, there is little structured control of individuals' actions. Children are guided towards self-reliance, rather than their labour being controlled through lineages (Woodburn 1982), and leaders have no redistributive roles or formal political power (Cashdan 1980: 119; Appendix A). Freedom to associate with (or dissociate from) others affects what people learn to do, and from whom. Knowledge and labour are therefore not strictly controlled by any individual, though there is potential for some practitioners to be more influential than others, and ritual activities are still generally more controlled (corporate, not individualized) than other spheres of activity. In this context, we might interpret the finger-prints of mostly immature individuals on Pavlovian ceramics as part of juvenile involvement with ceramic production (Králík et al. 2002; Králík & Einwögerer 2010).

Hayden's 'despots' seem founded more on warfare and production (Table 9.1) than ritual; while control of the latter is seen in all extant hunter-gatherers, initiation into such activities is not restricted in many groups, except by sex (Appendix A). Hayden (1998: 12) has argued for the transformation of food surpluses and labour into less-perishable wealth, such as the accumulation of exotic resources or prestige goods. The drive to accumulate such prestige would lead to competition to attract the (best) craftspeople to produce such wealth (Hayden 1998: 17). As we have already seen, population levels and environmental productivity were not elevated enough to restrict people's motility, making it hard to control them. Indeed, the best craftspeople – if we can demonstrate the existence of despots in some parts of the Upper Palaeolithic – would surely have had greater negotiating power if their skills were in demand. They could thus range widely, and move between groups, on the strength of their skills. The potential for identifying the movement of such expert practitioners is constrained by preservation/recovery and by our confidence in identifying the 'hand' of such people in the archaeological record (artworks, specialist knapping, etc.).

At present, there is little Upper Palaeolithic evidence for the production of consistent surpluses that would sustain an elite; instead groups might have had intensive seasons of activity, when surpluses were processed and stored for subsequent periods of low environmental productivity. In such situations, the activities of specialists would vary over the course of the year, perhaps concentrated in periods when their participation in subsistence was not so important. Thus, equalities of outcome and/or opportunity would still be possible (Table 9.1), with every member being able to make individual contributions to the overall life of the group.

Who consumed which resources?

Resource use (including the sourcing, processing and sharing of materials) is one of the easier ways to track Upper Palaeolithic individuals' agency: how did it fit into household and broader economies? Late Magdalenian sites in northern France give some indication of resource movements round sites, and the potentials for inequality within living groups. Pincevent level IV-20 covers *c.* 4500 sq. m, and within it at least eleven hearths show refitting evidence for contemporaneity (David & Orliac 1994: 158; Enloe 2010a: 41). Assuming perhaps five people per group, David and Orliac estimated *c.* 55 people occupying the site for several weeks in autumn. Refitting of reindeer bones, and reconstruction of butchery patterns, clearly indicates sharing at the point of distribution among members of a socio-economically integrated community of households (Enloe & David 1989; Enloe 2010a,b). Meat-rich portions of single reindeer (upper forelimbs) were distributed over distances of up to 63 m (Enloe 2003), though marrow-/fat-rich distal limb elements seem not to have been shared, instead being restricted to what might have been successful hunters' households (Enloe 2003). The latter (hearths M89, V105, T112) are marked by rich flint and bone assemblages, and more variety of reindeer body parts (Enloe 2003). The asymmetric, but extensive, distribution of resources (donor-recipient or reciprocal sharing) might show strong potential for inequalities to develop, through control of what one household chooses to give another, or even deciding to stop sharing (Zubrow 2010). However, retention of some body parts does not necessarily prove inegalitarianism, and could instead be interpreted as akin to carcass division seen in immediate-return societies (Appendix A). Inegalitarianism would be easier to demonstrate if some households consistently received low meat-yield portions (phalanges, etc.) rather than the upper limbs documented by Enloe and David. The penecontemporaneous site of Verberie (level II.1) shows a different pattern of resource distribution, with primary butchery evidence (corporate processing?) being found at the site (Audouze & Enloe 1997). Sharing seems to have occurred at the point of consumption, but there is no evidence for Pincevent-like reciprocal sharing (Enloe 2010a). The site is much smaller than Pincevent, with the excavations covering some 400 sq. m, and it is possible that the site might have been occupied by one household (Audouze 2010). If there were more than one household at Verberie, there is no evidence of sharing between them. Faunal refits in this assemblage are much more restricted than those at Pincevent, with material moving an average maximal distance of *c.* 4 m (*c.* 20 m at Pincevent), and not shared between hearths (Enloe 2010a). The most securely refitting carcasses were found in a single large dump, between the two main hearths, implying a more communal consumption of food (Enloe 2010a), which might in turn imply some control within a single household over what people ate, and when. The strategies seen at Pincevent might indicate equality of opportunity (the down-the-line sharing of resources was too weakly discriminatory to be classed as structurally inegalitarian), while those at Verberie had more potential to promote equality of resources (if the site were occupied by a single household) (Table 9.1).

In theory, resource consumption would also have been affected by skill level: less-experienced or less-skilled practitioners would have been less efficient in resource use, with mistakes leading to discard of material (Pigeot 1990; Audouze & Cattin 2011). However, there are also clear examples of skilled individuals making artefacts more complex and complicated than necessary. Such objects would include Aurignacian split-based antler points and ivory musical pipes, and Solutrean leafpoints. It is difficult to know the extent to which these examples represent display or prestige items; all three were subsequently replaced/survived by simpler versions of the same artefact type (various simpler-based osseous points, bird-bone pipes and various unifacial knives and spear-tip forms), which might imply diachronic decreases in prestige, through lower time investment in manufacture and fewer 'redundant' features. Current archaeological evidence cannot falsify interpretations proposing a variety of skilled practitioners within essentially egalitarian societies: we cannot identify the exclusive actions of socio-economic specialists. Palaeolithic art varies greatly in quality, and we cannot demonstrate that the skilled knappers of Solutrean leafpoints were the same specialists producing elaborate osseous artefacts. Ceramics, wherever present in the Palaeolithic, are hard to define as 'exclusive' technology. The basic resources (wetted sediments) are hard to monopolize, and both Pavlovian and Epigravettian figurines seem to have been fired in domestic hearths (Farbstein & Davies 2017; Soffer et al. 1993). Economic support for non-subsistence activities might have been more flexible in Upper Palaeolithic groups than is often assumed (Hayden 2003: 131), with each group member having the opportunity to switch between subsistence provision and elaborate manufacture of non-subsistence goods over the course of a season or year, as determined by preference or ability. Skills could be (and probably were) distributed through the group, rather than in the control of a small sub-group, ensuring that devotion of 'surplus' time to non-subsistence activities might have moved around the group, rather than being held in the hands of a few specialists who delivered 'prestige.'

The role of 'prestige' goods in personal and corporate exchange networks also needs definition, and 'prestige' itself is variously characterized. Increasing distance from a source can transform the mundane into the exotic and prestigious (Gamble 1999: 95), as can expenditure of time and expertise in manufacture (including the sourcing of particular resources). Hayden's (2008: 85) definition is more functionalist, with prestige items being used to resolve problems, or to pursue socio-political goals. However, such problems and goals are difficult to define for the Upper Palaeolithic, so focus has tended to shift to 'ritual' contexts. Given that ritual, prestige, objects can be found in acephalous delayed-return societies (Woodburn 2005), e.g. Australian Aborigines, without requiring transegalitarian societies, their presence in Upper Palaeolithic contexts need not indicate transegalitarian organization (Layton 2005). Personalized prestige objects, perhaps used in ritual contexts, might include pendants and beads (especially perforated human and animal teeth), raptor bones, talons and feathers, and highly decorated 'utilitarian' objects (e.g. spear-throwers): all compatible with portability and mobile lifestyles (Henry-Gambier et al. 2004; Svoboda 2006; Laroulandie 2016; Álvarez-Fernández 2009). Small, portable artworks could have been personal objects (especially if adapted for wearing on the person), but alternatively their surface wear and polish could have arisen through more communal use. Shells, amber, lithic/mineral and osseous materials are easier to track than bone, antler and ivory, although ivory must have been imported into Gravettian northern Italy (Mussi 2000: 363). Very few show the distances (600–1000 km) described for the Pacific Northwest Coast (Hayden 2008: 92; cf. Féblot-Augustins 2009; Hussain & Floss 2016). The oolitic limestone used in the Willendorf 1 figurine seems to have come from Stránská skála, near Brno: a Euclidian distance of 136 km (Binsteiner et al. 2008). This transportation of resources contrasts with the earlier Gravettian (Pavlovian) ceramic Dolní Věstonice 1 figurine, found broken (by firing) in a large hearth in the 'upper settlement' of site I (Oliva 2005: 66; Soffer et al. 1993: 271). Such differentiation of mobility must have meant that prestige-through-distance would have varied within what we see today as an emic artefact class, and also has implications if we wish to see Gravettian female figurines as objects exchanged between groups to mitigate climatic challenges (Gamble 1982).

Network structure is key to reconstructing the social contexts of exchange and 'prestige' goods. The latter can be controlled and hidden more in closed societies with hierarchies, whereas exchanged resources/objects are more mobile (and ephemerally owned) in open-networked societies (Fig. 9.5). Resource exchange via down-the-line transmission, aggregations and personal networks would have worked differently in 'open' versus 'closed' social networks, yielding different opportunities for potential inequalities. If groups were small, and/or dispersing, open social networks would have ensured they were more successful in mitigating unpredictable or new environments (Fig. 9.5: E, and perhaps F): resources and knowledge would be distributed through personal networks, and periodically through aggregations and down-the-line transmission. More closed social systems would exert greater control over what was exchanged and by whom, with down-the-line transmission and personal networks being more restricted and hierarchical, and also competitive in the case of aggregations (Fig. 9.5: G, H).

The range of materials used in Upper Palaeolithic pendant manufacture varies from the local to exotic: ivory, chlorite, calcite, talc, haematite, lignite, amber, bone, animal and human teeth, marine and fossil shells for the Aurignacian alone (White 2007). Simple proximity to sources of resources does not explain the patterns we see in sites, implying that network connections must have structured resource use and exchange. The greater quantity of talc beads at Brassempouy than in the Castel-Merle sites might be explained by the former's greater proximity to the Pyrenees, yet Isturitz is even closer to those mountains, but has none. Instead, ivory was almost exclusively used at Isturitz, although amber is the only material at that site to yield a bead production *chaîne opératoire* (White 2007: 294–5). Aurignacian ivory beads at the Castel-Merle sites appear to have been manufactured in winter (White 2007: 296), presumably with the beads moving outwards along exchange networks, while marine shells from the Atlantic and Mediterranean coasts moved in opposite directions to Castel-Merle (Taborin 1993). Desirable (prestige?) items are revealed in what seem to be sculpted ivory marine shells in two Aurignacian sites (La Souquette; Spy) (Otte 1979: 304; White 1989: 378), while a Gravettian ivory pendant that mimics a fossil cowrie was found at Pair-non-Pair (Taborin 2000): were these pieces made for individuals that had no access to the real shells (envy and/or imitation)? If so, there was inequality of access to resources (Zubrow 2010) at these sites, but whether 'fake' shells amount to transegalitarianism is hard to demonstrate without demonstrable inequalities of access to other, currently unknown resources. Some materials, however, could not be reproduced or faked, and would need to be obtained directly or via exchange with areas that possessed them. Many are perishable, ensuring we cannot test their importance or sources in the Upper Palaeolithic record: wood suitable for making tools (e.g. spear handles), mastics and hides. Hide-processing is evident at sites such as Dolní Věstonice II and Pavlov I (Wojtal et al. 2012, 2018), but not in notably high quantities. If hides were exchanged for other resources, it does not seem to have been intensive, and thus we have to look elsewhere for evidence to support Upper Palaeolithic transegalitarianism. While our discussion of these materials must remain hypothetical at present, we should not forget that such materials were important, and that we cannot trace the movements of all materials important to Upper Palaeolithic groups.

Specialist objects may also inform us about Upper Palaeolithic inequalities. Such items (musical instruments, weapons, adornment, pigment mixtures, lamps used for accessing deep parts of caves) might have been privately owned, rather than being communal items. Musical instruments, in durable resources (bone, ivory: Conard et al. 2009) are intermittently found in the Upper Palaeolithic record, though it should be remembered that such objects were not essential for musicking, and anyway could have been made from more perishable materials (Lawson & d'Errico 2002). The idiosyncrasies of particular instruments might correspond to the manufacturing techniques of individual makers and/or the preferences of the player, if those were not the same people. The Aurignacian and Gravettian bird-bone pipes from Isturitz show consistent obliquity of the finger-holes in relation to the long axis, implying a formalized playing style (Lawson & d'Errico 2002): were such practices agreed by players, and if so, were such agreements informal or enforced? The latter does not prove transegalitarianism, as ritual standardization is also found in more egalitarian foragers. Playing an instrument is not intrinsically zero-sum, as it does not prevent involvement of others with the music, unless the space is too small or inaccessible to allow large group participation. In such contexts, the use of musical instruments in exclusive ritual behaviours might be argued, though most recovered instruments have been recovered from what appear to be generalized living spaces. Magdalenian bird-bone pipes from Isturitz appear to be less technically complex than the earlier Aurignacian-Gravettian ones (Lawson & d'Errico 2002), implying different requirements over time.

Apparent 'caches' of Upper Palaeolithic objects (Davies 2001; Peresani 2009; Verpoorte 2012; Steguweit 2015; Kilby 2019), would appear to be the actions of individuals or sub-groups provisioning the landscape for re-tooling when necessary (Binford 1979; Kuhn 1995). The alternative explanation (hunters carrying replacement osseous points on their person, and re-tooling when at rest at a site) does not explain why some Aurignacian sites have huge numbers of such points, while others have very few or none). Caching might have restricted access to such objects/materials at the intragroup scale: those that knew the locations of these caches would be able to utilize them, whereas others would not. However, such behaviour is not unique to inegalitarian societies, as many economically egalitarian hunter-gatherer societies today have hierarchies of knowledge (Table 9.1; Appendix A). Delayed-return strategies are thus suggested (though are hard to quantify) in Upper Palaeolithic provisioning strategies (Appendix A). Some Magdalenian sites suggest the provisioning of deep caves with lamps, sometimes in pairs; they seem to have been placed strategically in Lascaux (de Beaune 1987: 571–2). As with apparent caches of osseous points, not every cave art site yielded lamps (Rouffignac, Niaux, Les Trois Frères, etc.), implying the use of other light-sources, or the removal of lamps from deep caves after use (most were recovered from 'domestic' contexts) (de Beaune & White 1993: 112). It is hard to tell if lamps (each supplied with animal fat resources throughout their use-lives) were personal or communal objects, with interpretations largely based on archaeological context (special-activity/'ritual' vs. 'domestic') and levels of decoration (personalization?). Some highly decorated lamps have been interpreted as being used in special rituals, e.g. one found in the *Puits de Lascaux* (de Beaune 1987: 573).

Locales that can be controlled, owing to their size or accessibility, can make it easier to evaluate the level of restriction in the use of certain resources. However, such discussion relies on the deposition and leaving of resources in those places; if resources were carried out of the special activity areas, it is impossible to evaluate potential inequalities deriving from restricted resource use. The gallery above the Magdalenian camp at La Garma shows clear evidence of people moving along it, but relatively little material evidence of activity, apart from some painted signs (Arias 2009: 266–7). Other caves have more substantial evidence of specialized use of resources in deep galleries, e.g. placement of objects in fissures/cracks and on ledges, cave art, clay sculptures of animals, mostly, but not exclusively, from the Magdalenian (Arias 2009; Medina-Alcaide et al. 2018). The Hohlenstein-Stadel *Löwenmensch* (Aurignacian) is more typical of the earlier Upper Palaeolithic: an object positioned in a restricted part of a site, with very little other evidence of activity nearby (Kind et al. 2014), which may have been used by a whole group, or a smaller sub-group (initiates?).

Hayden (2003, 104) has emphasized the importance of initiation ceremonies, perhaps driven by starvation or predation, but of course such ceremonies are not unique to transegalitarian societies or restricted to certain lineages in current foragers (Appendix A). It is hard to evaluate evidence for initiation on extant Upper Palaeolithic human remains (incisions, tattoos, piercing, removal of body parts, etc.: Hayden 2003), but it may be possible to interpret the incised markings on Aurignacian figurines (e.g. Hohle Fels female figurine, Hohlenstein-Stadel *Löwenmensch*) as somehow reflecting initiation. Pre-20 ka child/infant burials recovered from central Europe are often of neonates (Krems-Wachtberg 1–3, Dolní Věstonice ('DV-')4, etc.) (Einwögerer et al. 2006; Svoboda 2006): presumably too young to have been initiated before death, but which are sometimes accompanied by considerable investment of time and resources (ochre, ivory, mammoth scapulae). These child burials are also marked by their proximity to domestic contexts, rather than being hidden in relatively inaccessible locations. Identifying more complex, transegalitarian cultures in the Upper Palaeolithic that valued women (as means of wealth transfers) and children (as means for investment of surpluses in expensive maturation ceremonies that increased value at marriage) is perhaps easier for Lateglacial (post-20 ka) inhumations, when the number of elaborately buried (including rich grave-goods) females achieves greater parity with males. Before 20 ka, relatively few females were given such treatment (DV-3, Crô-Magnon 2, Pataud, Ostuni 1, Brno III, and possibly the now-missing Sunghir 8: Pettitt 2011; Trinkaus et al. 2014). It is thus difficult to evaluate Hayden's (2003: 130) contention that a significant increase in the burial (sometimes with great wealth) of women and children occurred in the Upper Palaeolithic, unless one focuses on the Lateglacial.

Burials are perhaps the best-explored aspect of Upper Palaeolithic funerary practice, but fragmentation and other procedures seem to have been commoner. There are no clear burials for the Aurignacian, and Gravettian, Solutrean, Epigravettian and Magdalenian funerary practices are varied (Henry-Gambier et al. 2004; Fabbri 1992; Garralda 1992; Le Mort & Gambier 1992; Straus et al. 2015; Henry-Gambier 2018). Funerary practices do not simply consume resources; the dead (whether complete inhumations or isolated body parts/skeletal elements) can be treated as resources in their own right, e.g. cases where intentional deposition, selective redeposition, or fragmentation and transformation into pendants, grave goods, etc., can be demonstrated (Henry-Gambier et al. 2004; Svoboda 2006; Trinkaus et al. 2014; Straus et al. 2015). Discrete body parts and elements were sometimes found in association with burials (Sázelová et al. 2018). We may ask if Aurignacian and Gravettian examples of perforated human teeth (Henry-Gambier et al. 2004; Svoboda 2006: 26) represent personal items, given they are adapted to be carried on the person. Whether they were personally owned or held in trust for a group, their final resting places are not distinctive or structured, so it is impossible to say more about their potential significance for inequality: why might they have been discarded as if waste?

Sunghir individual 4 is more straightforward: the deliberate deposition (following a long period of curation and treatment with red ochre) of this femoral diaphysis in association with Sunghir 2 gives it a clear context, which gains additional significance when the genetic relationships of Sunghir individuals 1–4 are considered (Sikora et al. 2017). None of these four males was closely related (i.e. was more than three generations apart), and there are subtle differences in the materials and treatments accorded different individuals. While many features are shared between Sunghir 1–3 (mostly the wealth of body adornment and ochre, indicating the wearing of richly decorated clothing), there are quantitative and qualitative differences (Appendix D). The Sunghir 2 and 3 juveniles have more ivory beads than the mature adult Sunghir 1, scaled about two-thirds smaller than those associated with the latter (White 1993), allowing large numbers to be incorporated onto the smaller clothing worn by children. Other ivory objects ('bracelets') were numerous on the arms of Sunghir 1, but were present in lower quantities on Sunghir 2 and 3, who instead were accompanied by ivory 'lances' and lattice-worked ivory discs. Both Sunghir 1 and 2 had several dozen perforated fox canines on their heads (caps/hoods?), but Sunghir 2 also had at least 250 pierced fox teeth incorporated into a belt, as well as an ivory mammoth sculpture placed under his left shoulder (close to where Sunghir 4 was laid) (Trinkaus et al. 2014; White 1993). These three inhumed individuals consumed resource quantities at levels currently unknown for other Upper Palaeolithic funerary sites; not only were the graves richly provisioned, but the grave-goods were personalized. This conspicuous consumption would certainly imply inequality of treatment (the other inhumations at the site were probably slightly later, and seem to have been less richly provisioned), but the puzzle is that the environment was not particularly productive (Appendix B). Could transient inequalities (and ascribed status) have arisen in this peripheral group, perhaps based on *ritual* rather than socio-economic controls, without needing a secure resource base that produced consistent surpluses? The thousands of body ornaments that were included in the burials would have taken over 10,000 hours of material collection and production time (White 1993), but such activity must have preceded the deaths: were old materials/artefacts included in the burials, and thus taken out of circulation? Bader recorded a felid paw, clusters of ivory beads, 'apparently from discarded clothing' (Trinkaus et al. 2014: 16), as well as perforated fox teeth, broken pieces of ivory spear, small pierced stone pendants and ochre, in the cultural layer at Sunghir, implying these artefacts and resources were not confined to the burials. Central European Pavlovian funerary practices (some inhumations) also incorporated resources, but in lesser quantities than seen at Sunghir. Some superficial similarities are present between the two regions, e.g. use of perforated canid canines, ivory pendants and ochre in inhumations, but there are also differences: (modified) mammoth scapulae capping some burials (Pavlov 1, DV-4, Brno II, Krems-Wachtberg double burial, Předmostí I), and the Dolní Věstonice Triple Burial was essentially laid on the ground surface, associated with hearths, and covered with a wooden structure (Trinkaus et al. 2014; Svoboda 2006, 2008; Einwögerer et al. 2006). Many human remains at these sites are fragmentary (individual bones and teeth; isolated body parts), and scattered in the cultural layers, making them impossible to relate to particular resources and/or objects (Svoboda 2006; Trinkaus et al. 2000, 2010, 2017).

Can we identify the lineage-based expenditure of resources on funerary treatments of the dead, primarily inhumations? The aDNA evidence indicates exogamous mating networks for Sunghir (Sikora et al. 2017), and all genomes come from males of heterogeneous lineages, while dietary data (stable isotopes and zinc traces) imply that Sunghir 1–4 did not consume the same diets (Appendix D). Some level of dietary heterogeneity does not disprove a lineage-based control of food for elite individuals (Appendix A), but it does make it difficult to be certain such a socio-economic structure existed at Sunghir, particularly as we lack remains from more group members to test the isotopic and mineral trace values and aDNA. Some individuals from Dolní Věstonice, Pavlov and Krems-Wachtberg have yielded aDNA (Fu et al. 2013, 2016; Posth et al. 2016), showing some intra-site lineage diversity. It has been suggested that two of the three males from the Dolní Věstonice Triple Burial (DV-14 and DV-15) shared a mitochondrial haplogroup (U5), and thus a maternal connection (Fu et al. 2013: 556), with DV-13 possibly being a paternal half-brother (Mittnik et al. 2016: 5). However, it should be remembered that the similarities in mitochondrial and Y-chromosome haplogroups at Sunghir were interpreted as more distant relationships after more detailed genomic analyses (Sikora et al. 2017). If the individuals of the Triple Burial were closely related, the allocation of resources to their inhumation might have been based in lineage. The Pavlov 1 and DV-16 burials share mitochondrial and Y-chromosome haplogroups, but we cannot be certain they were contemporaneous or diachronic members of a lineage. While these Dolní Věstonice and Pavlov individuals were buried with grave goods, the quantities and variety of the latter do not match those seen at Sunghir, despite the greater environmental productivity of the local area. More genomic work is needed on these Central European Gravettian burials before we can speak with confidence about marriage network structure. Ancient DNA from isolated human skeletal elements (DV-42 and DV-43, both found close to central hearths in a settlement unit (Svoboda 2006)) adds some mitochondrial haplogroup diversity, but these remains were not accompanied by any resources (i.e. grave goods): were they themselves 'resources' in social or symbolic activities?

The re-use of space, and sometimes of human body parts, could have operated at all scales of access, from private (individuals or sub-groups) to whole groups or aggregations. If DV-42 and DV-43 were re-used in domestic contexts, near central hearths, this use might imply sub-group or group involvement. Other examples, owing to space restrictions, might have involved rather more restricted numbers of participants. While the El Mirón 'Red Lady' was buried in a relatively large cave, the grave was in a restricted part of the site, behind a large block and *c.* 2 m from the cave wall (Straus et al. 2015). The original inhumation, and subsequent removal of body parts (cranium and most of the long bones) might thus have been conducted by a restricted number of participants. The burial contained objects (pendants, needle fragments, antler projectile tips, etc.) that cannot be confirmed as part of the burial (Gutiérrez-Zugasti & Cuenca-Solana 2015); only a covering of red ochre was re-applied to the bones after they had been disturbed (Marín-Arroyo 2015). This ochre was presumably specially obtained for this purpose (from a source *c.* 26 km to the north), as the ochre elsewhere on the site was more locally sourced (Román et al. 2015).

If the surviving Upper Palaeolithic individuals were specially selected for funerary treatment, their consumption of resources did not follow a standardized pattern, either within or between sites, or whether synchronous or diachronic. While there are some repeated traits (e.g. use of ochre, body adornment and grave goods), the individuals themselves display heterogeneous nutritional, activity and ontogenetic histories, even given the fact that we lack remains for most people from the period. Such funerary sites were not restricted to the most productive areas (southwest France, Moravia), but also occurred in unproductive peripheral occupation regions (Paviland, Sunghir). Given the scanty British record of the Gravettian (Jacobi & Higham 2011), it is not even certain that the individual buried at Paviland was a long-term local resident; he could have spent much of his life elsewhere in Europe (including land now submerged by sea).

While the wealth and variety of animal resources exploited in Dolní Věstonice and Pavlov might have led some researchers to label them 'feasts' (Wojtal et al. 2012, 2018), there is no evidence to suggest single events of resource mass-consumption. The evidence for large-scale consumption of stored food is equally contentious. While some pits in Upper Palaeolithic sites on the Russian Plain and central Europe (Soffer 1985, 1989) have been interpreted as for storage (for bones or meat still on the bone) within or just outside dwelling structures, other researchers have questioned whether the contents of some pits were primary (i.e. fresh meat, inferred from articulated skeletal elements) or secondary (i.e. waste disposal) (cf. Soffer 1989; Iakovleva et al. 2012; Svoboda et al. 2016). Further west in Europe, away from permafrost conditions, evidence for clear storage pits is absent. Stellmoor implies the storage of seasonal surpluses, but the method of preservation is unclear (drying or smoking fillets, or immersion of carcasses?), and no storage features were identified. The same is the case for storage of foods that serve more as condiments to provide variety or improve taste, than as main dietary components: there is certainly potential to hide stores/caches of such materials (fungi, etc.) in secret locations for exclusive use by certain members of a group, but archaeological testing would demand a large sample of human remains (e.g. catastrophic death assemblage of a group) to test the composition of each member's dental calculus (cf. Power et al. 2015).

Evidence for physiological stress in Upper Palaeolithic human remains varies, but does demonstrate dietary fluctuations in both Moravia and Sunghir: such evidence might imply a lack/absence of storage to mitigate resource instability. While Harris lines (transverse lines in long bones) are relatively rare in Moravian Gravettian human remains (minor defects in DV-14 and DV-15 (both from the Triple Burial), DV-16 and Pavlov 1), they are much more pronounced and common in Sunghir individuals 1, 2 and (especially) 3, representing possible stress episodes (malnutrition and/or disease) (Trinkaus et al. 2006, 2014). Dental stress indicators (interruptions of tooth growth: linear and and pit enamel hypoplasias) are more common in Upper Palaeolithic humans from Sunghir and Moravia, generally indicating that individuals encountered most stress post-weaning (*c.* 2–5 years old) (Trinkaus et al. 2006: 456; 2014). However, Sunghir 3 had at least three separate (dental) stress events between the age of 1.5 and 5.6 years old, with Harris lines continuing until his death at the age of about ten (Trinkaus et al. 2014: 289–90). This individual also had bowed femora, as did DV-15, implying that mobility for both individuals was not easy, yet both show clear evidence of active lives (Trinkaus et al. 2006: 444; 2014: 288). DV-15 shows osteo-arthritic evidence of repetitive loading on the right arm and hand in particular (the left hand of DV-13 shows a similar pattern), implying the dragging of heavy loads beside/behind the body, perhaps using a strap (Trinkaus et al. 2006: 428, 443). Sunghir 1 (*c.* 35–45 years) had osteoarthritis in his thumbs, midcarpals and wrists, related more to activity levels and joint overloading than to age (Trinkaus et al. 2014). No such stress indicators have been identified in the surviving long bones of the El Mirón 'Red Lady,' perhaps indicating greater dietary stability in some Lateglacial groups (Carretero et al. 2015: 24). Upper Palaeolithic thus remains show a variety of activity levels and stresses, making it difficult to categorize individuals as 'elites' or 'transegalitarian.' Among the adults, osteoarthritic lesions related to repetitive, intensive tasks are common, but we cannot yet be confident in distinguishing craft/specialist activities from a palimpsest of different activities over the course of a lifetime.

Conclusions

Summarizing the evidence for the European Upper Palaeolithic, it is hard to support interpretations of consistent, structural transegalitarianism. Instead, I propose shifting patterns of Upper Palaeolithic resource consumption and ritual control that appear to mimic some aspects of the structural inequality stages defined by Hayden, but which appear to have been *ad hominem* rather than dynastic. Nevertheless, some changes over time are identifiable, e.g. some apparent differences in inhumations before and after 20 ka. Males seem to have been preferentially selected for funerary treatment and investment of particular types of resources in the period before 20 ka for some sites (e.g. Sunghir). LGM socio-politics were clearly subtle and diverse, probably varying by sex/gender, age and seasonal social organization (Wengrow & Graeber 2015), and reduced mobility/motility does not correlate with increased signals of inequality. The Solutrean is noted for its elaborate material culture, yet appears to lack any clear burials (unlike the preceding, more mobile Gravettian). The Magdalenian has complex and varied technology and funerary practices (including a more equitable proportion of female inhumations than seen earlier), yet its abundant art varies greatly in proficiency. There were certainly inequalities of resources, opportunity, outcome and ritual participation in the Upper Palaeolithic, though we should also remember there are inequalities of preservation and recovery that make it hard to establish baselines for the nutritional status and wealth of individuals. To what extent were individuals with elaborate funerary practices seen as special people by their groups? We do not have the remains of all their contemporaries against which to compare them, so tend to assume that buried individuals (primary and secondary inhumations) were intentionally important because they became fixed monuments in the landscape. Yet body fragmentation renders the dead portable on the person (e.g. Aurignacian human tooth pendants): would this behaviour be more suitable for highly mobile groups than for semi-sedentary ones (Table 9.2), given that it favours a personalized relationship with the dead rather than a spatio-temporally fixed, territorial-monumental one? Some sites fall between these poles of motility and immobility, such as the inhumations that were post-depositionally re-worked and bones removed. The fate of the missing long bones from the El Mirón 'Red Lady' burial is unknown: they might have been re-buried elsewhere, kept for use in ceremonies ('talismans' *sensu* Hayden (2003, 132)?), or fragmented/destroyed.

The ritual complexity of Upper Palaeolithic groups indicates strong potentials for inequality, but accompanying economic evidence is not available to support interpretations of transegalitarianism. Economically, resources were seldom stable enough to support the production of surpluses, implying that storage for was needed for lean seasons, rather than to support a non-productive elite. This apparent disconnection between overall environmental productivity and ritual complexity (e.g. Sunghir and Paviland) means we have to consider more nuanced, and possibly non-analogue, explanations for the patterns we see. The problem of equifinality makes it hard to discard interpretations of broadly egalitarian societies (perhaps with some 'despots,' or sub-groups controlling ritual activity) in favour of stratified transegalitaranism. Motility, within relatively unpopulated Europe, combined with resource unpredictability in many areas, would have allowed communities a reactive response to despotism. The Upper Palaeolithic can be seen as a series of population responses to fluctuating environmental conditions, including variations in the degree of mobility. Mobility, documenting changing human responses to shifting environmental conditions and potentials, seems able to explain much of the archaeological record. Innovations can be seen in this context of mobility, rather than the need to invoke 'aggrandizers' to drive change. Even the trade and exchange of material goods might instead represent direct procurement by highly mobile populations, e.g. by individuals less tied to childcare commitments (Fig. 9.5: E). For much of the Upper Palaeolithic, people do not seem to have been sedentary enough to allow transegalitarianism to flourish (Table 9.2): the early Upper Palaeolithic and earlier Magdalenian show evidence for high mobility, while the less mobile Solutrean evidently did not feel obliged to mark territories with burials.

There is little evidence of warfare in the Upper Palaeolithic (cf. Table 9.1). It is possible that it was present, but that the victims' remains were fragmented and not buried (though some might have been turned into tooth pendant trophies?). The Sunghir 1 individual certainly met a violent death, but the motive (if it was intentional and not accidental) for his demise is impossible to ascertain (Trinkaus et al. 2014); none of the other penecontemporaneous burials at the site or in the European Gravettian shows similar evidence for death from a weapon. Perhaps a better candidate for warfare might be the individuals from Maszycka cave, who have been interpreted as the killing of a Magdalenian group by neighbouring (Epigravettian?) competitors (Kozłowski & Sachse-Kozłowska 1993: 170); however, this violence may have occurred in the context of dispersing populations, rather than competition between semi-sedentary groups. At present, the available evidence can be explained as 'sporadic revenge raiding' (Table 9.2), rather than organized warfare.

Given that so many Upper Palaeolithic environments have no modern analogues, and were very spatio-temporally variable, assumptions that late Holocene complex foragers can be transposed onto the late Pleistocene run many risks. Indeed, the Holocene groups of the Pacific Northwest Coast themselves show a range of socio-economic organizations, from small, thinly scattered and highly mobile at the start of the Holocene, to more sedentary, densely populated and complex socio-political organization rather more recently (e.g. Ames 1991). More attention needs to be paid to local conditions in Upper Palaeolithic locales before we can be confident in moving from contingent explanations to generalizing ones.

To take an important example, the Sunghir site and funerary complex offer many challenges and opportunities for our interpretations of inequality in the Upper Palaeolithic. The wealth exhibited in the two intact burial pits (Sunghir 1–4) is extraordinary, possibly derived more from deposits of subfossil ivory (finite resources) than ongoing local environmental productivity (i.e. live mammoths). The reindeer at the site are thought to have been the forest ecotype, and thus not long-distance migrants (Trinkaus et al. 2014: 7). Much more work is needed on modelling and testing NPP estimates for Sunghir, and in using stable isotope and strontium analyses (if practicable) to tease apart the movements of prey species. More detailed evaluation of the economic basis and ecology of this locale would allow the extant data on nutritional status of the surviving individuals to be set into a more detailed exploration of potential inequalities. Currently, aDNA from Sunghir 1–4 indicates exogamous breeding networks, implying more open (not closed) social networks (Gamble 1999) that are less compatible with transegalitarian societies (Table 9.2; Appendix A). Yet the preponderance of male burials at the site implies some degree of male control of ritual knowledge (not necessarily of inequality in other socio-economic spheres: Appendix A). In contrast, the reworking, and re-resourcing, of the El Mirón female burial might imply more involvement of women in ritual knowledge.

Such detailed, localized studies need to be replicated across the full spatio-temporal span of the Upper Palaeolithic, wherever the evidence is (potentially) available. They are our best hope of reducing the effects of equifinality, given that outcomes and traits can have several explanations. The range of variability within Upper Palaeolithic technocomplexes means that we cannot generalize for each one: we cannot assume they are meaningful 'cultures' in an ethnographic sense. Few archaeological data are direct measures of a socio-economic aspect; most are proxies, from which archaeologists infer heterogeneous interpretations. More direct measures of behavioural complexity (strontium and stable isotopic analyses; aDNA) can be augmented by detailed study of site-formation processes (taphonomic factors need to be assessed before complex behaviour can be asserted) and experimental evaluation of important features (reconstructions of some large dwelling structures, e.g. on the Central Russian Plain, would benefit from rigorous testing of their viability). Testing the individual components of these structures will also provide information on the sources of materials used, and how landscapes were provisioned: caches of resources and tools, burial goods, and the resourcing of structures and artworks in deep cave systems. Once positioned, many of these concentrations of material can be viewed as caches, whose materials could be recombined or re-positioned as desired. In this sense, the mammoth dwellings at sites like Mezhirich were monumental constructions that required considerable labour for initial construction (Soffer 1985), but which could then be used as 'caches' of material suitable for other structures or purposes, if required. Likewise, the El

Mirón 'Red Lady' burial's status could have shifted after initial inhumation, as the burial was re-worked and its contents altered. In general, construction was a process, not an event.

When we set about evaluating inequalities in the Upper Palaeolithic, using ideas derived from the ethnographic record, it is useful to bear the following questions in mind:

- Scales of analysis: can we reach meaningful spatio-temporal scales in the Upper Palaeolithic for evaluating inequalities?
- How do we test the archaeological record against palaeoenvironmental proxies and reconstructions? Are there modern analogues for these environments?
- Can sex-based (and gendered) differences in application and control of ritual knowledge be identified, and at what spatio-temporal scales did they operate?

Huge strides have been made in the detailed, interdisciplinary study of the Upper Palaeolithic in recent years. It is now not beyond our ability to start unravelling the causes of equifinality.

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Note

1. The appendices to this chapter appear at the end of the online edition of the volume.
2. …Durant le période glaciaire, les plaines de l'Ouest de l'Europe étaient couvertes de prairies d'une richesse inégalée, parcourues par une abundance de mammifères susceptibles d'être chassés' (Hayden 2008: 82).

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Appendices to Chapter 9

Responses of Upper Palaeolithic humans to spatio-temporal variations in resources: inequality, storage and mobility

William Davies

APPENDIX A.

Table 9.A1. *Immediate- and delayed-return systems (Woodburn (1982, 2005)). These are not binary opposites, but extremes of a continuum of variation; many hunter-gatherer groups contain elements of both systems (though Woodburn (1982: 433) argues that immediate-return strategies practised by delayed-return societies are limited and have a low social value placed upon them).*

Immediate-return	Delayed-return
People obtain a direct and immediate return from their labour: eat the food foraged on the same day, or soon after. Social groupings are flexible, and fluid in composition. People free to move from one camp to another (temporarily or permanently) without penalty or loss of vital interests.	People hold rights over valued assets, which represent a yield, a return for labour and time, or are effectively managed as 'delayed yields on labour' (1982: 433). Four main types of asset (generally found in combination):
• Relatively simple, portable, utilitarian, easily acquired, replaceable tools and weapons, made with real skill but not involving a great deal of labour (cf. Bleed's (1986) Maintainable technology). No *dependence* on sharing/ pooling of resources or equipment (e.g. weapons, nets). Valued assets are temporary, e.g. carcass of a large animal, and are not accumulated. • Food is neither elaborately processed nor stored (cf. Binford's (1980) Foragers and Bettinger's (1991) Travellers), though portable storage is possible in small quantities. Nomadism is fundamental, with no fixed locations (dwellings, base-camps, hunting/fishing apparatus, ritual sites), resources or assets to constrain movement. • No management or control of resources: all individuals have direct access, though limited by sexual division of labour, to the uncollected resources of their territories/ranges. Potential defence of some fixed resources, e.g. patches of predictable plant foods. • Systematically eliminate distinctions (except those between sexes and initiated/uninitiated) of wealth, power and status. More autonomy for women than in delayed-return systems.	• Valuable (owing to manufacturing time, effort and expertise) technical production facilities that yield food gradually over months or years, e.g. boats, nets, fish weirs, stockades, traps (cf. Bleed's (1986) Reliable technology). • Processed and stored food or materials, usually in fixed dwellings (cf. Binford's (1980) Collectors and Bettinger's (1991) Processors). • Wild products that have been improved or increased by human labour (cf. Resource Management (Williams & Hunn 1982)). • Female kin bestowed by their male relatives in marriage alliances.
• People not dependent on *specific* others for access to basic requirements. All interpersonal relationships (not just kinship) emphasize sharing and mutuality, though not necessarily long-term or binding. • Weaponry provides direct and immediate access to social control; not mediated through formal institutions or through interpersonal relationships. No formal heads of household, though some individuals may have influence on certain group decisions. • Children generally have freedom to make choices: learning self-reliance. • Unrestricted access to food, water, other resources (shelters, tools/weapons, trading items) and ornaments. Equality of opportunity for individuals in access to resources (limited by sexual division of labour) is not always matched by equality of yield (those vary by skill, luck, persistence, capacity to work, etc.) (cf. Zubrow 2010). Flexible rules for acquisition of possessions: no-one depends on inheritance or formal transmission by preceding-generation close kin.	• Binding commitments and dependencies between people (based on kinship or contract), to secure yields and manage assets. People are bound to close kin and affines in relationships that commonly involve the constant exchange of goods and services in fulfilment of obligations; bound to each other through material obligations and interpersonal responsibilities. • Acephalous delayed-return societies show competition between heads of household (egalitarianism is horizontal, within social classes, and maintained by equal exchange of things of the same type – cf. Zubrow 2010) for wealth, prestige and status. • Intergenerational inequality; heirs controlled by their fathers (heads of household). • Relationships and access to resources are not equal between household heads, their wives, female kin and junior male kinsmen.
Individuals can choose their associates during residence, foraging, trade and exchange, and in ritual contexts. This right is constantly exercised, limiting enduring bonds and inhibiting development of authority and intragroup dependency. Fission-fusion used to resolve intragroup tensions. Group members often eat when they wish (if food available); allocated resources from sharing will be consumed by whoever happens to be around.	Vertical control of food and other resources (including assets), and access to them, helping to differentiate group members. Food often consumed in communal meals (allocations can be controlled, even for the heirs of household heads). Restricted ability to move between groups without penalty.
Religion and ritual: consecrated sharing in the context of joint participation of the whole community, even if select individuals might act as channels for numinous forces. Ability to become healers or to learn and practise religious beliefs and rituals not restricted or controlled.	Cults and restricted knowledge; using secret material and intellectual property of initiates; sacred objects often concealed in the landscape, and protected by secrecy, deception and threats of violence against non-initiates. Male cults often more powerful and elaborated than female ones, even in societies that are egalitarian in secular contexts. Within initiates, sacred knowledge can be shared in a less-restricted fashion.

APPENDIX B.

Table 9.B1. *Effective Temperature and Net Primary Productivity values for ethnographic foraging groupings and estimates for 42 ka, 30 ka and 21 ka. 'Q1' = first quartile; 'Q3' = third quartile. Ethnographic data from Binford (2001) and Kelly (2013).*

	Effective Temperature (ET): °C							**Net Primary Productivity (NPP): grammes carbon per sq. m per year**						
Ethnographic	*N*	**Mean & SD**	**Min**	**Q1**	**Median**	**Q3**	**Max**	*N*	**Mean & SD**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Polar	*17*	9.7 ± 0.8	8.5	9.0	9.5	10.3	11.6	*13*	158.4 ± 101.3	45	89	115	209	333
Sub-polar/cold forests	*35*	11.0 ± 0.8	9.0	10.5	10.9	11.25	12.7	*21*	402.9 ± 180.9	144	245	354	533	772
Pacific Northwest Coast	*18*	11.6 ± 0.8	10.5	11.1	11.7	12.3	12.7	*14*	795.7 ± 95.1	633	729.25	825	855.75	943
Plateau (forests)	*11*	12.7 ± 0.5	12.1	12.4	12.6	13.3	13.3	*8*	343.5 ± 77.4	259	284.5	319	389.25	464
Plains	*10*	12.9 ± 1.3	11.3	11.6	13.1	14.1	14.6	*9*	534.9 ± 242	283	397	432	706	1045
Great Basin	*19*	13.0 ± 0.9	11.7	12.4	12.9	13.6	15.0	*14*	250.7 ± 150.2	45	163.75	210.5	306	583
California	*32*	13.8 ± 0.7	12.7	13.3	13.8	14.4	15.0	*14*	564.9 ± 202.2	26	478.75	567	697.25	812
42 ka:														
Europe	*2424*	11.8 ± 1.2	7.7	11.1	11.9	12.6	14.7	*2424*	245.2 ± 97.1	2	179	248	307	624
Cantabria	*7*	10.6 ± 0.6	9.8	10.1	10.8	11.0	11.2	*7*	63.3 ± 84.8	0	0	0	118	207
Southwest France	*6*	12.3 ± 0.2	11.9	12.4	12.4	12.4	12.5	*6*	311.8 ± 30.5	273	290.5	310.5	335	350
Moravia	*2*	12.1 ± 0.2	12.0	12.0	12.1	12.1	12.2	*2*	283.5 ± 10.6	276	279.75	283.5	287.25	291
30 ka:														
Europe	*2293*	11.8 ± 1.1	7.6	11.1	11.7	12.6	14.5	*2293*	231.5 ± 92.2	1	169	237	290	595
Cantabria	*6*	10.3 ± 0.6	9.6	9.7	10.1	10.7	11.1	*6*	65.0 ± 52.8	0	20.25	84	93	127
Paviland	*1*	N/A	10.2	N/A	N/A	N/A	10.2	*1*	N/A	134	N/A	N/A	N/A	134
Southwest France	*7*	12.2 ± 0.2	11.8	12.1	12.2	12.3	12.4	*7*	292.9 ± 19.4	260	282.5	298	304.5	318
Moravia	*4*	11.8 ± 0.1	11.6	11.7	11.8	11.8	11.9	*4*	266.0 ± 13	257	257.75	261	269.25	285
Sunghir	*1*	N/A	11.4	N/A	N/A	N/A	11.4	*1*	N/A	272	N/A	N/A	N/A	272
21 ka														
Europe	*1792*	11.2 ± 1.1	7.6	10.4	11.1	12.1	14.1	*1792*	215.7 ± 99.9	1	153	216.5	271	731
Cantabria	*4*	10.0 ± 0.2	9.7	9.9	10.1	10.1	10.1	*4*	122.3 ± 198.8	0	0	36.5	158.75	416
Southwest France	*4*	11.0 ± 0.05	11.0	11.0	11.0	11.1	11.1	*4*	288.3 ± 3.5	284	286.25	288.5	290.5	292
Moravia	*1*	N/A	10.9	N/A	N/A	N/A	10.9	*1*	N/A	194	N/A	N/A	194	194

APPENDIX C: DEMOGRAPHY.

Table 9.C1. *Modelled/Estimated Upper Palaeolithic regional populations and densities (see below table for notes).*

Details	Occupation area (sq. km)	Site N	Metapopulation				Density (persons per 100 sq. km)				Regional group N
			Mean	Range	Median	Interquartile range	Mean	Range	Median	Interquartile range	
Hahn (1977):											
Central & Eastern Europe Aurignacian	[5,000,000–10,000,000]	N/A	500,000–1,000,000					10.0–20.0			
Straus (1986):											
Eastern Asturias (Magdalenian)	1250	N/A	200–250 (scaled up to 2000–25,000)					16–20			
Biraben (1988):											
France:											
Châtel.-Aurig-Gravettian	*c.* 550,000–700,000	209 (410)	*c.* 8000–10,000					1.14–1.82			
Aurignacian-Gravettian	*c.* 550,000–700,000	?	*c.* 9000					1.29–1.64			
Solutrean	*c.* 700,000	66 (520)	15,000–20,000					2.14–2.86			
Magdalenian	*c.* 550,000–700,000	301 (480)	15,000–20,000					2.14–3.64			
Delpech (1999: 36):											
c. 21–22 ka (*c.* 18,000 uncal. BP)	100,000	N/A	750				0.75				
c. 17–19 ka (14,000–16,000 uncal. BP)	600,000	N/A	49,500				8.25				
c. 15.4–17 ka (14,000–13,000 uncal. BP)	1,500,000	N/A	258,750				17.25				
Rozoy (2001; 1996):											
Final Magdalenian:											
Perigord – Vienne + Quercy	35,000	*c.* 154	6000 (6500)				17.14 (18.57)				
Pyrenees	35,000	87	N/A (2500)				N/A (7.14)				
Massif central	25,000	63	N/A (1500)				N/A (6.0)				
Provence-Languedoc	15,000	>25 (23)	2500 (1000)				16.67 (6.67)				
Saone-Alpes	20,000	39	N/A (1500)				N/A (7.5)				
Pincevent-Ardenne	15,000	36	1200–1500 (1000)				8.0–10.0 (6.67)				
Bocquet-Appel & Demars (2000):											

Table 9.C1 *(cont.).*

Details	Occupation area (sq. km)	Site N	Metapopulation				Density (persons per 100 sq. km)				Regional group N
			Mean	Range	Median	Interquartile range	Mean	Range	Median	Interquartile range	
Aurignacian: southwest France	65,700 (57,800)	159	3421				5.21 (5.92)				
Rest of France	545,800 (486,400)	60	1303				0.24 (0.27)				
Britain, Low Countries, Germany	831,200 (585,300)	32	706				0.08 (0.12)				
Gravettian: southwest France	65,900 (57,800)	119	4429				6.72 (7.66)				
Rest of France	561,600 (486,400)	61	2254				0.4 (0.46)				
Britain, Low Countries, Germany	950,400 (585,300)	29	1088				0.11 (0.19)				
Solutrean/Badegoulian (LGM): southwest France	75,300 (57,800)	136	5541				7.36 (9.59)				
Rest of France	579,400 (486,400)	83	3396				0.59 (0.7)				
Britain, Low Countries, Germany	296,100 (245,000)	0	0				0 (0)				
Magdalenian: southwest France	65,900 (57,800)	194	10,046				15.24 (17.38)				
Rest of France	561,600 (486,400)	294	15,271				2.72 (3.14)				
Britain, Low Countries, Germany	950,400 (585,300)	284	14,860				1.56 (2.54)				
Kretschmer (2015); Maier et al. (2016); Maier & Zimmermann (2017); Schmidt & Zimmermann (2019):											*Median (Q1–Q3):*
Portugal: earlier Gravettian	12,493				156	179–131			1.25	1.43–1.05	3.6 (4.2–3.0)
Later Gravettian	18,798				159	194–102			0.85	1.03–0.54	3.7 (4.5–2.4)
LGM	15,883				221	429–88			1.39	2.7–0.55	5.1 (10.0–2.1)
Southern Spain: LGM	17,395				242	469–97			1.39	2.7–0.56	5.6 (10.9–2.3)
Southeast Spain: LGM	8128				113	219–45			1.39	2.69–0.55	2.6 (5.1–1.1)
Eastern Spain: LGM	7183				100	194–40			1.39	2.7–0.56	2.3 (4.5–0.9)
Northeast Spain: LGM	53,63				75	145–30			1.4	2.7–0.56	1.7 (3.4–0.7)
Northern Spain: Aurignacian	18,973				264	134–818			1.39	4.31–0.71	6.2 (19.3–3.1)
Earlier Gravettian	21,270				265	305–223			1.25	1.43–1.05	6.2 (7.1–5.2)

Table 9.C1 *(cont.).*

Details	Occupation area (sq. km)	Site N	Metapopulation Mean	Metapopulation Range	Metapopulation Median	Metapopulation Interquartile range	Density (persons per 100 sq. km) Mean	Density Range	Density Median	Density Interquartile range	Regional group N
Later Gravettian	15,900				135	164–86			0.85	1.03–0.54	3.1 (3.8–2.0)
Iberia: Upper-Final Magd.	57,000				2990	1750–3550			5.3	6.2–3.1	69.5 (40.7–82.6)
Pyrenees: Aurignacian	2809				39	20–121			1.39	4.31–0.71	0.9 (0.5–2.9)
Upper-Final Magd.	18,900				80	70–160			0.4	0.8–0.4	1.8 (1.7–3.6)
Southwest France: Aurignacian	31,430				437	221–1356			1.39	4.31–0.71	10.3 (31.9–5.2)
Earlier Gravettian	60,201				793	1010–313			1.32	1.68–0.52	18.4 (23.5–7.3)
lLater Gravettian	32,920				279	340–178			0.85	1.03–0.54	6.5 (7.9–4.1)
Franco-Cantabria: LGM	135,574				1887	3659–755			1.39	2.7–0.56	43.9 (85.1–17.6)
Early Magd.									0.16	0.004–0.31	
Middle Magd.									0.18	0.11–0.32	
Upper Magd.									0.48	0.3–0.56	
Final Magd.									0.48	0.3–0.55	
(Southwest France:) Upper-Final Magd.	26,600				1850	1180–2080			7.0	4.4–7.8	42.9 (27.4–48.4)
Narbonne/Aude: Aurignacian	4600				64	32–198			1.39	4.31–0.71	1.5 (4.7–0.8)
West Central France: Aurignacian	3080				43	22–133			1.39	4.31–0.71	1.0 (3.1–0.5)
Central-southwest France: Upper-Final Magd.	33,200				210	130–390			0.6	0.4–1.2	4.8 (3.1–9.1)
Burgundy: Earlier Gravettian	25,308				333	425–132			1.32	1.68–0.52	7.8 (9.9–3.1)
Later Gravettian	14,951				127	155–81			0.85	1.04–0.54	2.9 (3.6–1.9)
Jura/W. Alps: Upper-Final Magd.	28,900				260	150–410			0.9	0.5–1.4	6.0 (3.4–9.6)
Paris Basin: Upper Seine valley: LGM	16,205				226	437–90			1.39	2.7–0.56	5.2 (10.2–2.1)
(Paris Basin:) Upper-Final Magd.	10,700				240	170–380			2.2	1.6–3.6	5.5 (4.0–8.9)
South Rhône: Aurignacian	5792				81	41–250			1.39	1.39–0.71	1.9 (5.9–1.0)

Table 9.C1 *(cont.)*.

Details	Occupation area (sq. km)	Site N	Metapopulation				Density (persons per 100 sq. km)				Regional group N
			Mean	Range	Median	Interquartile range	Mean	Range	Median	Interquartile range	
Earlier Gravettian	9693				121	139–101			1.25	1.43–1.04	2.8 (3.2–2.4)
Later Gravettian	11,853				100	123–64			0.84	1.04–0.54	2.3 (2.9–1.5)
Southern France: LGM	19,114				266	516–106			1.39	2.7–0.55	6.2 (12.0–2.5)
Provence: earlier Gravettian	6507				81	93–68			1.24	1.43–1.05	1.9 (2.2–1.6)
Later Gravettian	0				0	0			0		0
Provence/Liguria: LGM	6017				84	162–33			1.4	2.69–0.55	1.9 (3.8–0.8)
Britain: Upper-Final Magd.	12,700				160	120–260			1.3	0.9–2.0	3.7 (2.8–6.1)
Belgium: Aurignacian	7276				218	153–308			3.0	4.23–2.1	5.1 (7.2–3.6)
Earlier Gravettian	19,731				328	489–194			1.66	2.48–0.98	7.6 (11.4–4.5)
Rhine-Meuse: Upper-Final Magd.	19,800				230	130–440			1.2	0.7–2.2	5.3 (2.9–10.3)
Upper Danube: Aurignacian	4654				140	98–197			3.0	4.23–2.1	3.3 (4.6–2.3)
Earlier Gravettian	20,361				187	313–174			0.92	1.54–0.85	4.4 (7.3–4.1)
Later Gravettian	0				0	0			0	0	0
Swabian-Franconian Alb: Upper-Final Magd.	21,700				460	140–310			2.1	1.4–5.3	10.6 (7.1–26.5)
Northwest Czech republic: Aurignacian	1216				10	7–15			0.84	1.24–0.59	0.2 (0.4–0.2)
Middle Danube: Danubian/Moravian Aurignacian	19,720				166	117–244			0.84	1.24–0.59	3.9 (5.7–2.8)
Earlier Gravettian	56,723				292	421–152			0.51	0.74–0.27	6.8 (9.8–3.5)
Later Gravettian	23,692				172	459–128			0.73	1.94–0.54	4.0 (10.7–3.0)
Central Europe: LGM	22,159				32	53–30			0.14	0.24–0.14	0.8 (1.2–0.7)
Southern Poland (Kraków): Aurignacian	2865				24	17–35			0.84	1.24–0.59	0.6 (0.8–0.4)
Upper Tisza: Aurignacian	2678				33	11–72			1.23	2.71–0.39	0.8 (1.7–0.2)
Middle Tisza: Aurignacian	2095				26	8–57			1.23	2.71–0.39	0.6 (1.3–0.2)
Prut: earlier Gravettian	10,753				224	290–182			2.08	2.7–1.69	5.2 (6.8–4.2)

Table 9.C1 *(cont.)*.

Details	Occupation area (sq. km)	Site N	Metapopulation				Density (persons per 100 sq. km)				Regional group N
			Mean	Range	Median	Interquartile range	Mean	Range	Median	Interquartile range	
Later Gravettian	5696				41	110–31			0.72	1.93–0.54	1.0 (2.6–0.7)
LGM	22,392				33	46–31			0.15	0.21–0.14	3.7 (4.5–2.4)
Eastern Central Europe: Upper-Final Magd./ Epigravettian	18,200				170	110–270			0.9	0.6–1.5	4.0 (2.6–6.2)

Notes:

Hahn (1977):	Based on site and intra-site structure sizes, artefact/faunal remains densities, and ethnographic comparisons. ≥2500 people assumed to have lived in western Germany (based on Lone & Ach valleys, Wildscheuer and Lommersum); if missing evidence is considered, the same area did not have more than 25,000 people. Local group sizes of 20–30 people.
Straus (1986):	For southernmost (warmer) part of eastern Asturias (10,000–15,000 sq. km): 200–250 people in an autonomous regional group within a fraction of that territory (1250 sq. km today: slightly larger in Lateglacial?). Calculation is based on 80–100 red deer herds of 100 individuals each, supporting 8–10 specialist 25-person bands.
Biraben (1988):	Dupaquier found it hard to distinguish Châtelperronian, Aurignacian and Gravettian, owing to temporal overlap. Demic increases attributed to the Solutrean & Magdalenian, in part owing to technological developments. Estimate (a) was derived from site numbers in the *Atlas Archéologique Universel* (1978) (numbers multiplied by factor of 10); that in (b) was derived from site numbers in *La Préhistoire Française* (1976). Number of sites over duration of technocomplex is scaled by a Restitution Coefficient (logarithmic logistic curve): weighting of earlier technocomplexes was increased to avoid over-dominance of most recent Palaeolithic.
Delpech (1999):	Estimating LGM-Lateglacial ungulate productivities (and resultant human population densities) for the region stretching from north of the Pyrenees and across to the east of Poland (mostly the North European Plain).
Rozoy (1996 & 2001):	Site N, mean meta-population & population density values taken from 2001 paper, with 1996 ones in parentheses. 1996: Based on prey productivity (boar & red deer) and energy requirements. Cantabrian estimate taken from Straus (1986) for an autonomous regional group from southernmost areas in eastern Asturias, plus 1500–2500 people from the second Iberian group. Estimates for sites on plains to north of the Ardennes have been merged, as it is unclear what their distributions mean demographically. Rozoy identified six distinct population groups in Middle-Upper Magdalenian, separated geographically; each regional group could comprise 1500–2000 people, spread over 30–50 bands of 50–60 people; territories of 50,000 to 200,000 sq. km. 2001: rescaled earlier calculations to account for Delpech's (1999) population density estimates. Only three French regions specifically mentioned, and re-scaled using Delpech's (1999) density of *c.* 17 persons per 100 sq. km.
Bocquet-Appel & Demars (2000):	Based on archaeological site data (numbers/densities, sizes, occupation duration, etc.). Division between Viable areas (including now-submerged land) and Coinciding Surfaces (i.e. above modern sea-level: perhaps more useful in obtaining population densities, given that very few submerged archaeological sites have been found?). Demographic modelling incorporates ethnographic studies of climatically similar hunter-gatherers.
Maier & Zimmermann (2017); Maier (2017); Maier et al. (2016); Schmidt & Zimmermann (2019):	Integration of climatic, ethnographic and archaeological data for four main phases (earlier and later Gravettian, Solutrean/Badegoulian (LGM) and Magdalenian). Archaeological sites are plotted on maps, analysed with Thiessen polygons and largest empty circles (to measure site densities), and combined with other data (e.g. raw material provenancing patterns (exchange assumed to reflect aggregation phases in fission-fusion cycles) and ethnographic group size data from selected foraging groups (direct counts of numbers per group). Focus on median and interquartile range values. Median aggregation group size from extant hunter-gatherers taken to be 43 people.

Table 9.C2. *Characterizing two colonizing strategies (Beaton 1991: 216).*

	Transient explorers	**Estate settlers**
Demography:		
Budding threshold	Low	High
Group composition	Stable	Slightly fluid
Inbreeding	High	Low
Fecundity	Low	High
Extinction probability	High	Low
Economy:		
Different ecological zone tolerance	High	High
Estate	Unconstrained	Bounded
Archaeology:		
Site forms	Very similar	Varied
Tool inventory	Generalized, conservative	Specialized, inventive
Range of activity/site	Repetitive	Varied
Strategy	Forager/pursuer	Collector/searcher
Colonizing logic:		
Diet breadth	Narrow	Wide
Geometry	Lineal	Bow-wave/radial
Ecology	Patch-similar	Cross-patch

These modelled pioneer/transient explorer (highly mobile) groups (Table 9.C2) share many characteristics with Bettinger's (1991) 'Travellers': briefly occupied and widely spaced settlements, low population densities and high sensitivity to demographic change, and the major subsistence costs being travel, search and scouting. Such groups would live well below the environmental carrying capacity, ensuring their competitive fitness was low. Bettinger's 'Processors' exist closer to the environmental carrying capacity (thus competitive fitness is high), and exploit a broad spectrum of resources (the major subsistence costs are procurement and processing of resources), have groups rich in females, and live at high population densities for extended periods in closely spaced settlements. Such economies might reflect more intensive, post-dispersal residential occupations seen in all phases of the Upper Palaeolithic, with lower motility (*sensu* Weig 2015) and restricted (e.g. circulating/tethered) mobility. The durability and nature of any resource 'hot-spots' would determine whether they would generate contests rather than scrambles (Boone 1992), and underpinning any value attached to them would be knowledge exchange and network structure.

Upper Palaeolithic refugia (Table 9.C3) would represent the opposite process to dispersal, whereby preferred resources and conditions contracted and/or shifted spatially, forcing demographic reorganization and possible local extirpation of groups. Whether populations were expanding/dispersing or contracting, it is not self-evident that resource selectivity was narrow or broad spectrum, respectively (*contra* Beaton 1991; Bettinger 1991). There might have been situations where relatively unspecialized diets (tracking familiar resources in selected patches/biomes) would have provided more reliable food for dispersing populations, and refugial conditions might have arisen among Processor groups specializing in a restricted number of food taxa.

Evidence for highly predictable and defensible/divisible resources that would sustain 'Political networks' (see Fig. 9.5: G) is at best ambiguous for the

Table 9.C3. *Population Events for MOIS-2 Western Europe (after Gamble et al. 2005). Similar events cannot yet be identified in MOIS-3, owing to restricted numbers of reliable dates, sigma values spanning climatic fluctuations, and uncertainties about the specific hominin authors of some technocomplexes. Solutrean assemblages would fall within Population event 1, while sites such as Maszycka cave (Population event 2) and Pincevent (Population event 3) would have fallen within expansionary phases. The Ahrensburgian of Stellmoor fell within Population event 5. [See main text for more discussion.]*

Population event	**Settlement pattern**	**Phylogeography**	**GRIP stratotype**	**GRIP ice-core years (ka) BP**
1: Refugium	Dispersed	Low population size	LGM – GS-2c	25 – 19.5
2: Initial expansion	Pioneer		GS-2b – GS-2a	19.5 – 16
3: Main expansion	Residential	Founder effect and expansion	GS-2a – GI-1e	16 – 14
4: Stasis	Nucleation		GI-1d – GI-1a	14 – 12.9
5: Contraction			GS1	12.9 – 11.5

Upper Palaeolithic. The remaining three networking options (see Fig. 9.5: E, F, H) seem likelier, but are difficult to map directly onto technocomplexes. This is because the networking criteria used by Fitzhugh et al. test our expectations for Upper Palaeolithic demographies: were dispersing/colonizing groups more likely to have had open, exogamous, networks (Fig. 9.5: E), or ones intermediate between open and closed (Fig. 9.5: F)? Such strategies would have enabled reduction of the risks of dispersing into unfamiliar landscapes, e.g. evidence of early modern humans interbreeding with Neanderthals in Eurasia (Fu et al. 2014, 2015). Dispersing groups that moved as discrete, closed, networks, where endogamy and lack of information exchange with other groups were normal, would encounter problems of demographic sustainability (cf. Prüfer et al. 2014; Sikora et al. 2017). It is conceivable that such groups might have been forced into endogamy/inbreeding and closed interactive networks by the lack of other groups in the areas they were dispersing through (i.e. 'empty' landscapes), or through encountering groups with closed, territorial networks; such situations would have rendered these groups particularly vulnerable to major environmental deteriorations. As more residential 'infill' occupation of landscapes occurred after initial dispersal (Table 9.C3), one might expect interaction costs to decline as populations became more stable, allowing more intensive use of environmental resources (derived from greater adaptive depth and detailed local knowledge) and a wider range of marriage systems.

An individual would have had different motility potentials across their lifespan or between seasons/years, which may or may not have spatio-temporally coincided with those of other group members. Various activities (resource processing and storage, ceramic technology, funerary practices, etc.) might also serve to restrict mobility, at least temporally, for some individuals. 'Scouting' or 'walkabouts' by individuals with fewer ties to a location (e.g. unmarried, no children) might have served to track preferred resources in unoccupied landscapes, rather than population pressure pushing whole bands gradually forward in a wave-of-advance (Beaton 1991; Davies 2001).

APPENDIX D: SUNGHIR CASE STUDY

Table 9.D1. *Summary information for the Sunghir remains (56.176°N, 40.502°E). Data from Trinkaus et al. 2014; Trinkaus & Buzhilova 2012, 2018; Alexeeva et al. 2000; White 1993; Bosinski 2015. Dates from Marom et al. 2012; Dobrovolskaya et al. 2012; Nalawade-Chavan et al. 2014; Trinkaus et al. 2014, 11. Date corrections (CalPal2007_HULU) given at 2σ (95 per cent) (www.calpal.de). aDNA from Sikora et al. 2017.*

Specimen	14C date	Estimated age at death	aDNA	Grave goods	Notes
Sunghir 1 (grave 1)	OxA-X-2464-12: 28,890 ± 430 (hydroxyproline) [CalPal: 32,290–34,362 cal. BP]; KIA-27006 (femur): 27,050 ± 210 (ultrafiltration) [CalPal: 31,462–32,118 cal. BP].	35–45 years (Trinkaus et al. 2014) [cf. late 40s/ early 50s according to Trinkaus & Buzhilova (2012: 655)]	Male (Y-DNA haplogroup C1a2); mtDNA haplogroup U8c.	Variable staining with ochre on the body; especially rich on the cranium. ≥2936 subrectangular, rounded and subrectangular/oval beads/pendants; 'tens' (Trinkaus et al. 2014: 17) of perforated arctic fox canines, twelve on the forehead. A small pear-shaped schist pendant (painted red, with a small black dot on one side) on chest and 25 ivory rings/'bracelets'. A few lithic tools, some of which were located between the femora.	Clear burial pit. Adult male buried in a full set of inner and outer garments, as well as headgear. Perimortem wound (10 mm long, 1.1–2.2 mm wide and 6.5 mm deep) to first thoracic vertebra, caused by a sharp, thin object entering the body adjoining the left clavicle: no evidence of healed bone. Very worn teeth, especially on upper molars (less on the lower molars): the cause of this non-masticatory specific wear is not known. Calculus present on teeth. Microwear on molars suggests a significant plant (starch) consumption, as well as meat. High concentrations of zinc suggest a diet rich in vertebrate protein. Osteoarthritis in thumbs, midcarpals and wrists: in part related to activity levels and joint overloading (not simply age-related). Faint Harris lines on distal radii and partial ones on tibiae: remnant adolescent stress?
Sunghir 2 (grave 2)	OxX-2395-6: 30,100 ± 550 (hydroxyproline) [CalPal: 33,308–35,280 cal. BP]; OxA-15753 (tibia fragments): 25,020 ± 120 (ultrafiltration) [CalPal: 29,475–30,503 cal. BP].	*c.* 12 years	Male (Y-DNA haplogroup C1a2); mtDNA haplogroup U2.	Few bones show ochre-staining; concentrated on the skull, shoulders and left ilium. 1 massive ivory lance (2.47 m long and several kg) along his right side (and continuing along the left-hand upper body of Sunghir 3). An ivory disc, with latticework carving, standing upright on its edge in the soil: perhaps mounted over the tip of a now-decayed (wooden?) lance. 4903 ivory beads, of the same forms (but roughly 2/3 smaller) as seen in grave 1), plus a string of very small and thin beads (*c.* 1 mm thick) beneath the pelvis; ≥40 perforated arctic fox teeth on top of the head, mixed in with ivory beads; the remains of a decorated belt (>250 pierced arctic fox canines). An ivory pin at his throat (fastening for a cloak?), and an ivory indeterminate animal figurine on his chest. A large ivory mammoth sculpture was under his left shoulder, and Sunghir 4 was laid beside his left arm. ≥8 ivory 'bracelets' on his arms. A small tubular bead (from a bird bone?) was found in his upper left torso.	Grave 2: two immature individuals buried head-to-head in an elongated burial pit. Left forearm and hand bones of Sunghir 2 appear to be missing (no adornments in that area of the body either). Possible perimortem trauma in middle of left ilium: angular edges to the hole (fatal, if a wound from the front?). Very little tooth-wear (little more than polish): weak chewing and/or soft food? Weakly developed muscle insertions on head and body. Flat upper face and nasal bones slope sharply downwards: unlike faces of other Sunghir individuals. Calculus present on teeth. Microwear on a premolar and molar implies significant plant (starch) consumption, with lower meat consumption than seen Sunghir 1 and 3. Concentrations of zinc are also lower than Sunghir 1, 3 and 4, implying a lower consumption of vertebrate protein. At least one stress event documented in the teeth (linear enamel hypoplasias): at least two months in duration between age of about 2.5 and 3 years (subsequent stress periods between age of 3 and 5, but little sign of stress after that age). Weak evidence of stress-related growth disruption in long bones: one faint Harris line in proximal end of right fibula. Bone remodelling occurred after the age of five? A void in one thoracic vertebra: possibly a localized benign cyst or a parasitic infection.

Table 9.D1 *(cont.)*.

Specimen	14C date	Estimated age at death	aDNA	Grave goods	Notes
Sunghir 3 (grave 2)	OxX-2395-7: 30,000 ± 400 (hydroxyproline) [CalPal: 33,190–35,142 cal. BP]; KIA-27007 (humerus): 26,000 ± 410 (ultrafiltration) [CalPal: 30,071–31,831 cal. BP]; OxA-15751 (tibia fragments): 25,430 ± 160 (ultrafiltration) [CalPal: 29,640–30,912 cal. BP]; OxA-15754 (tibia fragments): 24,830 ± 110 (ultrafiltration) [CalPal: 29,255–30,463 cal. BP].	*c.* 10 years	Male (Y-DNA haplogroup C1a2); mtDNA haplogroup U2.	More extensive ochre-staining than seen for Sunghir 2: concentrated on the skull, shoulders, left ilium (with a thick layer of ivory beads) and right leg. 5274 ivory beads, plus another *c.* 115 preserved in the ochre on the ilia and 6–12 mixed with the hand bones; roughly 2/3 size of those from grave 1. No pierced arctic fox canines, nor a pendant on the chest. ≥13 ivory 'bracelets' on his arms. 2 pierced antler batons, one decorated with rows of drilled dots (White)*, at his side. Smaller ivory lances than seen alongside Sunghir 2 (scaled down?). 3 ivory discs (one small and two much larger) with a central hole and carved latticework, like that adjacent to Sunghir 2. The small disc was to the left of his head, while the other two were at his sides, accompanying the pointed ivory shafts (one of whose points was inserted into the central perforation of one of the larger discs; a *c.* 15 cm long linear array of microflakes from the disc to the lance tip might indicate armatures.	Relatively short femora (in comparison to the humeri and tibiae), which have very pronounced anterior curvature/bowing. Unlikely to derive from rickets, as symmetrical, so thought to be congenital. Sunghir 3 is more robust than Sunghir 2, even though younger at time of death, and his muscle insertions are also more robust. Seems to have been an active member of the group, with indications in the skeleton that his mobility was not constrained. More tooth wear than seen in Sunghir 2. Microwear studies of his molars suggest high carnivory (higher than seen in Sunghir 1 and 2), and this is supported by high concentrations of zinc: a diet rich in vertebrate protein. There is evidence in the teeth for at least three separate stress events between the age of 1.5 and 5.6 years. Stress seems to have been generally persistent for his first five years of life, varying in intensity not presence. Harris lines in the femora (7 lines in each) and tibiae (2 lines in each) likewise suggest that Sunghir 3's systemic stress continued until his death (reflecting either serious resource fluctuations, or his general frailty). High levels of calcium in the bones might reflect this individual's systemic abnormalities.
Sunghir 4 (grave 2)	OxX-2462-52: 29,820 ± 280 (hydroxyproline) [CalPal: 33,518–-34,646 cal. BP].	20s/30s	Male (Y-DNA haplogroup C1a2); mtDNA haplogroup U2.	Bone surface is highly polished (intentionally, or from repeated handling?), and medullary cavity filled with ochre. Broken proximal and distal ends are irregular (resemble dry bone breaks), though also appear burnished (from handling?). Spatially associated with Sunghir 2.	Very robust human femoral diaphysis, with missing proximal and distal ends (from lesser trochanter to mid-distal diaphysis). A smaller individual than Sunghir 1, and isotopic signature (e.g. very low levels of calcium) in the bone implies a different geographic origin for him, and/or a different postmortem history. Otherwise, the bone appears healthy.
Sunghir 5	OxA-X-2666-52: 26,042 ± 182 (amino acids) [CalPal: 30,288–31,692 cal. BP].	30s/40s (similar to Sunghir 1?)	Poor endogenous aDNA yield.	Associated with a large flat stone, abundant ochre, an arctic fox canine and an ivory rough-out/blank for a bead (latter two might derive from the cultural layer, rather than have been specifically deposited with the skull).	Isolated cranium: disturbed burial (ice-wedge and solifluction evidence immediately adjacent)? Found in cultural layer above grave 1 (sq. P-157). Healed minor traumatic lesion over right orbit. Some (age-related) periodontal degeneration.

Table 9.D1 *(cont.)*.

Specimen	14C date	Estimated age at death	aDNA	Grave goods	Notes
Sunghir 6 (cultural layer)	OxA-31755: 884 ± 23 (ultrafiltration) [CalPal: 703–943 cal. BP]; OxA-X2653-36: 925 ± 29 (hydroxyproline) [CalPal: 761–945 cal. BP].	Younger adult (in 20s)?	Male (Y-DNA haplogroup I2a1b2); mtDNA haplogroup W3a1.		Partial mandible from cultural layer above grave 2; date indicates historical age. No lesions: healthy bone.
Sunghir 7		Adolescent/ young adult?			Now lost. Partial femur from between graves 1 and 2, in the cultural layer. Possibly female?
Sunghir 8		16–17 years (mid to late adolescent)?		Unclear if grave goods were incorporated in the burial (no artefacts were found).	Very fragmentary, and now lost: cranial fragments and a crushed femur were recovered *c.* 200 m south of grave 2. Probably from a grave dug into sediments below cultural layer. Possibly female.
Sunghir 9					Skeleton; now lost. Found in a quarry southeast of Graves 1 and 2, in 1972.
Sunghir 10 (grave 2bis)		Adult		Partially covered in ochre. 3 perforated schist pendants; ivory beads; perforated arctic fox canines, small bone tubes, a bone awl; a finely worked biface; 18 cm-long worked mammoth tusk, a small ivory ring; a worked fossil mollusc shell; 2 reindeer antler 'clubs'.	Buried in an extended position; very deteriorated remains. Found within the cultural layer (hence its poor preservation?). Immediately overlies grave 2 (Sunghir 2 and 3).

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